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**Bus rapid transit as formalization: Accessibility impacts of transport reform in  
Cape Town, South Africa**

by

Lisa Rayle

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requirements for the degree of

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in

City & Regional Planning

in the

Graduate Division

of the

University of California, Berkeley

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Fall 2017

**Bus rapid transit as formalization: Accessibility impacts of transport reform in  
Cape Town, South Africa**

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Lisa Rayle

## Abstract

Bus rapid transit as formalization: Accessibility impacts of transport reform in Cape Town, South Africa

by

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Doctor of Philosophy in City & Regional Planning

University of California, Berkeley

Associate Professor Daniel Chatman, Chair

Many cities worldwide are introducing bus rapid transit (BRT) into contexts where informal transport modes serve a substantial part of the public transport market. These BRT initiatives are intended, among other goals, to formalize existing transport systems and to improve accessibility. However, the extent to which BRT reforms actually improve residents' ability to reach activities remains in question. In this dissertation, I contribute to the empirical and theoretical literature on informal transport by investigating how BRT reform has impacted accessibility for residents of Cape Town, South Africa.

How have Cape Town's transport reforms affected accessibility and its distribution amongst different population groups? Why have reforms had these effects? I address these questions using three methods: (1) an accessibility index computed using a transport network model, (2) a difference-in-difference approach using intercept survey data, and (3) interviews with users and stakeholders.

The accessibility model suggested that, in this specific case, the BRT reforms slightly improved accessibility to retail, office, and hospital uses for the majority of residents. Because informal modes were only partially removed, only a small fraction of residents experienced reduced accessibility. The survey findings showed BRT was more effective as an upgrade of existing formal modes than as a replacement for informal transport. Survey respondents realized travel time benefits not by switching to BRT from informal transport, but by switching to BRT from existing formal transit – conventional bus and train. Shifting from conventional bus to BRT was associated with an average commute time savings of 10 minutes. The BRT appears to differentially provide better accessibility to white and high-income residents, although black residents realized the greater travel time savings because they were more likely to switch from conventional bus and train.

Evidence suggests these particular outcome are best explained by changes in the institutional and incentive structures behind transport provision. The shift from informal transport to BRT involved: formalizing multiple dimensions of transport provision in multiple dimensions; expanding the scope of goals for public transport; and changing the relationship be-



tween transport providers and users. These changes in transport provision help explain why BRT reforms were more effective as an upgrade for formal transport than as a replacement for informal modes.

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# Chapter 1

## Introduction

Many cities around the world have faced growing transportation challenges, as growing urban populations strain existing public transport systems and increasing numbers of vehicles crowd streets, leading to intractable congestion, long commutes, air pollution, and unsafe roads. City leaders struggle to satisfy residents' and businesses' need for travel with environmental and social concerns within limited budgets. In many cities, government-managed public transport remains underfunded and poor in quality, while privately provided 'informal' transport often adds to congestion, pollution, and accidents (Cervero and Golub 2007).

City leaders have increasingly turned to bus rapid transit (BRT) as a means of meeting these challenges (Hidalgo and Gutierrez 2013). As a technology, BRT is differentiated from conventional bus systems by an exclusive, segregated busway with a dedicated right-of-way, signal priority, off-board fare collection, and platform-level boarding (ITDP, 2013). According to advocates, a well-designed BRT system allows a passenger capacity, travel speed, and comfort level closer to rail than to conventional bus, but at a much lower cost (Hidalgo and Hermann 2004; Hensher 2007; ITDP 2013).

In all but the newest cities, BRT arrives in an environment where public transport is already well established. Informal modes might serve a large proportion of the transport market, often having emerged where government involvement in transport falls short (Gwilliam 2008b). On the informality continuum, we can characterize more informal transport modes generally as those with smaller-scale private operators, relatively weak government regulation and oversight, and labor-intensive service (Cervero 2000). Every city has its own form of informal transport, including shared taxis, motobikes, autorickshaws, colectivos, dollar vans, matatus, jitneys, and many others. Cities that adopt BRT may also have existing public transport modes, such as conventional buses or heavy rail, that are more likely to be government-subsidized and with more government oversight. In large cities especially, BRT typically is introduced into a landscape with many diverse transport modes from across the formality spectrum.

The introduction of BRT often involves major changes to the existing transport system. Indeed, reform of existing transport services is often part of the plan, and might mean formalization of informal modes. As Paget-Seekins et al. (2015) pointed out, BRT interventions

in cities with informal transport usually involve formalization because, compared to informal transport, BRT requires “more professional management,” “better-capitalized operators,” a more “complex organizational arrangement,” and the “capacity to write and enforce contracts” (p. 424). Ardila (2008) argued BRT is unusually effective in transforming the nature of competition. According to Hook (2005, p. 184), BRT has proven “a mechanism for the government to establish effect regulatory control over largely privatized systems” because, compared to alternative strategies, it offers wide public appeal and fast implementation at relatively low cost to the government (Hidalgo and Carrigan 2010). Thus, formalization may not involve BRT, but BRT is a widely used means of accomplishing formalization.

Cities also often intend BRT to improve upon more formal public transit as well. Cities with limited government resources often struggle to provide adequate bus or rail systems, since high-quality systems that are also affordable for riders usually require public subsidy. When quality lags, mass transit can be caught in a vicious cycle of declining ridership, falling revenue, and service cuts (Gwilliam 2008b; Gomez-Ibanez and Meyer 1993). City leaders have often seen BRT as a way to break this cycle, and reinvigorate public transport systems with renewed financial investment and political commitment.

Hundreds of cities have adopted BRT with the intention of replacing, reforming, or upgrading existing transport systems (Hidalgo and Gutierrez 2013). While the literature has documented many of these reforms (Gilbert 2008; Venter 2013; Wood 2015a; Rizvi and Sclar 2014; Flores Dewey 2013), we have limited knowledge of the extent to which they have improved accessibility for the public. How do BRT interventions affect accessibility and its distribution, compared to pre-existing informal transport? When BRT involves formalization, what is gained, and what is lost?

## 1.1 Formalization and accessibility

### Informality and transportation

Because formalization of informal transport is such a common and important part of BRT reforms, in this dissertation I will pay particular attention to how BRT-driven transport formalization affects accessibility, and how the accessibility provided by formalized services like BRT compares to that provided by less formal modes.

The concepts of informality and formalization are hard to define and remain under-explored in the transportation literature. Cervero and Golub (2007), for instance, defined informal transport services as “those operating without official endorsement” (p. 446). This definition is questionable because, although many informal modes begin illegally, many eventually receive some form of endorsement without change to service characteristics. Are they still informal? What about situations in which governments officially tolerate unendorsed services? Many authors prefer to avoid the term informal entirely. Behrens et al. (2016), for example, prefer to define “paratransit” as a collection of transport modes that are distinct from “formal transit.”

Still, the transportation literature acknowledges informal transport as a useful concept. The term “informal transportation” appeared in print as far back as the late 1960s and early 1970s, when U.S. policymakers became interested in how local, unplanned transportation served poor, elderly, and/or rural populations lacking access to conventional public transit (Burkhardt 1969; Hauser, FHA, and Research Triangle Institute 1974; Institute of Public Administration 1975). Since then, informal transport has come to be most often associated with developing countries, where small, private transport providers thrive in a context of under-resourced governments and structural unemployment. In some countries, informal transport accounts for the majority of urban travel (Cervero 2000; Finn 2012; Behrens, McCormick, and Mfinanga 2016). Researchers have occasionally shown interest in informal transportation in the U.S. as well, usually in the context of immigrant communities (Valenzuela Jr., Schweitzer, and Robles 2005; Mukhija and Loukaitou-Sideris 2014; Goldwyn 2016).

Transport considered ‘informal’ comes in many forms, as Cervero (2000) described in his survey of transport in developing countries. From Jakarta’s bajajs (motorcycle taxis) to Rio de Janeiro’s vans to Hong Kong’s Public Light Buses, informal modes develop characteristics according to local context. Despite this diversity, Cervero suggested that, compared to formal modes, informal transport tends to be less planned, less scheduled, more flexible, with smaller vehicles, often cash-based, and provided by small-scale, private entrepreneurs. Researchers do not agree on a definition of informal transport, though most would agree the common characteristics of informal transport tend to arise from a lack of government oversight and private-sector provision. Behrens et al. (2016) identified three dimensions of paratransit: the degree of regulation of competition, the degree of flexibility in service planning, and the degree of business formality. Although all of these authors acknowledge interconnections between these dimensions, they stop short of explaining how exactly regulation, business formality, and service planning interact to produce certain modes. They do not tell us why informal transport modes in different countries so often develop similar service characteristics. Without this level of understanding, it’s harder to predict how formalization will affect service characteristics and, ultimately, accessibility.

Because their economic structure allows them to respond readily to demand, informal services in many cases offer fast, convenient, and affordable mobility to people who depend on public transportation (Cervero 2000; Cervero and Golub 2007). These benefits, however, typically come at the cost of high accident rates, pollution, labor exploitation, poor customer service, and especially congestion.

Informal transport modes often coexist with other modes in diverse multimodal landscapes. For example, Mumbai’s autorickshaws share the streets with privately operated metered taxis and carry passengers to the publicly provided commuter rail. Rio de Janeiro’s vans and motorcycle taxis connect with regulated, concessionaire-operated buses and the public metro.

## Accessibility and formalization

Accessibility is the ease of reaching the activities that bring people to cities in the first place—jobs, shopping, services, social interactions (Handy and Niemeier 1997). Unlike mobility, which merely refers to the ability to move around, the concept of accessibility reflects how people actually experience traveling in cities because it considers not just the transportation system, but the number, location, and quality of potential destinations. For this reason, researchers have argued planners should aim to increase accessibility rather than just mobility—whereas continual highway building might maximize mobility, maximizing accessibility requires balancing both land use and transportation (Handy and Niemeier 1997; Geurs and van Wee 2004; Levine et al. 2012).

Accessibility has also proven to be a particularly useful concept for analyzing distributional impacts. Countless studies have focused on distributional impacts by using accessibility maps to easily visualize spatial disparities and/or by comparing accessibility indices for different population groups (Bocarejo and Oviedo 2012; Foth, Manaugh, and El-Geneidy 2013; Golub and Martens 2014; Grengs 2015; Lucas, Wee, and Maat 2016).

BRT reforms typically aim to achieve multiple goals simultaneously—and improving accessibility is often one of them. In comparison with the informal modes it often replaces, BRT can potentially reduce congestion and thus increase travel speeds by consolidating people into fewer higher-capacity vehicles, and/or by using dedicated right-of-ways to avoid congested roads (Levinson et al. 2003). But formalization does not necessarily improve accessibility for everyone. Capital-intensive public transit like BRT typically transforms more disperse and flexible point-to-point service into more fixed service in trunk-and-feeder configurations (Hook 2005). Following a reform of this type, we would expect accessibility improvements for those whose travel patterns fit the main service, but not necessarily for passengers who have to travel outside the main corridors, whose journey might now require more transfers, or those who travel at non-conventional times, who might now experience reduced service frequency.

Informal modes may offer superior accessibility in many developing country contexts. Cervero and Golub (2007) have argued that, compared to formal public transport, informal modes are better able to “respond quickly to changing markets” and are “more in-tune with their passenger’s [sic] demands” (p. 448). With smaller vehicles, they can offer higher frequency service and can more easily “maneuovre in crowded city streets” (Cervero and Golub 2007, p. 448).

Moreover, the ability of BRT to improve accessibility presupposes the existence of a government capable of planning, implementing, and managing such a system. BRT advocates like the non-governmental organization EMBARQ emphasize that successful BRT requires government commitment through planning, implementation and operation phases, in activities like system planning, user education, and contract management (Hidalgo and Carrigan 2010). Research on BRT implementation in several cities suggests negotiation with existing informal transport operators is both important and highly demanding of government resources (Schalekamp and Behrens 2013; Flores Dewey 2013; Paget-Seekins, Dewey, and

Muñoz 2015). Rizvi and Sclaar (2014) highlighted the importance of sustained political commitment and meaningful public engagement in creating successful BRT in India. Despite its comparatively low costs, BRT does require capital investment and usually public operational subsidy (Hidalgo and Carrigan 2010). Even without BRT, other reforms like competitive tendering, in which the government aims to shape competition, requires governments to effectively negotiate and manage contracts with private-sector transport providers (Walters and Jansson 2008; Hensher and Stanley 2010).

In developing countries especially, governments may simply not have the experience or resources needed to succeed in these tasks. The fact that BRT “demands more capable operators and governments” (Ardila 2008, p. 15) might motivate governments to expand their capabilities, but what happens if they do not? In this case, as Cervero and Golub (2007) argued, informal transport that can function without much government involvement may provide better accessibility, and residents may be better off without BRT interventions.

## 1.2 What we know about how BRT affects accessibility

Despite decades of cities’ attempts at BRT reforms, we understand relatively little about how they actually affects accessibility for users. BRT studies typically report accessibility impacts in terms of the change in travel times for trips within main corridors; for these we would expect the reduction in congestion to improve travel time. For example, in Bogotá BRT is credited with reducing travel times on corridors (Echeverry et al. 2005; Hidalgo, Pereira, et al. 2013). In Jakarta, BRT reportedly reduced travel time on the main corridor by 59 minutes in the peak period (Ernst 2005). BRT users in Delhi also benefited from reduced travel times on the corridor (Tiwari and Jain 2012). However, fewer studies consider the wider impacts on those who travel outside the main corridors. Those that do, such as in Bogotá, have found BRT had much less impact (Munoz-Raskin 2010; Combs 2017). Even on main corridors, BRT might not offer shorter travel times if passengers must walk further to access stops or wait longer to board a bus (Gilbert 2008).

Additionally, existing studies typically focus on travel times, rather than a broader concept of accessibility. Many authors argue more meaningful accessibility measures take into account land use patterns and travelers’ needs (Geurs and van Wee 2004; El-Geneidy and Levinson 2006). Tiwari and Jain (2012), for example, incorporated land use into their assessment of Delhi’s BRT, but had to limit analysis to the BRT corridor only. Delmelle and Casas (2012) evaluated the citywide accessibility impacts of BRT in Cali, but did not consider how accessibility by BRT compared to that of informal transport. The literature on other types of government intervention in informal transport markets, like competitive tendering, has mainly focused on supply-side impacts such as vehicle numbers and service frequencies, as well as congestion (e.g., Estache and Gómez-Lobo 2005). While these factors would influence users’ accessibility, I am not aware of any studies that directly considered

the impact of reforms on users' accessibility.

Without understanding effects on users outside main corridors, and without considering the spatial distribution of users' origins and desired destinations, we are left with an incomplete picture of the social equity implications of BRT interventions. In particular, the focus on corridor-level impacts tends to deemphasize potential effects for residents in more peripheral locations, who in many developing countries are likely to be lower-income. If BRT is intended to improve accessibility for low-income residents, this is an important oversight. Moreover, we have only a vague understanding of the means through which formalization affects accessibility.

### 1.3 Research questions and hypotheses

In this dissertation, I address gaps in the literature by asking the following broad questions. Does accessibility increase when BRT is introduced into a context with transport modes of varying levels of informality? How do changes in accessibility affect different population groups? Through what pathways in transport provision do BRT reforms affect accessibility?

I consider these questions in the particular case of public transport reform in Cape Town, South Africa. The City of Cape Town, after previous unsuccessful attempts at upgrading and restructuring its informal public transport, adopted a strategy of incrementally replacing minibus taxi services with BRT. Using Cape Town as the case study, I address the following questions: *In what ways did Cape Town's transport reforms and introduction of BRT change public transport provision? How did these reforms affect accessibility for various population groups? Why did the reforms result in these outcomes?*

#### Hypotheses

I began the research with the following hypotheses, in response to the research questions.

*Question 1: In what ways did Cape Town's transport reforms and introduction of BRT change public transport provision?*

I expected the most important aspect of Cape Town's reforms to lie in changes in relationships between the main actors in public transport provision: transport operators, the government, and the public. Specifically, in the existing informal system, transport operators would relate to the public mainly through market competition – operators would be incentivized through the profit motive to find out about users' travel needs – with little involvement by government. In contrast, after BRT reform the government would play a more central role. The relationship between previously informal transport operators and the public would be mediated by government. Operators would be incentivized to meet contract obligations, and it would fall to government agencies to understand user needs and interact with the public. I hypothesized these changes in incentive structures would affect accessibility through changes in service characteristics. Whereas existing informal operators provided

a service that responded quickly to changes in user demand, the new BRT might sacrifice demand-responsiveness for broader goals, like serving passengers with disabilities.

*Question 2: How have these reforms affected accessibility for various population groups?*

The Cape Town case presents an interesting opportunity to study the effects of BRT intervention because, at the time of this study, the city's transport existed in three stages of reform. I expected the city's transport reforms to have different accessibility impacts in each of these areas. Accordingly, in the case of BRT in Cape Town, I hypothesized the following.

1. In Phase 1 of the BRT service area, BRT has replaced all previously existing modes of public transport, mainly informal minibus taxis and contractor-operated conventional buses. For the population located here, I expected accessibility to improve for those within the main trunk route, but has declined for those further away.
2. Where Phase 2 of the BRT will be built, the city has implemented a new express bus service as a pilot project. This new express service shares the branding and most other characteristics with BRT, but without the separated busway along the full route. In this Phase 2 area, previously existing minibus taxis and conventional buses still operate, along with a severely under-funded commuter rail service. For these residents, I expected accessibility to have increased because BRT introduced an additional option.
3. In the rest of the region, BRT has not yet been introduced and previously existing public transport remains. In these areas I expected that, although BRT reform has increased accessibility for some disadvantaged communities, specifically those who benefited from having both BRT and minibus taxis available, overall BRT formalization has reduced accessibility for disadvantaged communities, compared to what previously existed.

*Question 3: Why did the reforms result in these outcomes?*

The accessibility impacts of BRT reform depend greatly on the capacity of government to plan and design a system, write and enforce operator contracts, and engage in ongoing management and maintenance. Particularly important is the need for government authorities to understand travel demand and user preferences, and translate that into system design. In comparison, the incumbent informal transport requires little of governments. Informal operators respond directly to demand through market competition, and they are closer to the community, so they are more prepared to understand and satisfy travel demand. Their more flexible nature allows them to more easily respond to demand.

Compared to other cities, the government in Cape Town has moderate capacity to plan and manage transport. Thus it's difficult to predict whether it will be capable of taking on the responsibilities required by BRT. Cape Town, compared to other cities, also faces extreme socioeconomic inequality and segregation that make providing equitable transport more difficult. In the case of Cape Town, I initially expected to find the following:



- Because the public transport authority had little experience in public participation or transit planning, it was not able to understand and respond to user needs as well as informal operators. The lack of government capacity negatively affected the ability of transport authority to improve accessibility.
- The government did not have a strong incentive to represent citizens' interests in proportion to the population, and it favored those who were politically most powerful, mainly middle-class, white car drivers. As a result, the transport reform differentially benefited accessibility for these groups.

## 1.4 Methodology

In this dissertation, I used a mixed-methods approach to investigate the impacts of BRT intervention on accessibility, focusing on the specific case of Cape Town. I analyzed the accessibility impacts of the first phase of Cape Town's BRT, five years after it was first introduced. To compare the accessibility provided by BRT with that provided by the previously existing services, I employed three complementary methodological approaches. In the first, I estimated quantitative measures of accessibility to various land uses via a computational model of the minibus taxi system. In the second method, I analyzed travel times reported by respondents to a survey of public transport users. Third, I interviewed BRT and minibus taxi users to better understand their needs and preferences, and how the introduction of BRT has affected their travel experience. In all three, I compared changes in accessibility among population groups as differentiated by proximity to the BRT and by race and income.

I conducted these analyses within a case study of Cape Town's public transport reforms, in which I relied on interviews with transport providers, political leaders, planners, and public transport users, along with review of documents. The interviews with transport users complemented the user survey and provide a more comprehensive and more nuanced assessment of changes in accessibility. Through the stakeholder interviews and document review, I identified the ways in which Cape Town's reforms changed transport provision, and explained why these changes led to the observed accessibility outcomes.

To elaborate, the methodology has four parts:

### 1. Case study of Cape Town reforms

These approaches to measuring accessibility are embedded within a case study of transport reform in Cape Town. In order to describe the case context, I conducted interviews with 18 planners, government officials, and transport providers involved in the BRT and reform plans. I also reviewed publicly available documents, such as plans and white papers, relevant to the transport reforms. This research served two purposes: it helped me describe what reform actually involved in the Cape Town case, and it allowed me to identify the ways in

which it resulted in the accessibility impacts I observed. In other words, the case study research helped me answer the question, “why did BRT reform have these effects?”

## 2. Model-based accessibility index approach

Here, I measured accessibility impacts using an accessibility index approach. I computed a score that represents accessibility to various types of opportunities available within a given travel time of residents living in a given location. I compared this accessibility index, sometimes known as the *cumulative opportunities* approach, for minibus taxi and BRT modes, and for time periods before (pretest) and after the introduction of BRT (post-test). In order to compute the accessibility score for minibus taxi, I employed travel time estimates from custom-built network routing model of the minibus taxi system, which relied on minibus taxi route and frequency data provided by the City of Cape Town. The model results show the extent to which changes in the transport technology – specifically, network design and service frequency – influence accessibility and its distribution. In other words, the accessibility index approach isolated the effects of network and service design. It also illustrated the effect of land use patterns on accessibility.

## 3. Survey-based approach

In the second approach to measuring accessibility, I analyzed data collected via a custom-designed intercept survey of Cape Town residents both within and outside of the BRT service area. The survey of 1,580 travelers targeted minibus taxi and BRT users, and asked respondents to report their typical travel times for work and non-work travel in current (post-test) period and, retrospectively, for the pretest period. I use a difference-in-difference approach to analyze the effect of BRT introduction on travel times among various population groups, accounting for whether or not respondents changed their home and destination locations. The survey measures actual reported changes in travel times among Cape Town travelers in response to the transport reforms.

## 4. User interviews

In addition to the user survey, I interviewed 54 individual public transport users about their experiences and travel decisions regarding the BRT reforms. While the survey-based approach focused on travel time changes, the user interviews provided a fuller picture of how travelers in Cape Town have actually experienced transport reforms and the motivations for their travel choices. The interviews provided an assessment of accessibility impacts in terms of not just travel time, but other aspects such as comfort, safety, and reliability.

## 1.5 Selection of Cape Town as a case study

Cape Town's public transport reform makes a good case study for a several reasons. First, Cape Town introduced BRT into a landscape with several existing transport modes, including informal transport, which makes this case similar to that in many other cities. Cape Town's BRT, called MyCiTi, was initially modeled after Bogotá's Transmilenio (Wood 2014b), and in terms of technical specifications and business structure it followed international best practices. Moreover, as in many cities, the BRT was intended as a means of formalizing the informal transport sector, among other goals. Second, Cape Town is a city with moderate government capacity. The government has the competency and authority to regulate the informal sector to a certain degree and to undertake a large-scale project like MyCiTi, but still has many resource constraints that limit its ability to, for example, enforce all regulations against illegal transport operators or provide high-quality rail transit. Thus it falls in the middle ground where formalization through BRT might be successful, or it might not.

Third, the timing was right. When I began studying Cape Town, MyCiTi had been operating for five years, an ideal amount of time for a post-hoc evaluation: long enough to find observable impacts, but still short enough to conduct a retrospective survey. Fourth, with a population of 3.7 million, Cape Town is a medium-sized city, which makes this case more relevant to the many growing, medium-sized cities now considering BRT. Fifth, with its high socioeconomic inequality and segregation, Cape Town demonstrates the social equity issues faced by many cities in the developing world, just in more extreme terms. Finally, Cape Town offered a relatively practical place to do research, since I could partner with the University of Cape Town and since a good deal of secondary data and planning documents are available.

## 1.6 Summary of findings

The case study showed Cape Town's reforms have so far altered the city's public transport in terms of both the physical service provided and the institutional structures behind them. In the Phase 1 service area, it physically replaced nearly all of the existing public transport system. In the Phase 1 area, the City designed the new BRT to replace existing minibus taxi service, and the City removed most minibus taxis from the streets, with some remaining in high-demand areas due both to technical complications with licensing and to vehicles operating illegally. In the Phase 1 area, BRT also replaced the aging conventional bus service provided by a private company, Golden Arrow, under a government-issued contract. In the high-demand corridor where MyCiTi Phase 2 will be built, the reforms added a new transport option. Here, the N2 Express, the express bus service that was part of the MyCiTi system but without full-fledged separated busways, was added on top of existing minibus taxi, commuter rail, and conventional bus service.

Across the city, the introduction of BRT in Cape Town represented a realignment of public

and private sector responsibilities in transportation. It involved an increased commitment and authority on the part of the municipal government to plan, finance, manage, and regulate public transportation, and an increased financial but reduced managerial responsibility on the part of the federal and provincial governments. It also meant expanded public sector involvement in transportation in a context where the private sector had previously been more important. These shifts in responsibilities changed the institutional and incentive structures behind transport provision, with consequences for service characteristics.

I identified three main aspects of the MyCiTi reforms important in influencing public transport accessibility. First, the reforms involved changes in transport providers' motivations and goals. Whereas minibus taxi operators had a single goal of maximizing revenue, MyCiTi aimed to achieve multiple goals, which expanded the scope of objectives from merely responding to existing users' travel demand to broader societal interests like reducing congestion, improving road safety, and social integration. Second, MyCiTi changed the way in which transport providers understand users' needs and preferences, through changes in the relationship between providers and users. With minibus taxis, operators learned about users' needs through market competition. In contrast, with MyCiTi the City's transportation authority used methods like surveys, public meetings, and customer service feedback to learn what users wanted. Third, the reforms formalized public transport provision in Cape Town, at least in the MyCiTi area, partially replacing a relatively informal service (minibus taxis) with a more formal one (MyCiTi). MyCiTi traded the flexibility of informal transport for potential economies of scale possible with a large-scale government-managed system. Compared to the existing formal modes, MyCiTi represented an increase in public investment in transportation, replacing outdated and poorly performing services with newer vehicles and modern technology.

Overall, my research suggested Cape Town's BRT reforms resulted in increased accessibility for the average resident. Impacts differed by location and population group, however. For residents in the Phase 1 area, the replacement of existing public transport with BRT mostly improved accessibility when measured by the amount of office, retail, and hospital activities reachable within a given travel time. MyCiTi resulting in residents in the Phase 1 area being able to access on average 1% to 9% more retail and office activities compared to 2011, even though many minibus taxi routes were removed. In the N2 Express area, where BRT was added on top of existing minibus taxis, accessibility unsurprisingly improved as travelers gained more choices.

MyCiTi's clearest travel time benefits came less from replacing informal transport, as was intended, and more from upgrading existing formal public transport. Controlling for changes in origin and destination, when survey respondents switched from train and conventional bus to minibus taxi, they saved just as much or even more time than respondents who switched from train and conventional bus to MyCiTi. According to regression analysis of the user surveys, commuters who switched from Golden Arrow to MyCiTi saved an extra 10 minutes (or had a travel time increase 10 minutes smaller), on average, compared to those who did not. Switching from train to minibus taxi had a similar effect: respondents could expect an extra commute time savings of about 12 minutes, compared to those who did not make that

switch.

In comparison, respondents who switched from minibus taxi to MyCiTi had travel time savings that were small and statistically insignificant, for both work and non-work travel. In addition, access to MyCiTi had no discernible effect changes in work travel times; however, for shopping and personal visits, those with a home and destination in the MyCiTi service area had on average a 6.2-minute travel time savings.

Evidence from the user survey and interviews therefore suggested one of the most important results of Cape Town's transport reforms was not what I initially expected. MyCiTi was most important as an upgrade to poorly performing government-subsidized modes of conventional bus (Golden Arrow) and the train. Atypically, in Cape Town the train was widely known as the least desirable mode of travel in every regard except price—residents considered it slow, unreliable, unsafe and uncomfortable, although very cheap. Moreover, its service appears to have declined in recent years, as the national government has increasingly struggled with management of its state-owned enterprises (Crowley 2015; England 2014; Onishi 2015). The survey findings suggest many train passengers may have switched to MyCiTi or to minibus taxi in response to declining train service quality and saved travel time as a result. The cost of switching was higher fares, as both taxis and MyCiTi are more expensive than the train.

MyCiTi was intended to replace Golden Arrow, and in the Phase 1 area, Golden Arrow routes were removed to make way for MyCiTi, and the Golden Arrow company itself participated in the reform by becoming a shareholder in one of the MyCiTi operating companies. In the case of the Phase 1 area, the travel time savings associated with switching from Golden Arrow to MyCiTi, but not from minibus taxi to MyCiTi, suggest that BRT was a clear improvement over conventional bus, at least in terms of travel time, but not clearly an improvement over informal minibuses.

With respect to the distribution of accessibility benefits, existing residential patterns, with their extreme racial and economic segregation, largely determined who benefited from the BRT. In terms of households served, the BRT network favored white and upper income residents disproportionately. However, since most white and upper income households previously used car and not public transport, their travel times did not necessarily improve with the BRT. In contrast, the BRT did improve travel times for large numbers of nonwhite and lower-income travelers, mainly because these travelers previously had very poor formal public transport options.

Citywide, the reforms apparently increased accessibility for all racial and economic population groups, but not equally so. According to the accessibility model, the greatest accessibility increases in percentage terms were for high-income and white households to retail uses, thanks to the higher concentration of high-income and white households near MyCiTi's Phase 1 trunk corridor. On the whole, coloured residents appear to have had the smallest gains in accessibility 2011 to 2015. Taxis provided greatest accessibility to blacks when considering trips of 45 minutes or more. Although it appears MyCiTi provided the largest accessibility increases to white and high-income residents, at least at the 30- and 45-minute thresholds, the addition of the N2 Express greatly increased accessibility for the limited

number of residents near those stops, who are predominantly lower-income and non-white.

MyCiTi's accessibility benefits sometimes came at the cost of higher fares and sometimes not. MyCiTi fares are subsidized and depend on the type of ticket, but are almost always higher than train fares. They are comparable in price to Golden Arrow, so commuters who switched to MyCiTi from Golden Arrow generally benefited in both time and cost. Compared to minibus taxis, MyCiTi may be slower, but it is usually cheaper, depending on the trip. Unlike taxis, MyCiTi offers free transfers and is cheaper per kilometer for longer distances. However, for short, direct trips the taxi fare is often but not always a bit lower than the saver peak-period MyCiTi fare.

The findings partially supported my hypothesis that lack of government capacity would prevent the introduction of BRT from providing greater accessibility benefits, although part of the reform itself was increasing government capacity. Early in the planning process, the City of Cape Town had limited understanding of travelers' needs, and even as that capacity improved, the inflexible nature of BRT made it harder to overcome early mistakes, such as problematic stop placement and inefficient fleet mix. The BRT reforms' failure to significantly improve accessibility over minibus taxis was better explained by the incentives and internal characteristics of transport provision than by the nature of the relationship between transport providers and users. In the Cape Town case, the formalized system was not as demand-responsive as the previously existing informal system, for reasons that appear to be inherent to informal transport.

## 1.7 Contributions to the literature

This dissertation offers both theoretical and empirical contributions to the transportation literature, filling gaps in the current research. It significantly adds to theory by offering a more complete conceptualization of informal transport, explaining why informality expresses more than other concepts like regulation and market-driven provision can alone. I suggest conceptualizing formalization as changes in four dimensions—relationship to government, relationship to labor, private sector provision, and internal organizational structure and practices—allows us to better explain consequences for accessibility. This dissertation describes what BRT reform entails in the case of Cape Town and explains why, when BRT involves transport formalization, it can be expected to significantly change service characteristics.

Specifically, the Cape Town case study offers an example of how BRT reforms can change the relationship between transport providers, users, and the government. It illustrates how changes in these relationships lead to, first, altered incentive structures that influence the extent to which public transport responds to users' travel needs and, second, which population groups are considered as users. It supports existing literature that suggest BRT at least in developing countries should be understood as an expansion of government authority and commitment in public transport, and shift in goals from the market-oriented focus on travel demand fulfillment to broader public interest concerns.

The dissertation contributes to empirical research with an analysis of accessibility and its distribution before and after a BRT intervention, using a novel data source from one city. It also uses original data to explain the mechanisms by which formalization through BRT affected accessibility in this particular case. While only a single case, this study adds to a body of research on effect of BRT in other cities. This analysis addresses questions currently at the forefront of transportation research regarding the relative accessibility benefits of informal transport versus bus rapid transit.

## 1.8 Policy implications

This research speaks directly to policymakers wondering how best to provide public transport. My finding that, in the Cape Town case, BRT was more effective when replacing existing bus and train services than when formalizing minibus taxis suggests that planners and policymakers might consider BRT more as a way to upgrade existing public transit than as a one-size-fits all solution to transport. In the case of BRT as formalization, specifically when service-based contracts are used, policymakers should not expect the new system to replicate features of the informal system without operational subsidies.

The Cape Town case highlights the importance of considering local land use patterns in planning BRT. That land use influences travel demand is obvious, but in Cape Town officials and planners did not anticipate the degree to which the separated land use – especially, segregation between work and home – would create unbalanced travel demand that seriously strained BRT capacity. More generally, the case suggests that, if planners expect BRT to compete with existing informal modes, a solid understanding of users' travel needs is key.

This research has the most direct relevance to decision-makers in developing countries with sizable informal transport sectors, but it may also resonate in U.S. cities where governments at all levels have been slowly retreating from regulation and where, arguably, informal services are filling the vacuum. This study may be of interest to leaders in cities where ride-hailing has, arguably, reintroduced informality into a very formalized system. In all cases, though, lessons should be taken with caution, as this research represents only one case of formalization in one particular local context. For policymakers, this dissertation will be most useful in combination with other studies that can put the Cape Town case in perspective.

## 1.9 Organization

The remainder of this dissertation is organized as follows. Chapter 2 reviews the existing literature on informal transport and BRT as a response to informality. It presents a conceptual framework for understanding transport formalization that is useful in predicting how formalization may affect accessibility for users. In Chapter 3, I present the Cape Town context, and describe how Cape Town is similar to and different from other cities that have attempted BRT reforms. In the following Chapter 4, I describe what BRT reform actually

involved in the Cape Town case and how it might be expected to affect accessibility, drawing on stakeholder interviews and document review.

The next three chapters present research findings. Chapter 5 details the accessibility index approach, presenting the network-based accessibility model. In Chapter 6, I present methodology of and findings from the user survey. Next, in Chapter 7, I discussed findings from the user interviews, which provide more context for the survey findings. Finally Chapter 8 concludes with a discussion and synthesis of results, along with implications for policy and future research.



## Chapter 2

# Bus Rapid Transit as a transport reform

The transport literature has documented the spread of bus rapid transit (BRT) from a niche concept in Brazil to cities of all sizes and stages of development around the world (Hidalgo and Gutierrez 2013). In low- and middle-income countries where government resources are limited, BRT has been especially popular as a lower-cost alternative to more capital-intensive mass transit like metros or light rail systems.

The BRT technology—a bus network with dedicated lanes and vehicles and stations designed for rapid boarding—is typically credited to Curitiba, Brazil, where the city has grown around planned bus corridors since the 1970s (Lindau, Hidalgo, and Facchini 2010). It was the early success of Bogotá’s BRT system, Transmilenio, however, that propelled the spread of BRT as a means of transport sector reform (Hidalgo and Hermann 2004; Wood 2014b; Montero 2016). By 2016, at least 204 cities around the world had adopted BRT (EMBARQ 2016).

In all but the newest cities, BRT enters an environment where existing transport modes have built up over time. BRT might arrive to meet a system dominated by government-subsidized mass transit. BRT’s predecessors might also be informal transport modes that are less regulated and privately provided. Most likely, especially in larger cities, BRT is introduced in a context with multiple varied transport modes, from both ends of the informality spectrum. When a city decides to create a new BRT network, it is usually in response to perceived inadequacies in the existing transportation system. Government-subsidized transit might be under-resourced or inefficient. More informal transport might be more fragmented and more chaotic.

This situation arises due to a history of inadequate government involvement or commitment to public transit. In what Gwilliam (2008b) identified as a regulatory cycle public transport, when government-provided public transit fails to meet residents’ travel needs, entrepreneurial transport operators often step in to fill the gaps. This ‘informal transport’ is usually less regulated, if not outright illegal, operated by relatively fragmented private operators, and does not receive official government endorsement or funding. While convenient, it

may produce problems like overcrowding, congestion, pollution and accidents. Meanwhile, government-endorsed public transport modes decline as informal modes siphon off passenger demand, leading to a cycle of reduced fare revenue and increased fares and/or decreases service cuts (Gomez-Ibanez and Meyer 1993; Vasconcellos 2001; Gwilliam 2008b).

This was the context in many cities when BRT began gaining in popularity (Wilkinson 2010; Flores Dewey 2013). Thus, a BRT intervention might mean the formalization of informal transport—including the consolidation of fragmented operators, regulation of previously unregulated services, increased government planning, management, and funding, and changes in physical service characteristics and fares. BRT intervention might also reform existing government-subsidized transport services, involving changes like capital investment, changes in planning and management, reforms in market competition and public subsidies, reconfiguration of networks, and service and fare changes (Kumar, Zimmerman, and Agarwal 2012; Hidalgo and Huizenga 2013; Hook 2005). Each case differs, but across cities that have introduced BRT there are some common experiences.

## 2.1 Informality in transport, and its formalization

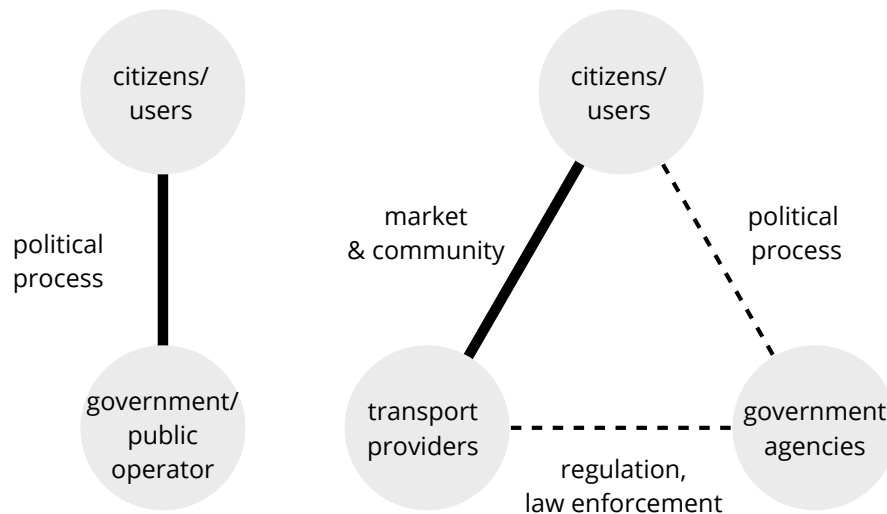
BRT often involves formalization, but what does informal mean in the first place? What is it about informal activities that makes them informal? Which aspects are the most fundamental is a matter of debate. The literature on both informal transport and informal activities generally tends to emphasize four broad themes: the relationship of the activity to the state, the private sector nature of the activity, the relationship of the activity to labor, and internal organizational structure and practices. I find it useful to think of informality in transport as defined in terms of external relationships – the way the transport industry relates to government and the public – and internal relationships – the way transport providers relate to each other and to their employees.

Before going further, it is important to note that informality is a continuum, rather than a binary concept, a point emphasized in the broader literature on urban informality (Peattie 1987; Moser 1978; Portes and Sassen-Koob 1987; Rakowski 1994). An activity, or mode of transport, may be more or less informal. There is no magic dividing line between formal and informal.

### Transport informality and external relationships

Paget-Seekins and Tironi (2016) proposed a framework representing how transport formalization changes relationships between the government, transport providers, and citizens. The authors developed their framework based on case studies of transport formalization through BRT in Santiago, Bogotá, Quito, and Mexico City. I will add to their model an emphasis on who is responsible for identifying and meeting user needs, and how that actor is incentivized to do so. Figure 2.1 depicts my modified framework.

Figure 2.1: Conceptual relationships between citizens, government, and transport providers



(a) Public monopoly and (b) informal governance regimes. *Adapted from Paget-Seekins and Tironi, 2016.*

According to Paget-Seekins and Tironi’s (2016) model, when public transport is provided by a public monopoly, the transport provider is itself part of the government (e.g., a government authority or state-run company) or a heavily regulated public monopoly. In this case, it relates to citizens primarily through the public participation (or the political process), and secondarily through ridership. The provider has two main goals: financial sustainability, which incentivizes it to control costs, and political stability, which incentivizes it to keep users content.

In contrast, under a strongly informal system with private provision and weak regulation the government plays a much weaker role. Paget-Seekins and Tironi’s (2016) did not include government at all in the model for informal transport, but I propose some weak links with government are relevant.

### Relationship to government

*Compared with formal public transit, informal modes are less regulated and operate with less government oversight.*

In one of the most widely cited articles on informal transportation, Cervero and Golub (2007, p. 446) wrote: “Technically, informal services are those operating without official endorsement. Usually this means vehicles and operators do not have appropriate licenses, permits, or registration papers from public authorities to provide collective-ride services to

the general public.” Finn (2012, p. 47) declared the first defining aspect of informal transport is that it “originated in unauthorized or even illegal operations. Mukhija and Loukaitou-Sideris, considering informal activities more broadly, defined “informality in practice as activities unregulated by the state” (Mukhija and Loukaitou-Sideris 2015, p. 447). Gwilliam (2008b) treated informal transport in developing countries as unregulated or deregulated transit service, without using the term “informal” at all.

The problem with these definitions is that “unregulated” and “unendorsed by government” do not appear to describe the full extent of informal activities. It’s clear Cervero and Golub’s (2007) concept of informal transport included services that operate under official regulation, but with lax enforcement. The collection of activities Mukhija and Loukaitou-Sideris considered informal, which included push-cart vendors, backyard dwellings, and parking practices, also covered activities that are partially regulated, that fall into a gray area, that are regulated but the regulations not enforced, or in which regulations are deliberately evaded.

For Behrens et al. (2016) and Schalekamp (2015a), regulation of competition was one of three dimensions that define paratransit (and paratransit may not always be “informal”). The authors proposed a continuum ranging from an “unregulated open market” to a “regulated monopoly” and placed formal transit toward the regulated monopoly end of the spectrum, with paratransit toward the unregulated end (Behrens, McCormick, and Mfinanga 2016, p. 6).

Other scholars have described informal activities as those that are not just unregulated, but fall outside the purview of the state, characterized by lack of government intervention or simply lack of government interest (Vasconcellos 2001). Squatter settlements and informal transport often flourish in peripheral communities where the state has little interest in intervening. In this view, informality results from lack of government capacity or even government neglect, and in place of government-provided public services communities fashion their own. In the case of Brazil’s favelas, for example, lack of water and electricity services and lack of support for housing forced residents to build their own systems (Caldeira 2001). In many developing countries, when public transport provided by governments proved inadequate, informal transport emerged to meet residents’ needs (Vasconcellos 2001; Finn 2008). For Yiftachel (2009), informality isn’t just a result of government neglect, since sometimes the official state policy is deliberate exemption from regulation. Instead, officially tolerated informality, or “gray spaces” are a deliberate means of enforcing social hierarchy (Yiftachel 2009). These views all carry an implicit argument that informal spaces result from governments’ unequal treatment, where informal status implies those spaces’ lesser value from the perspective of the state.

The literature also emphasizes ambiguity and uncertainty in regulatory status and relationship to the state. Roy (2009) suggested that, under informal regimes, regulations may be applied in an unpredictable way. Informal activities very often fall in between official definitions, leaving regulatory applications ambiguous; for example, Brown et al. (2014) detailed how food cart vendors are classified as motor vehicles even though they are more like restaurants. Uncertainty in these relationships to government and regulations engenders

a state of precariousness that thwarts long-term planning.

When the relationship between government and transport providers is mainly through (often loosely enforced) regulation, a minor consideration for providers is staying sufficiently within the law in order to keep operating. As shown in Figure 2.1, the government relates to users through a (often ineffective) political process, which has only relatively small influence on the service provided.

### **Relationship to the public**

*Informal activities are almost always private sector activities, rather than provided by the government or for humanitarian purposes, meaning economic profit motivates their behavior.* In the informal regime, transport providers mainly relate to passengers through competition in the market (Paget-Seekins and Tironi 2016). Presumably, providers have one goal – profit – and thus they act to maximize passenger fares while minimizing costs. Therefore the provider must understand user needs to the extent that it can attract passengers. It must also minimize costs, or at least control costs. Many engineering studies of bus transit view informal transport simply as private sector actors. They operationalize informal transport as privately-provided, unregulated service, where the operator is driven by profit maximization and mostly unconstrained by regulations (Bly and Oldfield 1986; Gronau 2000; Chavis and Daganzo 2013).

Although less emphasized in the literature, informal transport providers may have relatively strong social connections to the public. In many cases, informal operators live in the same community as their customers and may have personal relationships with them. As small-scale operators, they may have less “social distance” from their customers—for example, perhaps developing a language and set of social practices specific to the community (Woolf and Joubert 2013). Proponents of informal transport have often argued that closeness to the community they serve helps informal operators respond better to their users’ needs and preferences (Rimmer 1989).

### **Internal relationships and transport informality**

Internally, the informal transport provider differs in several important aspects from its formalized counterpart. The literature emphasizes the relations between providers and labor, the organizational structure among and within providers, and their internal business practices.

### **Relationship to labor**

Arguably, the idea of an informal labor market predates other uses of the concept of informality. Hart (1970; 1973) and the International Labour Office (1973) introduced the idea of an “informal sector” to describe economic activities in sub-Saharan Africa that fell largely outside of the regulated labor market. Hart and the ILO viewed informality as a potentially

beneficial way for those excluded from formal labor markets to earn income. While the literature on informal labor has focused more on activities like street vending than transportation, the literature does recognize that informal transport tends to operate outside of the formal labor market (Cervero 2000; Vasconcellos 2001).

Many authors have highlighted the entrepreneurialism of those engaged in informal activities (De Soto 2000). Informal work, in this view, is evidence of ingenuity in the face of adversity and a potential means for escaping poverty. Observing housing practices in developing countries, some authors have championed the benefits of informal, “self-help” housing solutions (Turner and Fichter 1972). Cervero (2000) recognized that informal transport provides employment and small business opportunities for many people who would otherwise have few options. In South Africa, the government has promoted informal transport as a way for disadvantaged black communities to earn income and build capital (Walters 2013). For some proponents, the entrepreneurial side of informal transport is not just an opportunity for the operators, but also fundamental to the mode’s competitive advantage because the profit motive encourages demand-responsiveness (Cervero 2000).

Critics, however, have highlighted the exploitative and subordinating aspects of informality, which primarily arise from informality’s relationship to labor. By subordinate, Tokman (1978) meant that any surplus generated by the informal sector is transferred to the formal. According to Tokman, one explanation for this subordinate position is that formal sector firms are those for which it is economical to pay for worker stability; jobs that don’t require stability go the informal sector. For Portes (1983), the informality found in developing countries is basically a mechanism to avoid or lessen state regulation of labor relations: the informal economy allows formal-sector workers to consume cheap goods by avoiding wage and benefits demanded by labor. It’s widely recognized that drivers and other informal transport employees receive low wages and are generally not protected by labor regulations that would govern wages, employment benefits, and work conditions (Vasconcellos 2001; Cervero and Golub 2007).

### **Organizational structure and business practices**

In attempting to differentiate informal transport from the formal sector, Finn (2012) heavily emphasized business organization structure and practices as a key defining aspect. Behrens et al. (2016) defined “formal” business practices as a dimension of paratransit distinct from regulation and service characteristics. For Schalekamp (2015a), this dimension encompasses ownership structure, management structure, and financial resources. In contrast to the larger companies or public monopolies of formal transit, the informal transport sector tends to be highly fragmented, with many small providers, who seem to have little incentive to merge (Cervero and Golub 2007; Gómez-Lobo 2007; Finn 2012). Operators tend to manage their businesses informally, often relying on cash and less often using conventional accounting practices, contracts, or regular payments. Lack of access to financial markets is another often under-appreciated aspect. Informal services are to a large degree self-financed by individual drivers or operators (Finn 2008; McCormick, Schalekamp, and Mfinanga 2016).

Estache and Gómez-Lobo (2005) suggested the organizational structure and informal practices may be linked: a reliance on cash and informal relationships rather than formal contracts might make it difficult to monitor drivers' behavior as fleets become larger. For example, drivers might easily under-report fares and pocket the extra cash. This keeps firms small and might prevent them from taking advantage of potential economies of network density or scope. In contrast, the opposite seems to occur in formal deregulated bus markets. Following bus deregulation in the UK, firms showed a strong tendency to merge, apparently to increase their purchasing power, access better financing terms, and take advantage of scale economies in management (Mackie, Preston, and Nash 1995; White 1997).

### **Interdependencies between these dimensions**

It is the interdependencies between these dimensions – transport providers' relationship to government, to the public, to labor, and to each other – that result in the distinct service characteristics of informal transport, like small vehicles, flexible routes, and low headways. According to Finn (2012, p. 47), “The mobility service provided by the paratransit sector is as much about the organization and dynamics of the sector, as it is about the offered service. These issues cannot easily be separated.” The literature begins to outline these relationships, but few if any studies have synthesized them in one place. My attempt to do so follows.

#### **Low labor costs enable small vehicles and flexible service**

It is not difficult to show through a simple cost analysis that the small vehicles often observed in the informal transport sector are made possible by low operational costs – in particular low labor costs – and that this hinges on vehicle size. Informal transport tends to use smaller vehicles—for the casual observer, this may be its defining feature. Smaller vehicles have certain advantages, as summarized by Gwilliam (2008a). Compared to large vehicles, they can respond more readily to demand, since it is easier to match capacity to demand. They are well-suited to thin markets, where it would be difficult to fill larger buses. Compared to large vehicles, small vehicles have lower headways, because it takes less time for the bus to fill, and can operate at higher speeds, since fewer passengers means they need to stop less frequently (Gwilliam 2008a).

However, all else equal, smaller vehicles have higher per-seat-kilometer costs than large vehicles. (The smaller the vehicle, the fewer passengers can be transported by a single driver and single gallon of fuel.) When demand is sufficient to fill larger buses, larger vehicles will cost less per passenger-km, and their advantage over smaller vehicles is even greater when labor costs are high. Walters (1979) and Glaister (1985) argued that from the perspective of the operator, small vehicles may be preferable even when demand and labor costs are high, because passengers are willing to pay more for the greater frequency and higher speed. Whether or not that argument is correct, small vehicles are clearly more likely to be economically feasible when labor costs are low (Gwilliam 2008a).

According to Gwilliam (2008b), in developing countries where labor is relatively cheap, labor costs might make up around 20% of a bus operation's total costs, in comparison to the roughly two-thirds of total cost in industrialized countries. The reasons for differing labor costs deserve closer examination. The formal wage rate obviously varies by place. But macroeconomic data also show a general gap in wages between formal and informal sectors (Marcouiller, de Castilla, and Woodruff 1997; Bargain and Kwenda 2009). One reason for the gap appears to be differences in skill; another is that informal businesses avoid costs associated with employment regulations such as minimum wages, workers' benefits, and workplace safety standards (Marcouiller, de Castilla, and Woodruff 1997; Bargain and Kwenda 2009). Avoiding labor regulations is certainly more likely in the presence of an abundant labor supply and weak regulatory regime, as in many developing countries.

Evidence from the informal transport literature might help explain how industry-specific factors determine differences in labor costs. Van Ryneveld (1989) suggested that a major differentiating factor between formal and informal service cost in South Africa was the flexibility of work hours in relation to peaked demand. In order to cover the morning and evening peak commute hours, a spread of 14 hours, conventional bus services would have to employ drivers for two shifts, even though many would be idle in the off-peak. In contrast, informal transport drivers customarily work all day, for both the morning and evening commute, as White (1981) pointed out in the case of Kuala Lumpur's minibuses. In other cases, informal transport drivers might drive the vehicle as a side job, picking up hours only in the peak.

Informal drivers readily work longer and more flexible hours than formal sector drivers for a couple reasons. Formal sector drivers might be covered by regulations or union rules that limit work hours. Formal work arrangements leave less room for flexibility. Informal workers might be willing to work long hours, or variable hours, because they have little other option, because each hour worked is a chance to earn more income, or both. The way in which drivers are paid is likely an important factor. Informal drivers who are paid through a target or commission system view each passenger as additional income, and are thus incentivized to work more hours. Formal drivers paid through a regular salary are usually not incentivized to work additional hours, unless they can collect overtime pay. It may also be that informal drivers see themselves more as an entrepreneur who works for himself or herself, rather than as an employee, and thus feels more motivated to work longer.

Van Ryneveld suggested (1989) that not only do low labor costs enable small vehicles, but the opposite is true as well: small vehicles help keep labor costs low. Large conventional buses require specialized skills to drive and to repair, while the skills needed to operate and maintain smaller vehicles like minibuses, sedans and motorcycles are generally widely available. Firms that use large buses must therefore retain a specially trained workforce, which more likely requires higher wages and formal work contracts.

Finally, employees of formal public transport companies, especially large public monopolies, are more often unionized than are informal transport workers. It may be because labor is more difficult to organize across a large number of small firms, as compared to at a large firm, as Van Ryneveld (1989) suggested. Or it may be that informal drivers who see themselves as entrepreneurs are less motivated to organize.



### **Other operational costs**

Because they also typically abide by only minimal service quality standards, if any at all, informal services may have much lower maintenance costs (Cervero and Golub 2007). Informal transport operators typically under-invest in maintenance, with consequences for safety and environmental impacts, but low maintenance costs also make small vehicles more economically feasible, for the same reason low labor costs do. In addition, smaller “off-the-shelf” vehicles require standard parts and tools for maintenance, in contrast to the specialized, and more expensive, parts needed for large buses.

### **Organizational structure and economies of scale**

Informal transport operators typically have very low administrative and overhead costs. This is a direct result of small firm size and informal business practices—informal transport owners usually manage at most a few drivers, and can do so without hiring administrative staff. As long as operators rely on cash and informal employment relations, it may be difficult for them to scale their fleet, since it becomes more difficult to monitor drivers and manage operations. Vijaykumar (1986) suggested that small firms can keep labor costs lower because they are less restricted by labor regulations, whether because they are more easily able to avoid government enforcement or because their workers are less likely to organize. Formal transport companies that do use corporate management and accounting practices may, in contrast, be able to realize economies of scale by sharing administrative and other fixed cost across vehicles. In an analysis of the Israeli bus sector, Berechman (1983) found economies of scale in company size, although Obeng (1985) argued such scale economies applied only to the short term. To my knowledge, no studies of economies of scale in the informal transport sector exist. However, the lack of scale economies in informal transport is consistent with the observed fragmentation of the industry.

**A reliance on self-financing prevents large-scale capital investment** Governments usually invest minimally in infrastructure or subsidies for informal transport services. Capital-intensive transportation, especially rail transit but also large buses, requires either public investment or private companies operating in formal financial markets. Financial institutions tend to stay away from activities unsanctioned by the government or subject to uncertain regulations (Flores Dewey 2013). Informal services are to a large degree self-financed by individual drivers or operators; if formal financing is available it is often from a limited number of providers at very high interest rates (Finn 2012; McCormick, Schalekamp, and Mfinanga 2016). Thus informal providers can typically afford only small vehicles, more likely second-hand ones. They are even more unlikely to invest in infrastructure like stations or technology like GPS or smartcard readers. They are also likely to under-invest in vehicle maintenance. The result is typically smaller vehicles that can suffer from age and deferred maintenance (Cervero 2000). More broadly, the lack of capital for investment results in emphasis on labor rather than capital inputs to service provision.

Lack of access to financing also perpetuates a reliance on cash and informal accounting methods. As long as they are dealing only with cash and personal investing relationships, informal operators have little reason to adopt formal business practices. If the activities become officially recognized and regulated, however, access to finance may prompt operators to corporatize (Schalekamp, Golub, and Behrens 2016).

**Without formal government recognition and regulation, self-regulation develops**

The informal transport sector may be fragmented and unregulated by the state, but it is not without organization and regulation. The downsides of over-competition provide a strong incentive for operators to engage in self-regulation to control market entry (Vasconcellos 2001; Gwilliam 2008b). Informal providers thus often organize into governance structures, which, while not “corporate,” might have complex structures and sophisticated rules (Cervero and Golub 2007; McCormick, Schalekamp, and Mfinanga 2016). Such associations sometimes take on the functions that a government regulator might—setting fares, controlling market entry, opening new routes, and punishing violators (Behrens, McCormick, and Mfinanga 2016; Cervero 2000). In this case it’s debatable whether the sector is truly unregulated (Vasconcellos 2001). However, there is still an important distinction: informal self-regulation, in contrast to government regulation, is not necessarily accountable to the public, but is only directly accountable to its members.

**Minimal regulation leads to over-competition, in “thick” markets** Without permitting fees or service standards—for instance, minimum vehicle safety standards—individual entrepreneurs can enter the market relatively easily. While some cities limit the number of operating permits, informal operators may find a way around them. In places with high demand (which is true of most large cities), the result is a large number of providers and an abundant supply of transport services—which can be a boon for travelers, but also leads to problems of congestion and overcompetition (Kahn 1988; Cervero and Golub 2007).

**Informal providers tend to serve—and belong to—marginalized communities** Informal transport typically thrives in spaces historically neglected by the state and provides mobility to markets not adequately served by government-operated transport. Governments may come around to tolerating or even endorsing informal transport, but this does not erase the history of marginalization by the state. That history might engender mistrust and helps explain why informal transport providers are often resistant to governments’ attempts to improve or reform service. Another consequence is that, compared to formal transport, informal providers are more likely to come from and belong to the communities they serve (Woolf and Joubert 2013).

## Government intervention in informal transport

Defenders of informal transport argue it is often fast, convenient, and affordable—its inherent market-driven flexibility and demand-responsiveness make it likely to provide superior accessibility, unless the congestion it so often produces outweighs its other inherent benefits (Cervero and Golub 2007; Finn 2012). Despite informal transport’s potential advantages in providing flexible, convenient, and affordable service, government authorities have found many reasons to intervene and push for formalization. As Cervero (2007) described, where demand is high and market entry barriers low, over-supply is common, leading to congestion. Without regulations to ensure service equity, profit-seeking operators might engage in “cream-skimming” behavior, in which service supply concentrates on the most profitable markets—those with high volume demand or high-paying customers—leaving less lucrative areas with insufficient service (Kahn 1988).

The literature has connected informal transport with many other problems as well, including poor safety, pollution, poor service quality, poor customer service, exploitative labor practices, discrimination, and even violence (Vasconcellos 2001; Cervero and Golub 2007; Estache and Gómez-Lobo 2005; Gilbert 2008; Joewono and Kubota 2007; Finn 2012; Portes 1983). These kinds of problems motivate government response. Finn (2012, p.47) goes as far to say a key aspect of informality is that it “is not considered desirable by decision-makers and planners.” The question then turns to what policy response is best. A range of responses are possible, from prohibition and stronger regulation and enforcement, to acceptance and recognition (Cervero and Golub 2007).

The debate over responses to informality is rooted in disagreement about what causes informality in the first place. On one side, some argue the presence of informal activities indicates insufficient government involvement. For example, Gwilliam (2008b) suggested informal transport historically emerged in developing countries in response to financial crises in state-owned public transport, and in the absence of strong enforcement of licensing and labor regulations. For Portes and Sassen-Koob (1987), informal activities arise in response to pressure to reduce costs, abetted by the government’s willingness to loosen or overlook labor regulations. In transportation specifically, some authors argue externalities such as accidents and pollution can only be addressed through government regulation (Estache and Gómez-Lobo 2005; Vasconcellos 2001; Gwilliam 2008b). If the cause of informal is insufficient government involvement, appropriate responses might be: better regulation and enforcement to reduce accidents and pollution and to protect workers, greater public investment, and intervention to shape competition. Other reasons might motivate a regulation-focused response as well. Notably, governments sometimes act against informal activities in order to assert state authority over elements that might pose a political risk to the government, or impose order upon what may be perceived as “chaotic” elements of the city (Mukhija and Loukaitou-Sideris 2014; Roy and Alsayyad 2004).

Others argue, conversely, that informality is a sign of overly burdensome regulation, thus the appropriate response is less regulation (De Soto 2000). According to Mukhija and Loukaitou-Sideris (2014), this response tends to emphasize the positive aspects of informal-

ity, including flexibility and income-earning potential, and the entrepreneurial drive of those involved. In this view, the presence of informal activities indicates the “true” market needs, and thus the appropriate response is deregulation and legalization of those activities. Deregulation and legalization are not the same as leaving informal activities as they are. Instead, these measures legitimize the activity and reduce regulatory uncertainty. De Soto (2000), for example, argued that the problem for squatters was not lack of housing, but lack of legal land titles, which prevented them from obtaining credit and investing in their property.

Deregulation and legalization may also be motivated by a pragmatic recognition of government capacity limits. Frequently, government leaders decide that addressing informal activities is not a priority given limited resources, and may simply tolerate their continued presence (Cervero 2000; Gwilliam 2008b). Arguments for minimal government response typically call for a reliance on self-regulation by the informal transport industry (Behrens, McCormick, and Mfinanga 2016).

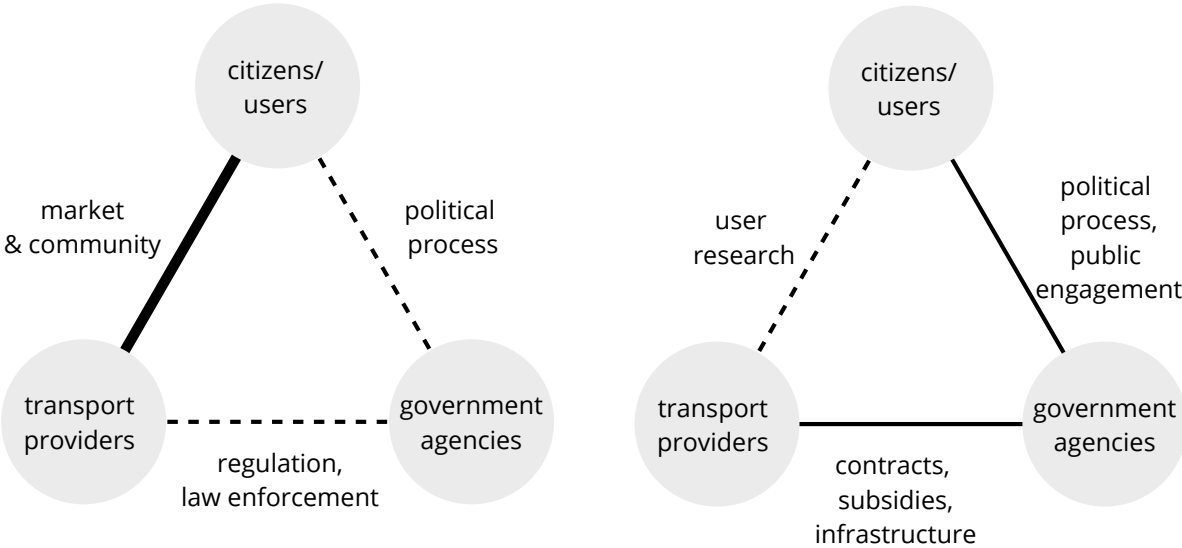
## 2.2 When BRT involves formalizing existing informal transport

In Paget-Seekins and Tironi’s (2016) model, when a previously informal system undergoes formalization, whether through competitive tendering or BRT, the links between providers, the government and citizens, in theory, become a more balanced triangle (see Figure 2.2). Private operators receive their main direction about what services to provide from the government, through contracts that outline service standards, regulation, and possibly subsidies. The incentive structure depends on the type of contract – with the more common, output-based contract, the provider is incentivized to meet contract obligations, which means the onus is on the government to figure out user needs and to write and enforce a contract that incentivizes the provider to meet them. With performance-based contracts, the provider holds more responsibility for identifying how to meet user needs, but the public authority is still responsible for evaluating performance in relation to user needs (Hensher and Stanley 2010). Citizens’ demands must be made, not to providers through the market or the community, but to government through the political process and public participation.

In short, whereas before transport providers were directly accountable to users through the market, in the formalized regime they are accountable to government through contracts, and government is accountable to users through the political process. This shifts the primary relationship from one between operators and users to multiple relationships: between operators and government and between government and users.

As Paget-Seekins and Tironi (2016) observed, the majority of the literature on transport formalization has been focused on the contracting relationship between transport providers and the government, leaving the relationship between government and the public largely overlooked. The same authors argued that, in their case studies, formalization has signaled “recognition of transit as a public good and a need for intervention in the market,” yet it

Figure 2.2: Conceptual relationships between citizens, government, and transport providers



(a) Informal and (b) formalized governance regimes. Adapted from Paget-Seekins and Tironi, 2016.

“largely has not been accompanied by a change in the direct involvement of the public in decision-making or accountability for the public funds” (Paget-Seekins and Tironi 2016, p. 182).

### 2.3 When BRT involves reform of existing formal transport modes

Reasons: - End underinvestment in public transit - Break vicious cycle of declining ridership, declining revenue, and service cuts - Signal, politically, city is modern and committed to transportation. - Introduce or reform competition in the transport market

Might include: - capital investment: stations, segregated busways, vehicles, accompanying urban design - reconfiguration of routes - restructuring of ownership or management - restructuring of contracts or competitive markets - consolidation of operations and management - changes in services or fares - integration with other modes

## 2.4 Alternatives to BRT; alternative responses to informality

The transportation literature appears to have come to a consensus that the public transit sector experiences inherent market failures that make at least *some* government involvement desirable. Debate remains over how much government involvement is appropriate. Evidence for the argument against full deregulation comes mainly from experience with bus deregulation in the 1980s in the UK and in Santiago, Chile.

### Experiments with deregulation

In the 1970s and 1980s, the high cost of public subsidies for transit and growing interest in free-market policies led the UK national government to pursue a policy of deregulation and privatization. The main thrust of the argument for deregulation was that public transport's problems resulted from public management and lack of competition; competition in a free market would improve efficiency and spur innovation (Beesley and Glaister 1985). Specifically, without regulatory barriers, more operators would enter the market, and the increased competition would pressure operators to reduce costs. They would also face pressure to reduce fares and innovate in ways that better served passengers' needs. To increase revenue they would expand service (Beesley 1989; Mackie, Preston, and Nash 1995).

Analysis of deregulation's effects in the UK, as summarized in accounts by Mackie et al. (1995) and White (1995), suggested that although by many measures the deregulated market was more efficient, many of the expected benefits did not materialize. Deregulation did appear to successfully reduce costs: before deregulation, labor accounted for about 70% of per-vehicle-km operating costs, while after deregulation operating costs fell by 35-45% across Britain (White 1995). Firms were better able to resist union pressure, and they reduced costs by lowering wages and reducing maintenance and administrative staff. Service levels in terms of vehicle-km increased, reversing the previous trend of decline, and some innovation resulted, such as replacing low-frequency large buses with higher-frequency minibuses. Because service levels served increased, productivity rose in terms of cost per vehicle-kilometer (White 1995). When Preston and Almutairi (2013) re-evaluated the long-term impacts of deregulation, they found that operating costs began to increase again after 2000, although in 2008 they still remained 20%-28% below 1985 levels.

However, under deregulation the market turned out to be less competitive than intended. Firms had a tendency to merge, apparently in order to achieve economies of scale in management, purchasing, and access to finance (Mackie, Preston, and Nash 1995). The argument for deregulation had rested on the assumption that in an open market new firms could contest the market share of incumbents. But according to Mackie et al. (1995), even without regulation newcomers were discouraged by inherent barriers to market entry; for example, incumbents had sunk costs (e.g., start-up costs) and advantages from local knowledge of the market. Moreover, incumbents limited market entry by controlling costs, by ensuring there

were no profitable gaps in services, and through predatory pricing (Mackie, Preston, and Nash 1995; Fernández and Muñoz 2007).

Surprisingly, fares did not decrease, and in fact increased. Between 1985 and 2008, fares increased by 55% in real terms outside of London and by 15% in London (Preston and Almutairi 2013). This was because services competed on frequency instead of price. Estache and Gómez-Lobo (2005) explained why fares in an unregulated market are likely to be higher than what is socially optimal. Passengers value short wait times and will strongly prefer to take the bus that arrives first, even if a lower-priced but otherwise identical second bus will soon arrive. Assuming the passenger lacks information about vehicle arrival, the first-arriving vehicle can thus charge a higher fare. Firms are thus incentivized to raise fares and increase frequency. Fernández and Muñoz (2007) developed this argument into a formal model, concluding that, all else equal, deregulated fares and free market entry result in higher fares but shorter waiting times.

Overall, deregulation in the UK failed to reverse the trend of declining ridership. Mackie et al. (1995) pointed out that in fact ridership declined even faster than predicted based on previous fare and service elasticities, and speculated it may have been due to reduced reliability and certainty for passengers. Preston and Almutairi (2013) used a demand forecasting model to show that at least some of the decline in ridership can be attributed to deregulation, as opposed to secular trends. However, ridership levels were maintained and over the long term increased in London, which unlike elsewhere in Britain had instituted a bus tendering system rather than full deregulation. Finally, White (1995, p. 201) concluded that, based on data available at the time, the slim profit margins were not sustainable “if vehicles are to be replaced at ‘normal’ lives” and, at returns averaging 4% annually, generally did not produce a good return on investment. Although total subsidies decreased dramatically in the first ten years after deregulation, they began increasing sharply in 2000, especially in London (Preston and Almutairi 2013), and by 2008 exceeded 1985 levels. (Per-passenger subsidies are probably still lower than in 1985, however.)

In Santiago, Chile, the bus sector also underwent deregulation and privatization in the 1980s. Prior to 1979, the city’s state-owned monopoly offered good network coverage but suffered from poor service quality. The government’s deregulation policy of 1979 turned the industry over to private firms, permitted free market entry and new routes, and allowed firms to set fares. The policy assumed that free entry and competition would result in greater efficiency, lower costs, and more diverse products. Higher efficiency would mean lower pollution and congestion, since more people would shift from cars to buses.

In their summary of the results, Fernández and Muñoz (2007, p. 28) wrote, “a decade later almost none of the goals pursued by authorities had been achieved.” As in the UK, fares increased, and in fact doubled—an increase that could not be explained by fuel prices (Estache and Gómez-Lobo 2005). Unlike in the UK where greater competition failed to materialize, in Santiago deregulation appeared to result in over-competition. The number of buses increased by 40% over four years, but capacity utilization of vehicles decreased, resulting in considerably worse congestion and air pollution (Estache and Gómez-Lobo 2005). After deregulation, the industry consisted of many small-scale operators, each with less than

two vehicles on average, a result Fernández and Muñoz (2007, p. 28) attributed to the operators' "lack of professionalism." Put another way, operators who lacked formal accounting and relied on cash and personal relationships were not able to achieve economies of scale resulting from sharing management costs, accessing finance, or buying in bulk, as did bus companies in the UK. In addition, after deregulation, the average age of vehicles increased, which also contributed to worsened pollution (Estache and Gómez-Lobo 2005). Public opinion towards the sector became very negative (Fernández Koprach 1994).

In sum, the experiences from the UK and Santiago suggest full deregulation of bus markets is likely to reduce costs and reduce waiting times for passengers, but increase fares above what is socially optimal. In neither case did competition work as expected: in the UK the market became oligopolistic and restricted new entrants, while in Santiago entry was too easy and over-competition resulted in worsened congestion and pollution. These nearly opposite outcomes appear to stem from the fact that formal business practices and corporate structures in UK bus companies allowed economies of scale, while informal operators in Santiago had little reason to consolidate—suggesting organizational and business practices are key aspects of informality that affect service. It's also possible the degree of competition depends on the level of demand (Cervero and Golub 2007)—demand was very high in Santiago and relatively low in the UK. In addition, deregulated buses in the UK were still subject to safety and environmental regulations, whereas in Santiago had less capacity to enforce such rules. In both cases, the reduced waiting times arguably meant greater accessibility for passengers, although more research would be needed to address this question. More broadly, the Santiago experiment was widely considered a failure, and has become a case study in why at least some form of regulation is necessary. In the UK, the problems resulting from deregulation forced even free-market adherents to admit some level of government intervention was justified (Mackie et al., 1995; White, 1995).

### **Government as market facilitator: experiences with competitive tendering**

After a history of public monopoly financial failures and disappointments of bus deregulation, competitive tendering emerged as a popular middle ground between public provision and the free market (Gwilliam 2008a). A goal of competitive tendering is to replace "competition *in* the market," in which operators compete for passengers on the street, with "competition *for* the market," in which operators bid for the exclusive right to provide service under a set of conditions (Gwilliam 2008a). The role of the public authority is thus to design the tendering system, conduct bidding process, and design and manage service contracts. Operators, usually private sector, provide the service. In the case of service-based contracts, the public authority is responsible for planning and network and service design; or, with performance-based contracts, operators are responsible (Hensher and Stanley 2010). The literature suggests competitive tendering has a mixed track record and its success depends on a host of factors.



Competitive tendering has earned overall positive evaluations in some places. London, for example, had adopted a tendering system while the rest of UK underwent full deregulation. As discussed in the previous section, ex-post assessments found operating costs in London decreased while ridership rose, and service quality improved, without generating significant congestion and safety problems. Although costs began rising again the long-term, London's tendering system was generally regarded as a success (Preston and Almutairi 2013). Hensher and Wallis (2005) reviewed estimates from competitive tendering cases across Europe, North America and Australia. They found that competitive contracts typically reduced operating costs on the order of 20-50% in the short- and medium-term, although costs crept back up in the longer term. One explanation for the long-term behavior is that gradual operator consolidation and collusion tends to reduce competition (Gwilliam 2008b; Gwilliam 2008a). According to Stanley and van de Velde (2010), several Dutch cities found forms of competitive tendering that worked well, if not perfectly. Albalade et al. (2012) argued that Barcelona appears to have maintained an effective level of competition in a competitive bidding system that emphasizes incentives and penalties.

The competitive tendering approach has also encountered challenges, as illustrated by the case of Santiago, Chile. In 1991, having judged deregulation a failure, Chile's government adopted a tendering system in which operators bid for the exclusive right to operate on a route. The government decided the routes, which were not altered from the existing routes that emerged under deregulation (Estache and Gómez-Lobo 2005). Fares were decided through competitive bidding. The state also directly purchased and scrapped old buses (Figueroa 2013). The positive results were lower fares and fewer buses, without a change in network coverage, while capacity utilization of vehicles doubled and waiting times remained very low (Figueroa 2013). These service characteristics suggest accessibility did not change much, although studies did not address this question specifically. The average age of buses dropped, and over half met emissions standards (Estache and Gómez-Lobo 2005).

Santiago's reforms left many problems, however. The formerly fragmented industry consolidated into route-based organizations, which colluded in pricing their bids such that the market was not truly contestable (Paget-Seekins, Dewey, and Muñoz 2015). Because the government made no changes to the network, many routes still overlapped, causing severe congestion on main corridors (Estache and Gómez-Lobo 2005). The biggest problem, according to Estache and Gómez-Lobo (2005), was accidents: in 2001, buses were involved in 7392 accidents in Santiago and on average, these accidents caused one death every three days. The authors attributed the high accident rate to the persistence of competition on the road. According to Figueroa, (2013, p. 93), competition on the road continued because "it was not possible to introduce corporate governance criteria" in the concession contracts – although Paget-Seekins et al. (2015) claimed operators did gradually adopt more corporate practices. None of these authors explained exactly why the concession system failed to end competition on the road, but available information suggests two possible reasons. First, the route-based contracts allowed operators to still compete on the many corridors where routes overlapped. Secondly, there was no fare collection reform. Even if drivers were paid a salary, given lax oversight they could still pocket some cash fares and were thus incentivized to

maximize passengers.

That competitive tendering has gained more traction in Europe, where government capacity is relatively strong, than in countries like Chile (Gwilliam 2008b), should not surprise. Barter (2008) showed that, unlike in developed countries where contracting usually replaced a public monopoly, in developing countries the incumbent was usually a mostly deregulated informal system. Paget-Seekins et al. (2015) suggested it's more difficult to reform competition in the latter case because the government often does not have the experience needed to design a bidding process, manage contracts, or enforce regulations. The literature makes clear designing a bidding process and effective contracts is complex; the process must carefully consider how to allocate risk, provide meaningful incentives and penalties, and remain adaptable for possible contingencies (Stanley and van de Velde 2008; Hensher and Stanley 2010). In a review of tendering in Brazil, for example, Rolim et al. (2010) found that in many cases the public authority failed to create a bidding process that was truly competitive, for reasons such as imposing excessive bidding criteria, allowing participation from consortia, and using a too-long contract period.

Some authors are optimistic governments can learn and build the capacity needed to pursue effective competitive tendering (Barter 2008; Rolim, Brasileiro, and Santos 2010). But such reform in developing countries also must typically overcome significant political opposition from incumbent operators, a challenge not present when replacing an existing public monopoly. Flores Dewey (2013) pointed out that in Mexico, like many countries, the informal transport sector grew to have substantial political strength and could challenge governments' attempt at reform. Vasconcellos (2001) argued that once a market is deregulated, it may be very difficult for the government to regain control, due to political opposition and to the difficulty of coordinating a large number of operators. Informal transport cartels may wield political control over parts of the city that rivals the state, and may, as in South Africa, use violence to enforce their authority (Khosa 1992; Dugard 2001).

## 2.5 Advantages of BRT, and why it's a popular choice

BRT-driven transport reform has a number of potential advantages that make it more attractive compared to reforms like competitive tendering or strengthened regulation, and compared to more capital-intensive transit interventions, like light or heavy rail. First, BRT ideally provides a high-quality transit system, comparable in quality to rail systems (Hensher 2007). The dedicated lanes, automated fare payment, and streamlined boarding systems of BRT promise to offer faster, more reliable, and more comfortable service compared to conventional buses. Whereas more limited reforms that focused on paratransit and conventional buses mostly targeted passengers dependent on public transport, high-quality BRT holds potential to attract private car users. It was therefore a compelling solution to problems of congestion and vehicle emissions, which helped galvanize support from international advocacy organizations (Wright and Hook 2007; Hensher 2007; Hidalgo and Gutierrez 2013). It can also appeal to a broad range of constituents, which would help build the political will

to invest public funds in infrastructure and tackle industry reform.

Second, as advocates have heavily emphasized, BRT networks tend to be much less expensive on a per-kilometer basis than rail networks (Hensher 2007). In a review of existing BRT systems worldwide, Deng and Nelson (2010) calculated BRT's average capital cost per mile at 52% that of light rail and 8% that of heavy rail, although these figures assume BRT uses an existing right of way and rail does not. Moreover, advocates found reason to believe that BRT operations could be financially self-sufficient, implying no subsidies would be necessary (Hook 2005). The promise of low initial cost and self-sufficiency are major benefits for governments facing constrained resources (Hidalgo and Gutierrez 2013). In addition, BRT networks can be built relatively quickly, a fact that appeals to elected officials looking for tangible results within a 3- to 4-year election cycle (Hidalgo and Gutierrez 2013; Wood 2014b; Montero 2016)

A third argument in favor of BRT comes from Ardila (2008). Drawing from cases in Curitiba, Bogotá, Medellín, and León de Guanajuato, he argued that BRT, compared with conventional buses, is more effective in establishing competition “for the market” because BRT corridors and centralized fare collection systems create tangible barriers to market entry, rather than relying only on enforcement. Specifically, only BRT-specified buses can physically access the stations and dedicated lanes; informal operators would be disadvantaged by having to compete in traffic. This is more effective than relying on under-resourced or corruptible enforcement agencies. Electronic fare cards also create barriers to entry for unauthorized competitors, since only operators participating in the system can accept them. (Although competitors could simply offer rides for cash.) With centralized fare collection, owners are paid per kilometer rather than per passenger, such that “bus companies maximize profits if the fleet is a reasonable size” instead of “maximiz[ing] profit as fleet size increases” (Ardila 2008, p. 13). While centralized fare collection can be effective without BRT, it is presumably easier to implement along with a new BRT system.

Fourth, BRT has been more politically feasible than many previous efforts at formalization in large part because it offers a more concrete pathway to transform the existing transport sector, thus mitigating political opposition from informal operators. As Hook (2005, p. 184) put it, BRT has been “a mechanism for allowing municipal government to establish effective regulatory control over largely privatized systems.” Bogotá's Transmilenio demonstrated that it was possible to benefit existing operators by including them as shareholder in the new BRT system (Hook 2005; Gilbert 2008). Cities like Mexico City and Cape Town, where the informal sector previously strongly resisted government reforms, could use Bogotá as an example to persuade existing operators to buy into BRT plans (Flores Dewey 2013; Wood 2014a; Montero 2016).

## 2.6 How do BRT reforms affect accessibility?

To summarize, we can understand informality in transport in terms of changes in multiple dimensions: the relationships between transportation providers and the government, the

public, labor, and other providers. The literature on informal transport identifies several reasons for governments to intervene in informal transport markets. As both public monopoly and full deregulation have proven problematic, competitive tendering and BRT – often both together – have emerged as preferred means of formalization. The literature has mainly focused on the process of formalization, particularly the contracting relationship between transport providers and government. The effects on users remain under-researched, as have the ways in which formalization changes the relationship between transport provision and the public.

### **The effects of BRT interventions on accessibility, and its distribution, are still unknown**

The extent to which BRT, compared to informal transport, improves accessibility, and for whom, remains an empirical question. Formalization through BRT might affect accessibility due to changes in the technology; specifically, changes in infrastructure, vehicle size, and network design – that are intertwined with each system of provision.

Defenders of informal transport emphasize its inherent flexibility and responsiveness to demand, traits which would be expected to contribute to superior accessibility (Rimmer 1989; Vasconcellos 2001; Cervero and Golub 2007; Finn 2012). In a market of small-scale, private-sector providers, each is incentivized to maximize fare revenue and thus seek out any unserved demand. Transport providers with low labor costs and who use small vehicles can more easily adjust vehicle capacity as demand changes. The lack of fixed infrastructure or rigid labor rules allows operators to adapt routes to demand. Low barriers to market entry, both economic and regulatory, mean that more providers can enter the market when demand increases. Small vehicles and lack of fixed infrastructure makes point-to-point routes more feasible, leading to faster service and fewer transfers for passengers. When fares are unregulated, providers can use demand-responsive pricing, a quick way to match capacity to demand. If operators come from the same communities they service, they may be more aware of residents' needs, and may be more accountable to their customers. Unlike most formal transit services, informal transport has the flexibility to drop passengers off at their door.

However, the characteristics of informal transport create impediments to accessibility as well. In situations with high demand and low market entry barriers, too many vehicles enter the market, leading to congestion (Cervero and Golub 2007). Congestion can slow travel speeds and reduce accessibility for all road users. Without regulations to ensure service equity, profit-seeking operators might engage in “cream-skimming” behavior, providing high levels of accessibility in lucrative areas while neglecting others (Kahn 1988). Without regular schedules, informal services may also be less reliable, another component of accessibility.

Detractors of informal transport argue that formal sector financing and management can provide high-capacity transit that provides better accessibility (Deng and Nelson 2010; Wright and Hook 2007; Hidalgo 2001). More efficient use of vehicles can reduce congestion,

and infrastructure that provides dedicated right-of-ways allows transit to bypass congestion. Although point-to-point service is less economically feasible with high-capacity vehicles, the higher travel speeds can compensate for the need for additional transfers. Problems with unequal distribution of service can be corrected through public-sector planning and cross-subsidization. With formal management and schedules, formal transport can be more reliable.

### **The role of government capacity in accessibility outcomes**

Additionally, we do not yet have a full understanding of *why* accessibility changes with formalization, if it does. Is it due to differences in the inherent technology of formal public transport, or differences in the implementation process? The literature strongly suggests that the level of government capacity is a key variable in determining outcomes of formalization; however, there is little empirical evidence of how authorities have actually performed. BRT requires government authorities to take on many more responsibilities than they would in an informal system, including writing and managing contracts with transport providers, coordinating planning and building of infrastructure, and a greater role in regulation and enforcement. If contracts are service based, governments must also take on the responsibility of understanding user needs and translating them into service design, which requires substantial public participation.

If government capacity is high, public authorities may be successful in fulfilling its responsibilities, and BRT may improve accessibility for the public broadly. In a democratic context where and citizens' travel needs are represented throughout the process, formalization may lead to a more equitable distribution of accessibility. However, if government lacks the capacity to carry out system design, financing, contracting, coordination, and especially public participation, formalization may result in lower accessibility. If citizens' interests are not equitably represented, those groups with greater influence in the political process may have greater accessibility, while other groups lose out.

In the remainder of this dissertation I will explore these hypotheses in the case of Cape Town's transport reforms. I expect evidence from Cape Town will shed light on how formalization, through BRT, affects accessibility for users – and why. In this particular case, is the main avenue for accessibility impacts, whether positive or negative, the technology of BRT? The capacity of the government to implement BRT? The nature of the relationship between users and transport provision? Or perhaps these dimensions are inseparable, and are best summed up as demand-responsiveness.

### **Existing research on outcomes of BRT interventions**

The record so far suggests BRT can be very effective in formalizing the transport sector, but the implementation process is often more difficult than expected. Bogotá's Transmilenio shows a "best case" outcome. Gilbert's (2008) evaluated impacts of Transmilenio by compiling information from many previous studies. He found that Transmilenio ended the worst of

competition on the street and, as a result, it had clear positive impacts on air quality, congestion, and accidents. The BRT earned generally positive public opinion and it became so popular overcrowding became a chief problem. However, the corporatization of the industry apparently went further than intended. The original aim was to include existing operators as shareholders in Transmilenio, ensuring they would profit from the reform. While many informal bus owners become shareholders in the new companies, Ardila-Gomez (2004) and Gilbert (2008) found evidence showing the bidding process favored large companies, and large investors have bought out smaller shareholders, by 2006 consolidating 88% of shares in the hands of 21% of investors. In addition, the reforms failed to remove all existing buses from the streets. By 2006, an estimated 20,847 old buses were still in operation, when the city had aimed to reduce the fleet to 10,000. Transmilenio operators complain of encroaching competition from informal operators (Gilbert 2008).

Research on how BRT reform has affected accessibility is comparatively slim. Delmelle and Casas (2012) measured accessibility by BRT in Cali, Colombia, and showed how the addition of a new corridor would improve accessibility in that part of the city. The authors also found that BRT provided greatest accessibility for middle class, compared to the lowest- and highest-class households. They did not compare accessibility by BRT with any alternatives, such as informal transport, so their analysis does not address the effects of formalization. (Chapter 5 includes more discussion on the methodology of these studies.) Analyzing the effects of Delhi's BRT, Tiwari and Jain (2012) showed that, based on changes in travel times for different modes, BRT improved accessibility within the corridor for both BRT users and bicyclists. The authors did not consider effects outside of the corridor.

There is a good deal of evidence that, although BRT may be more effective in formalizing transport when compared with alternatives like full deregulation or competitive tendering alone, it comes at higher cost. Reviews of BRT systems worldwide showed that capital costs are indeed much lower than for rail networks of comparable length (Deng and Nelson 2010; Hidalgo and Graftieaux 2008) but are still a major investment for governments facing significant financial constraints. In some cases, though, like Jakarta, design and construction shortcuts, made for political expediency, increased longer-term maintenance costs (Ernst 2005). Critically, long-term financial self-sufficiency no longer seems possible except on high-demand corridors, leaving governments having to subsidize operations (Paget-Seekins, Dewey, and Muñoz 2015; Gilbert 2008). In Mexico City, generous financial concessions to existing operators were necessary in negotiations for the first BRT corridor, setting up untenably high expectations for subsequent phases, and increasing costs overall (Flores Dewey 2013). In Santiago, regulatory capture and collusion in the bidding process increased contract costs (Paget-Seekins, Dewey, and Muñoz 2015).

Recent literature has called into question cities' optimism regarding the ease of implementing BRT. Challenges are both a question of political support and government capacity. Despite the example of Bogotá, in Cape Town and Mexico City, existing operators continue to mount political opposition, and giving public authorities less leverage in negotiations (Flores Dewey 2013; Schalekamp and Behrens 2013). BRT has not made it easier to set up truly competitive bidding processes (Paget-Seekins, Dewey, and Muñoz 2015; Gilbert 2008). In

a review of BRT systems worldwide, a report by the BRT advocate EMBARQ documented problems encountered in the planning, implementation and operation phases, the majority of which stemmed from public authorities' lack of experience and lack of capacity (Hidalgo and Carrigan 2010). Hidalgo and Gutiérrez (2013) summarized these challenges, highlighting common problems such as “rushed implementation,” “very tight financial planning,” “delayed Implementation of fare collection systems,” and “insufficient user education for” initial implementation. Despite admission that such problems were very common, the authors maintained their advocacy for BRT, arguing the “problems are associated with financial restrictions and institutional constraints, rather than intrinsic issues of... BRT” (Hidalgo and Gutierrez 2013, p. 11). Still, the research makes clear that BRT systems require a lot from public authorities: they must have the capacity to manage all the responsibilities that come with competitive tendering, plus additional competency in planning and overseeing a BRT system.

### **BRT in practice: why BRT is more often partial formalization**

When used as a formalization mechanism, BRT is usually intended to eventually fully replace the existing informal system (Hook 2005). While many cities have undoubtedly made progress toward formalization, in very few if any cases so far has BRT fully replaced the informal system. (The exception is perhaps in China, where government enforcement is unusually strong.) Even in Bogotá, informal operators still compete with BRT (Gilbert 2008). The reality in the vast majority of cities is that BRT – as an expression of a formalized system—coexists with informal operators. As a result, formalization is partial. Some call the resulting system a “hybrid” formal/informal system. Part of this is by design: BRT networks are best rolled out in phases, taking decades to reach complete build-out (Rizvi and Sclar 2014). The usual strategy with phased implementation is to prohibit informal operators in the areas where BRT has been implemented, while allowing them to operate in other areas—this of course relies on strong enforcement.

Another common reason that BRT in practice has resulted in partial formalization is that costs exceed initial projections, as in the case of Cape Town, Bogotá, and Mexico City (Gilbert 2008; Paget-Seekins, Dewey, and Muñoz 2015; Transport for Cape Town 2015). When costs exceed the financial resources allocated to BRT, cities may have to scale back their systems and allow informal operators to continue operating in unserved areas. Cities may also find it beyond their capacity to enforce prohibitions on informal operators and in particular to keep them from competing with BRT – a problem often worsened because integrated fare collection systems often take longer to implement than expected (Hidalgo and Gutierrez 2013).

In addition, not everyone agrees full replacement of informal operators is desirable. As discussed previously, informal transport has benefits of demand-responsiveness and affordability (Cervero and Golub 2007). Recognizing these advantages as well as the financial realities associated with BRT, some authors have recommended planning for “hybrid” BRT and informal transport systems, where, for example, BRT serves high-demand trunk cor-

ridors while informal operators serve as feeders (Salazar Ferro, Behrens, and Golub 2012; Salazar Ferro, Behrens, and Wilkinson 2013). While “de facto” hybrid systems are common, cities, Cape Town included have only begun to experiment in designing hybrid systems. As we will see in the Cape Town case, there may be compelling reasons to go this route.



## Chapter 3

# Introducing the Cape Town case study: context

In many ways, Cape Town's transport problems resemble those in many other cities in the developing world: its residents battle with long commute times, severe congestion, and high travel cost. Although the city's local flavor of informal public transport, the minibus taxi, provides fast and convenient transport for a sizable population, the minibus taxis (known locally as simply 'taxis,' not to be confused with metered taxis), are blamed for reckless driving, accidents, congestion, and crime. As in other cities, Cape Town has seen a solution to its transportation problems in BRT. City officials have envisioned eventually replacing informal minibus taxis with citywide, integrated, high-quality BRT, modeled after "gold-standard" BRT systems like Bogotá's Transmilenio. Like in other cities, Cape Town is motivated to build a BRT to reduce congestion, integrate several transport modes into a cohesive system, and assert more government control over the sector, a primary obstacle to reform is political opposition from the informal transport industry. In terms of political support and institutional capacity, Cape Town appears relatively well-positioned to successfully transition to formal transit: it has a stable, democratically elected municipal government that has shown political commitment to public transportation, and a professional government staff, although with little experience in public transportation specifically.

In this chapter, I will discuss how Cape Town's transport challenges are interdependent with its spatial and socioeconomic context, in ways echoing the challenges in other world cities, while also in some ways being more extreme. The city's Apartheid history created a social and spatial landscape similar to other cities in quality but unique in degree. This landscape has two important consequences for transportation today: (1) the pattern of land use and degree of socioeconomic inequality contribute to deeply unequal levels of accessibility and (2) the segregated, low-density pattern of development makes quality transport systems both essential and costly to provide.

### 3.1 An overview of Cape Town

Located in the southwestern corner of South Africa, where the Atlantic meets the Indian Ocean, Cape Town is South Africa's second most populous city and its second most economically important, after Johannesburg. As the country's legislative capital and the capital of the Western Cape province, it holds political importance as well. Historically a main center for trade and manufacturing, today the city owes its economic power to business and financial services, manufacturing, and tourism. In 2011, Cape Town had a per capita GDP of US\$15,721, and its overall GDP grew an average 3.7% each year between 2009 and 2014 (Stats SA). To put this in context, South Africa's per capita GDP ranks near the middle of countries worldwide, and Capetonians' incomes are above the countrywide average (World Bank 2016)).

Cape Town's central business district (CBD), located on the Atlantic coast near the historical port (Figure 3.1), is still the city's main economic and employment hub, although several other commercial and manufacturing centers have developed throughout the suburbs as well. The city's main tourism area lies along the coast south of the CBD, while manufacturing and commercial centers have spread along the highway corridors to the north and east. To the south, the historically white Southern Suburbs are home to much of the city's higher-income population. The mainly residential Metro Southeast houses a mostly lower-income non-white residents, a result of the city's history with policies to enforce racial segregation.

### 3.2 How Cape Town's socio-spatial landscape affects transportation

The transport challenges of Cape Town, and other cities in South Africa, have been heavily shaped by the legacy of apartheid. Apartheid-era policies left South African cities with extreme residential segregation by race, land use characterized by low-density settlements separated by long distances, and high levels of political division and distrust between races. The era of "separate development" began in 1948 when voters elected the National Party into power (Seekings and Nattrass 2005). What followed found precedents in earlier policies, dating back to the early 1900s, that suppressed blacks' political rights, employment opportunities, and property ownership (Clark and Worger 2004). According to Seekings (2008), the apartheid regime had three mutually dependent objectives: separate the races socially in order to maintain the purity of the white race, protect whites' economic privilege, and maintain white political power. The foundation of this system was the 1950 Population Registration Act, which required all residents to be registered and classified "as a white person, a coloured person or a native" (Parliament of South Africa 1950b, Section 5).

In terms of urban planning, no other policy had longer lasting impact than the Group Areas Act, which forced spatial segregation between racial groups. Even before 1948, blacks had limited access to urban land and laborers arriving from rural "native reserves" often

Figure 3.1: Map of City of Cape Town with general areas and neighborhoods



ended up in the informal settlements on the urban fringe (Mabin 1992). The 1950 Group Areas Act reinforced this pattern of urbanization by authorizing the government to designate specific areas for the exclusive use of certain racial groups. After a Group Area was declared, individuals from other racial groups were prohibited from “occupy[ing] land or premises”

within that area (Parliament of South Africa 1950a). The set of what were known as “pass laws” further enforced segregation by requiring black Africans to carry a “pass book” that specified the exact times and places a person was permitted to be present in white areas, usually only when they could prove employment in those areas (Parliament of South Africa 1952).

In Cape Town, the government used these laws to preserve the central business district and valuable coastal land for white businesses and residences, while blacks and coloureds were relegated to settlements, known as townships, on the urban periphery. Most infamously, the multiracial District Six neighborhood in the city center was declared a white-only area and 60,000 non-white residents were removed to the distant and then barren Cape Flats, also known as Metro Southeast (see Figure 3.1)(Besteman 2008). Townships grew during the 1960s as more and more rural blacks migrated to cities, and by the 1970s overcrowding prevailed. The overflow of migrants gave rise to informal settlements such as Crossroads (Mabin 1992). The result is a settlement pattern in which relatively high density and racially homogeneous outlying townships and informal settlements are separated from the city core by long distances with low-density development. Today, the Mitchell’s Plain and Khayelitsha areas in Metro Southeast are some of the country’s largest townships and the city’s most densely settled areas, with populations of over 310,000 and 392,000, respectively (Stats SA).

In 2011, Cape Town’s population of 3.7 million was 42% coloured, 39% black, 16% white, and 1.4% Indian or Asian (Stats SA). (In South Africa, “coloured” refers to people of mixed native African, European, and Southeast Asian ancestry.) The city today has among the world’s highest levels of residential segregation. Black and coloured residents are disproportionately likely to live in these outlying townships, from which they must travel long distances to reach centrally located jobs. White residents tend to live in lower density residential areas closer to the city center, the city’s largest employment hub. Low density settlement patterns prevail throughout most of the city with on average about 1,500 people per sq. km., with higher densities in townships and informal settlements. Khayelitsha, for example, has approximately 10,100 per sq. km. (Stats SA).

In addition, compared to most other world cities, Cape Town has very high crime levels, and fear of crime shapes people’s daily lives. South Africa ranks 8th internationally in homicides, with a rate of 34.4 per 100,000 inhabitants (UNODC 2013). Added to high income inequality, the residential segregation means non-white residents disproportionately bear the burden of long and expensive commutes. For city planners, the social divisions, as well as physical land use patterns, create steep challenges to successful BRT.

## **Post-Apartheid transformation**

In the late 1980s it became clear it could no longer retain power amid growing unrest, and in 1994 the National Party ceded control to the African National Congress (ANC), marking the end of Apartheid. The new government embarked on a mission to correct the past decades’ inequalities. By most accounts, the transformation process has been slow. Research on the post-apartheid social landscape of South Africa, and Cape Town, has generally found that

despite some progress on desegregation and the decoupling of race and class, changes in economic inequality and spatial segregation have been small and affect only a small proportion of the population, while the vast majority of non-whites remain disadvantaged (Seekings and Natrass 2005; Seekings 2008).

A good example of the slow progress is Black Economic Empowerment (BEE), a series of policies intended to increase nonwhites' access to economic opportunities previously denied to them. (BEE initiatives officially include all nonwhite racial groups, although in practice the system has been manipulating to promote African Blacks in particular.) The 1998 Employment Equity Act required all businesses of over 50 employees to demonstrate progress toward achieving an equitable employee racial composition (Republic of South Africa 1998), while the 2003 Broad-Based BEE Act set further targets for nonwhite ownership of businesses. Firms with high BEE scores are to receive preference in government procurement, concessions, and public-private partnerships (DTI 2003).

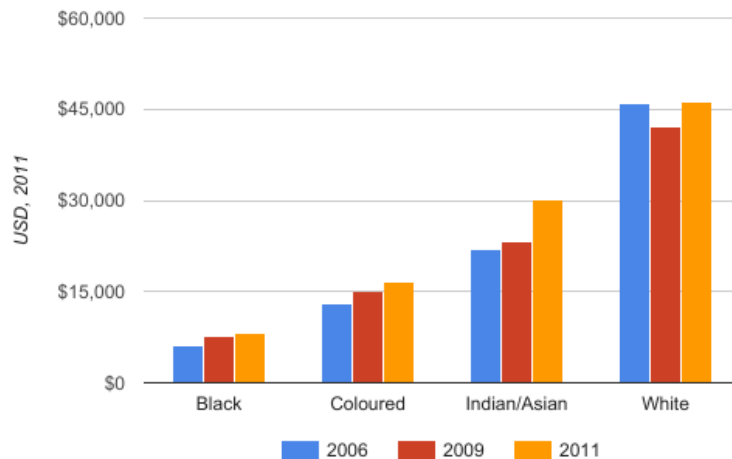
BEE policies have been credited with permitting the growth of a small black upper class, but research suggests the vast majority of blacks are left behind. Examining data from the census and Labor Force surveys, Seekings and Natrass (2005) showed that, between 1996 and 2001, a small number of blacks moved up into the associate professional and professional occupation groups. But whites also moved up—from associate professional to professional. During those same years, the racial composition of the economic elite (legislators, senior officials, and managers) stayed almost exactly the same, with 56% white in both 1996 and 2001. Analyzing census and labor force survey data, Crankshaw (2012) argued that “a substantial portion” of black and coloured residents have benefited from growth in low-wage service sector jobs. However, overall racial income differences have not changed, because any upward movement among blacks is countered by higher levels of black unemployment. Crankshaw's argument echoed Seekings and Natrass' (2005) in claiming that persistently high unemployment levels among blacks, which reached 24% in Cape Town in 2011 (Stats SA), have for decades hampered any movement out of poverty. It's worth noting that South Africa's minibuss taxi industry is one of the country's most important sectors for nonwhite-owned businesses (Woolf and Joubert 2013; Khosa 1995).

Although black middle- and upper-income groups have grown since 1994, the overall racial gap in income has in fact increased. In 2010, South African whites earned 4.4 times as much as blacks (R9,500 vs. R2,167 per month; \$1,225 vs. \$279 in 2010 USD), according to Stats SA coloured households earned a median of R2,652 (342 USD) per month, while the figure for Indian/Asian households was R6,000 (774 USD). As shown in 3.2, average annual household incomes vary predictably by race, and have generally increased between 2006-2011 (Stats SA). Across all races, Cape Town has very high income inequality; its Gini coefficient in 2011 was 0.67, among the highest in the world, up from 0.63 in 2009 (Stats SA).

### **Spatial segregation and race**

While the government has actively sought to empower blacks economically, efforts to end physical segregation have been less systematic. Some efforts have produced concrete change;

Figure 3.2: Average annual household income in South Africa by race, 2006-2011



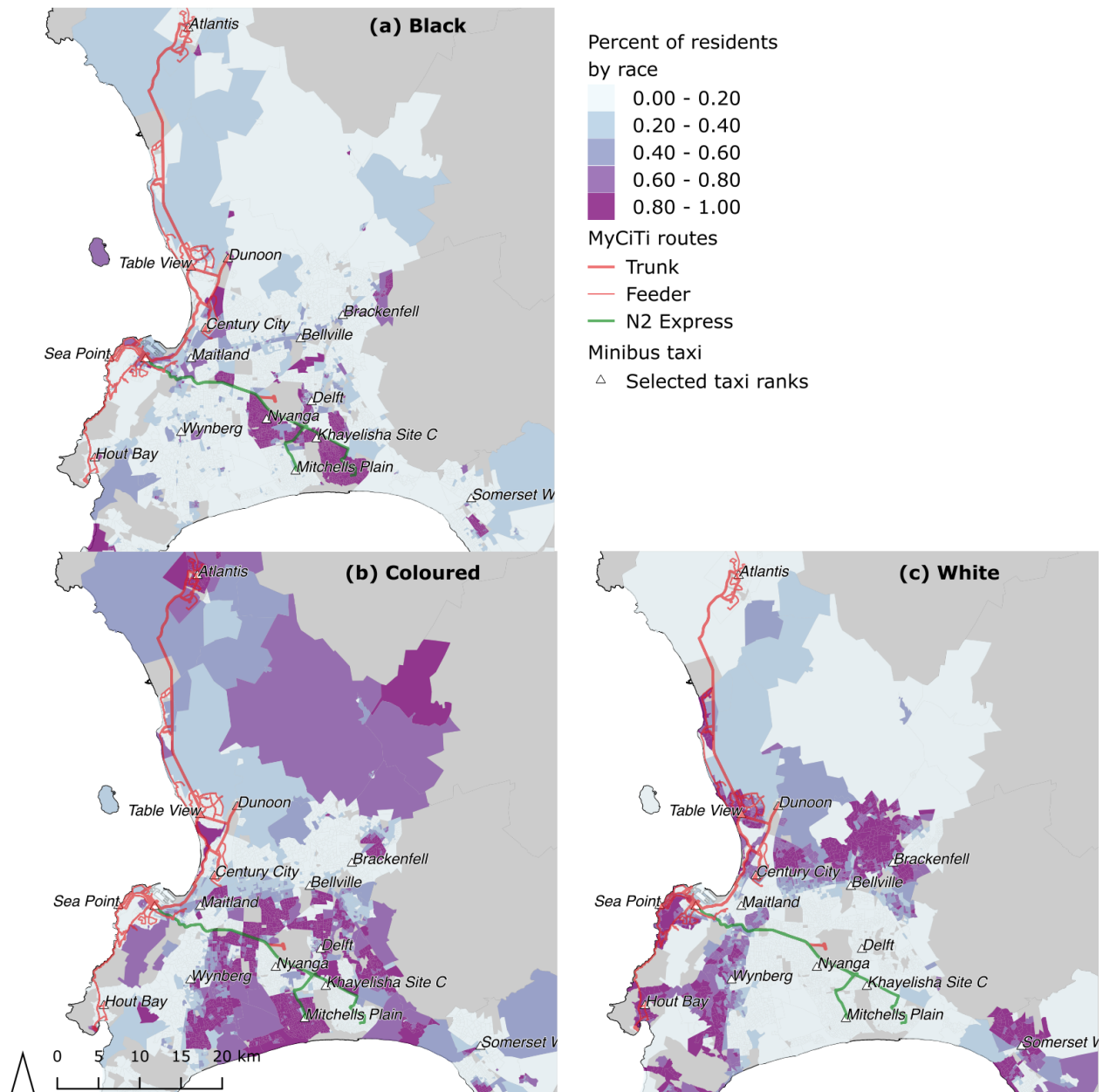
Source: StatsSA

for example, Cape Town's recent renovation of the central train station brought together formerly segregated trains bound for predominantly white and black areas. However, other government policies have worked against integration. For example, as Oldfield (2004) discussed, the majority of state-funded affordable housing has been built in low-cost peripheral areas, reinforcing apartheid geographies.

Thus, not surprisingly, the evidence on spatial segregation tells a similar story of minimal change. Across South African cities, racial segregation since 1994 has decreased slightly, but segregation indices remain very high (Christopher 2005). In Cape Town, Parry and Eeden (2015) used census data and Theil's entropy index to calculate racial segregation at a small spatial scale (the Census-defined small area layer). Theil's entropy index measures segregation on a scale from 0 to 1; a value of 0 implies groups are perfectly evenly distributed among spatial units, while a value of 1 implies groups are completely divided into different spatial units. The authors found that in Cape Town the index decreased steadily from 0.86 in 1991 to 0.66 in 2011. Still, a value of 0.66 is very high; for comparison, the most segregated city in the U.S. in 2000, Detroit, had a Theil's index value of 0.48. Focusing on high-poverty neighborhoods in Cape Town, Geyer and Mohammed (2015) found the census data from 2001 to 2011 showed an increasing gap, both economic and spatial, between low poverty and extreme poverty neighborhoods.

The slight declines in segregation indices appear to reflect the fact that a handful of neighborhoods are becoming more racially mixed, rather than gradual desegregation across the board. In Durban, Schensul and Heller (2011) found Census data showed a few neighborhoods, representing about 16% of the total population, had become more mixed from 1996 to 2001. These neighborhoods were mainly located in the city center or its inner edge,

Figure 3.3: Percentage of residents in each racial group for each Census spatial unit, Census 2011



Source: Stats SA

and were formerly white neighborhoods that added nonwhites as well as formerly Indian neighborhoods that added blacks. Yet 70% of the black population (about half the total population) in 2001 still lived in “legacy” black African neighborhoods, mainly townships with high poverty rates that had undergone very little change. The 2011 Census data for Cape Town tell a similar story (see Figure 3.3). The city center and some close-in neighborhoods (like Woodstock and Observatory) are now racially mixed, as are a handful of further-out suburbs (like Wynberg). But most township areas remain segregated: Atlantis in 2011 was 85% coloured, Mitchell’s Plain 91% coloured, Philippi 94% black, Khayelitsha 99% black (Stats SA). Some white suburbs have remained that way: e.g., Constantia (75% white) and Camps Bay (80% white).

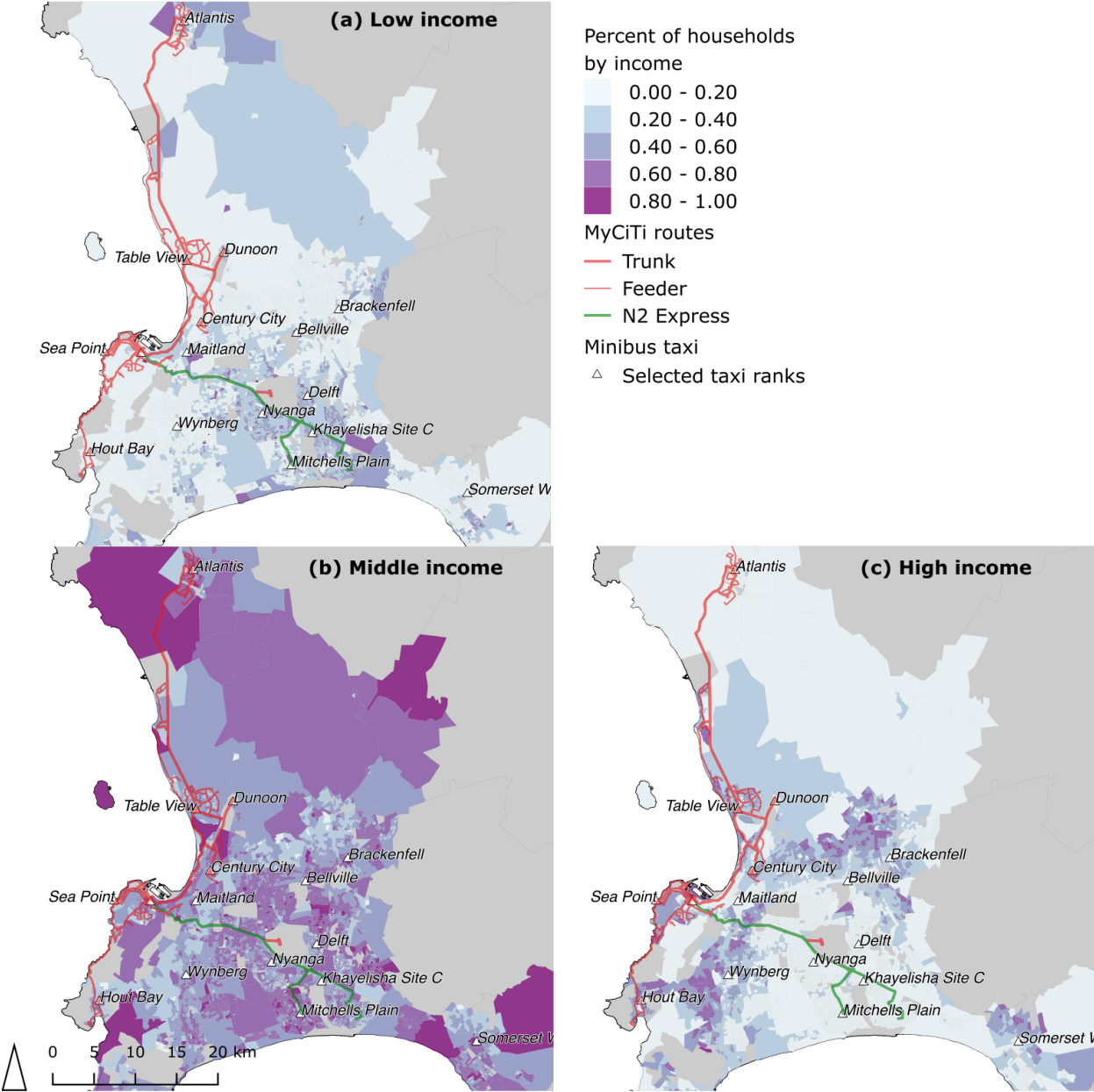
Among neighborhoods that have desegregated, racial mixing has not necessarily meant social integration. In interviews with residents of Muizenberg, a desegregating suburb, Lemanski (2006) uncovered little evidence of cross-racial social ties or a shared feeling of community. A few settings like churches and nursery schools did appear to facilitate social relationships between races; however, residents of different races generally perceived themselves to be part of different communities. Whites “escaped” to more white areas for example, by sending their children to schools in “white” suburbs, which was possible because having higher incomes, they were also more able to afford the time and cost of traveling to other locations.

Although not as extreme as segregation by race, Cape Town also exhibits strong spatial patterns by household income. Comparing Figure 3.4 with Figure 3.3, neighborhoods with concentrated high-income households not surprisingly overlap with white neighborhoods, as high concentrations of low-income households generally coincide with black neighborhoods. Middle-income households are prevalent throughout the city, with the greatest concentrations in predominantly coloured neighborhoods.

Social divisions fracture not just along race and income lines but also according to language, ethnic backgrounds, and national origins. For example, in a series of surveys conducted in 1995, 1998, and 2001, South Africans claimed to identify strongly with their language group, sometimes more strongly than with race (Bornman 2010). Of Cape Town’s three official languages—English, Afrikaans and Xhosa—English is the *lingua franca* and the dominant language of business and government. However, as a first language most of the population speaks either Afrikaans (35%) or Xhosa (29%) (Stats SA). Language is correlated with race: coloured residents are more likely to speak Afrikaans; nationally, 75% of coloureds speak Afrikaans as a first language and 21% English. The majority of whites are also native Afrikaans speakers, although at lower levels. Nationwide, 59% of whites speak Afrikaans first, while the 35% speak English (Stats SA). Xhosa speakers are almost exclusively black, and the vast majority of blacks in Cape Town speak Xhosa. However, black immigrants from other African countries, by Census counts at least 4.5% of the population in the Western Cape, can easily be identified by their lack of knowledge of Xhosa. Anti-immigrant attitudes and violence are pervasive, especially in low-income townships and informal settlements, where residents are more likely to perceive immigrants as competition for jobs (Monson 2015; Freemantle 2015).



Figure 3.4: Percentage of households by income for each Census spatial unit, Census 2011



Income categories are defined as: low (0-R19,600; 0-2,914 USD), middle (R19,601-R307,600; 2,914-45,734 USD), and high (over R307,600; 45,734 USD). *Source: Stats SA, Census 2011*

Meanwhile, coloured residents, occupy a complex intermediate position in the social hierarchy. While coloured people make up the plurality of Cape Town’s population—and they do control the provincial and municipal governments in the Western Cape—they are only 9% of the national population. National policies like Black Economic Empowerment have focused on empowering blacks, with much less special treatment for coloureds (DTI 2003). Some researchers have suggested today’s coloured residents feel frustrated, having been disadvantaged under apartheid and now overlooked by national initiatives (Adhikari 2009). Leggett (2006), for instance, cited this position as a potential explanation for the disproportionately high crime rates among coloured residents. Hence, in Cape Town any focus on social equity must consider how to advance “non-white” residents, not just blacks.

### 3.3 A profile of transportation in Cape Town today

A practical consequence of racial inequality and segregation is that non-white residents of Cape Town spend a disproportionately large amount of time and money on travel, while being less able to afford it. Overall, Capetonians spend a lot of time commuting. Data on transportation patterns in Cape Town comes from two main sources: the 2013 metropolitan-wide Cape Town Household Travel Survey (CT HHTS) and the 2013 National Household Travel Survey (NHTS). According to the CT HHTS, the average commuter spent 46 minutes each way in 2013. (The median travel time was 40 minutes.) Commute times vary a lot, though (standard deviation 39 min), with public transport users averaging over 1 hour each way. Residents of Mitchell’s Plain and Khayelitsha travel on average 59.3 min (median 60 min) and those in the northern part of the cit traveling only 38 min on average (median 30 min). The long travel times by Khayelitsha and Mitchell’s Plain commuters are not surprising, considering the majority use public transport and live roughly 30 km from the CBD along a congested corridor. Other job centers are not much closer and have fewer direct public transport links. Predictably, travel time varies by income group, with high income groups traveling on average 41.7 min (median 35 min), compared to 48.2 minutes (median 40 min) for the low income group.

Commuting, at least among some low-income residents, appears to be less burdensome than in the past, however. Cook’s (1992) account of Khayelitsha in the 1980s reported that residents of that township then traveled a total of 2 hours and 40 minutes daily on average, implying an average commute of 80 minutes each way.

Travel for Capetonians is also expensive. The average household spends 11% of its income on transport, as reported by the NHTS; those who use buses and taxis spend 15% on average. Passenger transport constitutes for an estimated 24% of gross geographic product in South Africa’s metropolitan areas, a much higher proportion than in other countries (Hunter van Ryneveld 2014).

Those who drive can save time, but at high cost. The CT HHTS reported that 53% of households owned at least one car; five percent owned a motorcycle (Table 3.1). Car ownership varies predictably with income: only 22% of low-income households owned a car,

while 97% and 94% of middle-high and high-income households did, respectively. Private motor vehicle (including motorcycle), accounted for 37.8% of trips. Everyone, it seems, would prefer their own car if they could afford it, but joining the 37% of commuters who drive means battling severe traffic congestion. According to an analysis of the TomTom Traffic Index, congestion adds an estimated 71% to morning peak travel time, making Cape Town the most congested city in South Africa and among the most congested cities in the world (TomTom 2016). In the Western Cape, those who drive to work spend on average more than twice as much on commuting as those who use public transportation (NHTS).

Table 3.1: Car ownership by income group

Number of cars	Percent respondents by income level				
	All	Low	Low Middle	High Middle	High
0	45.7	74.8	34.1	2.5	4.5
1	29.2	16.8	40.8	19.2	10.8
2	17.6	3.3	20.8	55.5	39.0
3	4.3	0.8	3.3	16.4	29.5
4+	1.5	0.3	0.8	6.4	16.1
missing	1.6	4.0	0.1	0.1	0.1
Total	100.0	100.0	100.0	100.0	100.0
n	22,332	8,473	11,464	1,711	784

*Source: CT HHTS 2013*

Although the slight majority of households have access to a motorized vehicle, public transport is still essential for a substantial proportion of the population. The CT HHTS asked respondents for their main mode of travel work or school, as summarized in Table 3.2. Just over a third, 34.4%, used public transport (including conventional bus, train, taxi, and BRT). Another 20.6% of trips were by foot and just 0.4% by bicycle. A not insignificant proportion of trips, 6.7% were by employer or school transport. The 2013 National Household Travel Survey (NHTS) conducted by Stats SA found a slightly different mode split. The discrepancy may be due to the fact that the Cape Town survey reported mode split in terms of trip, while the national one reported it in terms of individual travelers. Different sample methods may also account for the discrepancy. (See Chapter 6 for a discussion of the difficulties of conducting surveys in Cape Town.)

Cape Town’s commuter train, Metrorail, has a mode share of 13.3% and serves the city’s southern and southeastern suburbs (Figure 3.6). Many use the train because the fares are lower than for all other modes. The median train commuter spends ZAR 150 (15 USD) per month for transport to work, less than for all other motorized modes (Table 3.3). However, the train is notorious for overcrowding, slow and unreliable service, and high (perceived) crime rates. In Cape Town, respondents to the NHTS, for whom the train was available, listed “too much crime” and “trains too crowded” as the top two reasons for not using the train.

Table 3.2: Main travel mode, from CT HHTS 2013 and NHTS 2013

Travel mode	CT HHTS	NHTS	
	Main mode, work/school (in terms of % of trips)	Main mode, work (in terms of % of persons)	Main mode, school
Walk	20.6	8.2	40.6
Car as driver	25.2	39.1	2.0
Car, passenger	11.7	8.0	23.8
Train	10.9	17.5	5.1
Bus	7.9	7.5	3.6
Minibus taxi	15.3	14.8	11.5
Bicycle	0.4	-	-
Motorcycle	0.9	-	-
MyCiTi	0.3	-	-
Employer transport	3.7	-	-
Scholar transport	3.0	-	-
Other	0.3	0.9	1.8
Unspecified	0.0	3.9	11.7

In addition to the BRT, a regulated private bus operator, Golden Arrow, provides conventional bus service and in 2011 served 7.3% of work travel. The Golden Arrow’s arrows hundreds of routes crossed the entire city (Figure 3.7), although routes are being removed with the introduction of MyCiTi. The most commonly used public transit mode, with 15.1% mode share, is the taxi, these are 14-seat minibuses that serve designated routes, with on-demand stops and distance-variable fares (City of Cape Town 2015). Taxis are seen as convenient and relatively affordable—as shown in Table 3.3, taxi commuters tend to spend more on transport than train users, but less than bus. Taxis are also criticized for unsafe driving and poor customer service. NHTS respondents listed top reasons for not using taxis as “too much crime”, “drivers drive recklessly” and “drivers are rude.”

### Trip frequency and trip purpose

The main source for trip frequency and purpose in Cape Town is the 2013 HHTS travel diary, which recorded trips for 5,270 respondents. On average, respondents made 2.5 trips per day. The majority reported making a trip for work or school (42.8% and 18.8%, respectively). As a percentage of the total trips reported (after excluding trips made to go home or to transfer), 61.4% were for work or school, 17.3% were for shopping, 8.2% were for personal errands of various kinds (e.g., bank, pick up/drop off children), and 8.9% were for leisure purposes (such a visiting a person or recreation).

Table 3.3: Mean and median travel cost for public transport modes, single and monthly ticket

Single ticket		Cost (ZAR)		Cost (USD)	
Mode	n	Mean	Median	Mean	Median
Train	191	57.5	9	569	89
Bus	166	70.4	12	697	119
Taxi	3,747	28.5	9	282	89
MyCiTi	43	67	11	663	109
Monthly cost		Cost (ZAR)		Cost (USD)	
Mode	n	Mean	Median	Mean	Median
Train	1,948	159.8	150	1,581	1,484
Bus	590	315.2	350	3,118	3,463
Taxi	300	283.4	250	2,804	2,473
MyCiTi	5	147.6	200	1,460	1,979

Source: CT HHTS 2013

Table 3.4: Commute mode by race, Cape Town Metropolitan Area

Mode	Percent commuters by race			
	Black African	Coloured	White	Indian/Asian
Car as driver	13.4	34.5	86.7	61.0
Car as passenger	4.6	11.2	6.2	19.5
Minibus taxi	26.5	15.8	0.8	9.8
Train	28.7	19.3	2.5	7.3
Bus	11.0	9.6	0.2	0.0
Walk	14.3	8.2	2.3	2.4
Other	1.2	0.9	1.2	0.0
Unspecified	0.3	0.5	0.2	0.0
Total	100.0	100.0	100.0	100.0
n	762	1,277	600	41

Source: NHTS 2013

Whether because of cost or simply the lack of need for it, a large percentage of residents travel very little. In the CT HHTS, 25% of households did not travel at all for work or education on the reference day, although they may have traveled for other purposes. The high proportion of household that did not travel is partially explained by Cape Town’s unemployment rate, which in 2015 was 23.6% (Stats SA).

Capetonians are also early morning commuters: 40% reported leaving for work or school before 7AM (HHTS). According to the NHTS, 5.1% of blacks began their commute between

4AM and 5AM, while 0.7% of whites traveled that early. As I will show in later chapters, many commuters travel early in order to avoid having to travel after dark in the evening, when their route may be less safe, or because their commute is either very long or unreliable, so they must leave early to arrive at work on time.

### 3.4 Cape Town’s institutional context

Importantly for this research, the City of Cape Town’s jurisdiction extends across the entire metropolitan area. Thus the municipality holds administrative authority over the metropolitan region. Above the municipality are the provincial Western Cape government and the national government. The City itself is governed by a democratically elected city council, which elects a mayor.

In Cape Town, the City holds authority for some key aspects of urban transportation, thanks to national policies that beginning in the 1990s called for devolution of responsibilities from the national government to metropolitan authorities. The 1996 White Paper on National Transport Policy envisioned metro-level transport authorities eventually taking over commuter rail services, which were currently run at the national level. The 2000 National Land Transport Transition Act established metropolitan transport authorities, which in the case of Cape Town is the same as the municipality (Walters 2013). This enabled municipalities, which had authority over their entire metropolitan area, to engage much more effectively in transport planning. The 2009 National Land Transport Act (NLTA) opened the door for the devolution for additional transport planning responsibilities, such as managing transport operator contracts and preparing integrated land use and transportation plans, to the municipal level (Republic of South Africa 2009). These policy reforms are significant because they ultimately brought transport reform into the local political arena. In addition, municipalities have the ability to raise their own funding for transport through property taxes.

Devolution remains incomplete, though: while municipalities have authority over BRT, commuter rail is still provided by a national state-owned company. Similarly, responsibility for issuing operating licenses and scheduled bus service contracts remains at the provincial level. This division of responsibilities among different modes has made it difficult for metro authorities to rely on rail and conventional bus as part of their integrated transport networks, leaving BRT as their main policy tool (Wilkinson 2010; NDoT 2007; Schalekamp and Behrens 2013).

In terms of its ability to effectively carry out policy, the governance context in Cape Town can be characterized as moderate capacity. One measure of governance capacity comes from the World Bank’s Worldwide Governance Indicators project, which formulates indicators based on a wide variety of surveys and expert opinions. Between the years 2010 and 2015 South Africa ranked in the 64-66th percentile among all countries in terms of “government effectiveness,” a composite indicator designed to capture “perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political

pressures, the quality of policy formulation and implementation, and the credibility of the government’s commitment to such policies” (Kaufmann, Kraay, and Mastruzzi 2011, p. 223). On other indicators—“voice and accountability,” “regulatory quality”, “rule of law,” and “control of corruption – South Africa ranked between the 54th and 69th percentiles (The World Bank 2017). (It ranked lower in terms of “political stability and absence of violence/terrorism: 39-46th percentile.) Furthermore, the national government has shown support for public transport through BRT investment and has the ability to dedicate financial resources, albeit limited.

Within South Africa, the City of Cape Town is often recognized for the effectiveness of its government relative to elsewhere in the country. Cape Town earned Moody’s highest credit rating for a South African city, it was recognized by the agency Ratings Afrika as the South African metro area with the best financial management (Bernardo 2016), and in 2014 it earned the highest score for service delivery among the country’s eight largest metro areas (Lewis 2014). The City considers good governance an important objective: in its five-year plan it aims to be “a City that distinguishes itself as a well-governed and efficiently run administration” (City of Cape Town 2007, p.1).

### 3.5 Cape Town as an extreme case

As this chapter as shown, in terms of its transport system, Cape Town resembles many other cities now considering or undergoing public transport formalization. It is medium-sized, with a population size similar to most cities now building BRT. It is turning to BRT as a way to help formalize the informal transport industry and in doing so solve problems like congestion and reckless driving attributed to informal transport. Its level of government capacity ranks as moderate, raising the question of whether or not the government can manage a successful formalization process and whether or not formalization will benefit users.

In terms of social, economic, and spatial context, Cape Town’s history of apartheid creates more extreme challenges than those faced by its international counterparts. Yet these challenges are not unfamiliar in other cities. Group-based tendencies toward separation have shaped urbanization many other countries, as they did in pre-apartheid South Africa. Mabin, for example, argued, “in some respects apartheid was a (racist) response to previous failure to develop coherent urbanization policy” (Mabin 1992, p. 17). Seekings and Nattrass (2005) positioned their case study of South African economic structure as an extreme case of distributional inequality, arguing that despite factors that make it unique among countries in the Global South (i.e., a relatively small informal sector, more heavily institutionalized discrimination), it exhibits non-unique processes of stratification. It’s not unreasonable to compare South Africa’s racial inequalities with those in the U.S., which also has a history of institutionalized segregation and discrimination. Even decades after the Civil Rights movement, evidence shows that cities in the U.S. are still plagued by high levels of segregation and lingering housing discrimination (Galster and Godfrey 2005; Farrell 2008). Documenting the systematic discrimination and structural inequality that has led to racial segregation in

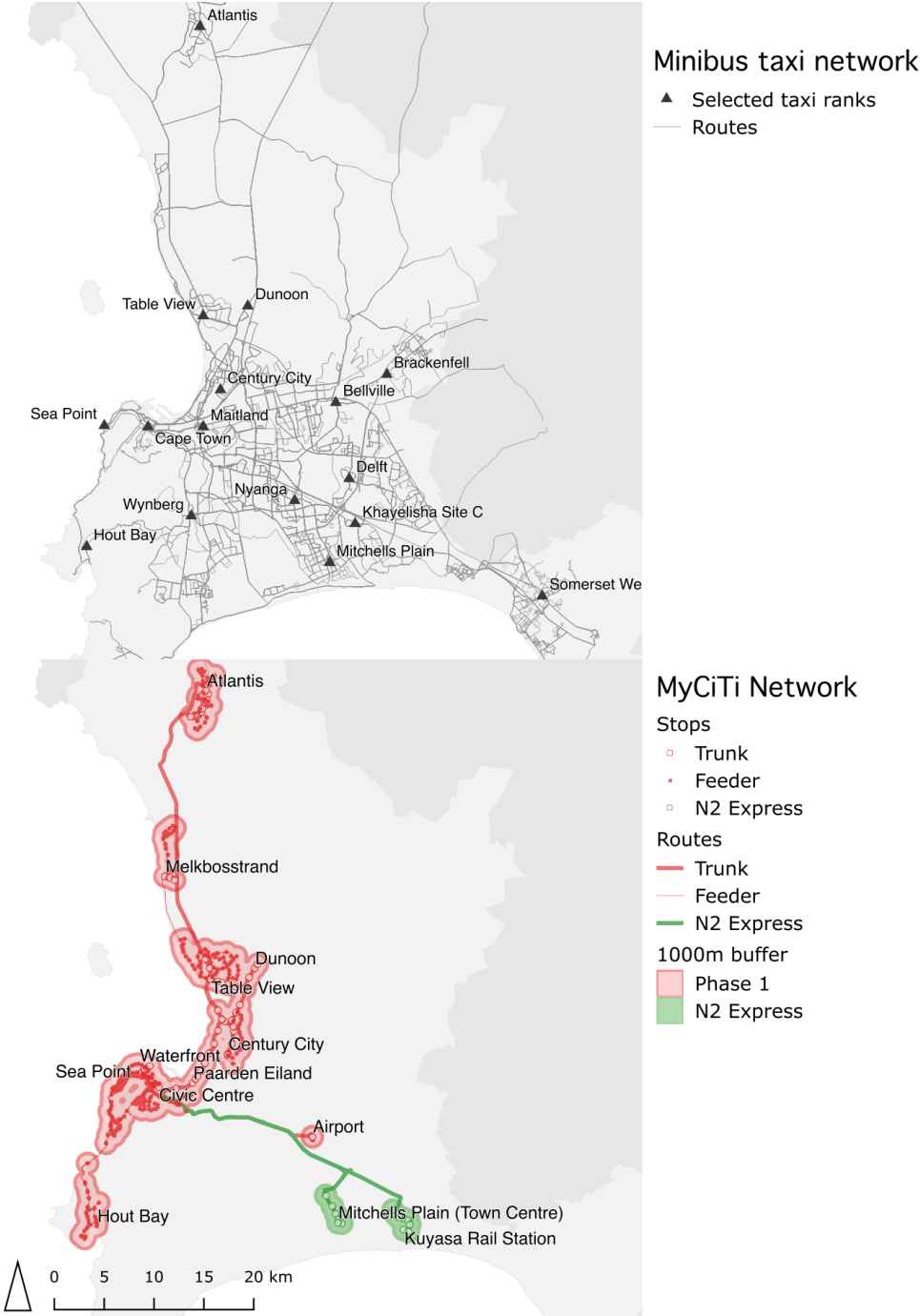
the U.S., Massey and Denton have gone so far as to call it “American Apartheid” (Massey and Denton 1993). Yiftachel (2009) has compared Cape Town’s uneven settlement patterns to those in Colombo, Tallinn, and Jerusalem, finding in each stratification by race, nationality or ethnic group expressed not only in economic and spatial terms, but also in terms of the level of citizenship. Cities in Latin America and South and Southeast Asia also have very high levels of socioeconomic inequality.

In terms of transportation issues, Cape Town may also be considered an extreme case, as travel times and distances are unusually large for a city of moderate population, mainly because the separation of townships from the central city forces poor residents to travel long distances. This separation may be large than in other cities of the same size, but the basic pattern is common to many cities in developing countries. In places like Rio de Janeiro, Mumbai, and Mexico City, a major challenge for transport planners is to provide mobility for poor residents concentrated on the periphery.

In sum, Cape Town represents an extreme case of the socio-spatial issues faced elsewhere. No case study is completely typical, and all cases are unique in at least some ways. Cape Town is typical in many ways—in terms of size, its particular BRT implementation, and government capacity—and the way in which it is extreme—socio-spatial inequality—helps to demonstrate issues faced by many other cities.



Figure 3.5: Minibus taxi and MyCiTi networks



Top: Cape Town’s minibus taxi network with selected taxi ranks. Bottom: Cape Town’s BRT (MyCiTi) network with selected locations.

Figure 3.6: Cape Town’s commuter train network, Metrorail, with selected stations

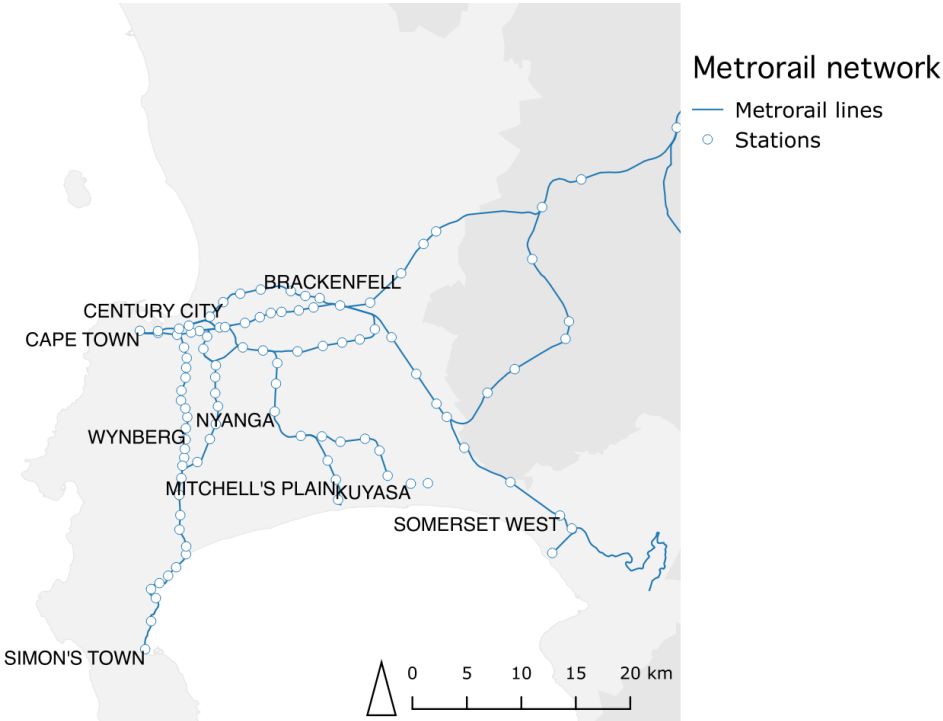


Figure 3.7: Cape Town’s conventional bus network, Golden Arrow



# Chapter 4

## Cape Town's BRT reforms

Across South Africa, the minibus taxi is ubiquitous on the street and instantly recognizable as an icon in popular culture. Public attitude is ambivalent: the taxi is valued as an integral and homegrown part of the transport system but also vilified for its contribution to chaotic road conditions and crime and violence. It has been this way since the 1980s, when deregulation and failures of government-subsidized transport fueled the taxi industry's growth. Between 2010 and 2015, Cape Town removed more than 700 taxis from the streets and compensated 337 operators (City of Cape Town 2015). In their place, the City rolled out MyCiTi Phase 1 trunk and feeder routes. While replacement of taxis was only one motivation for BRT, in completing this first phase of MyCiTi Cape Town took a big step toward reforming its public transport.

In this chapter, I will present the Cape Town context as a case study in BRT reform, especially as formalization of informal transport. After reviewing how the minibus taxi industry in South Africa emerged, I will discuss the position of taxis on the spectrum of informality. Next, I will outline how transport reform, specifically through BRT, has arisen partially in response to problems blamed on taxis. I will close this chapter with a discussion of how the introduction of BRT in Cape Town changed public transportation provision in the city.

### 4.1 Methodology

My research in this case study of Cape Town's transport reform draws from a combination of interviews, review of documents, and personal observations and experience. I obtained relevant documents from publicly available sources and local contacts. These included official plans and policies, technical reports, and financial projections. In a few instances I used information from media reports. In the course of research, I spent a total of six months in Cape Town, spread over three visits between 2015 and 2016. During this time, I used all forms of public transport and gained a first-hand experience of how the minibus taxis and MyCiTi systems work. I traveled to and around the areas that are the focus of transport

formalization: the Blaauwberg/Table View corridor, Mitchell's Plain, Khayelitsha, and the city center. In addition, particularly in tracing the historical development of policy, I make extensive use of existing literature.

## Interviews with key actors

Between 2015 and 2016, I conducted semi-structured interviews with 18 individuals involved in the planning and provision of MyCiTi (see Table 4.1). These individuals played roles that included political leadership, system planning, financial planning, operations planning, demand modeling, station and vehicle design, engagement and negotiation with the taxi industry, regulations, and contract management. I also interviewed minibus taxi operators who were also leaders in their respective taxi associations. Because I was ill during scheduled interviews on May 27th and 28th, 2015, these interviews were conducted and audio recorded by my research supervisor, Daniel Chatman, and our collaborator, Aaron Golub.

Interviews were typically one hour and sometimes up to two hours. Most were audio recorded and later transcribed. The exceptions were two of the taxi association leaders, of whom I did not feel comfortable requesting a recording due to the sensitive nature of the material. I also did not record one of the early interviews due to a technical problem.

In these interviews I asked questions about the decisions and motivations behind Cape Town's BRT initiative, the major challenges faced during the transformation, and thinking about the current decision-making environment. I also sought to understand differences between how the minibus taxi and MyCiTi systems function, especially the incentives faced by each actor. In particular, I sought to understand the ways in which MyCiTi reforms changed the provision of transport, the institutional structures behind it, and how those changes affected service characteristics.

In these interviews I asked a set of questions tailored to each individual's role. Some topics were common to all. For those involved in the early planning of MyCiTi, between 2007 and 2010, I asked about the decision-making process, especially the reasoning behind key decisions on service characteristics. I was specifically interested in three ways in which I hypothesized the transport reforms to influence transportation provision and therefore influence accessibility: (1) the goals and motivations of decision-makers, (2) formalization of transport along the dimensions of informality, and (3) the ways in which decision makers understood user demands and needs. I coded the interviews according to a predetermined list of themes that fell under these three hypotheses. I then organized the interview excerpts by code and synthesized to extract common ideas.

In addition to the interviews, I found the City's documents, especially the 2012 and 2015 MyCiTi Business Plans, to be helpful in identifying ways in the City made decisions and adapted over time. Some sections of these reports discuss in detail the City's missteps and lessons learned, accounts I found to be corroborated by interviews.

Table 4.1: Stakeholder interviews conducted

Name	Position	Organization	Interviewers	Date interviewed
Nico McLachlan	Managing Director	ODA	Lisa Rayle, Daniel Chatman, Aaron Golub	5/25/2015
Peter Grey	Senior Planner, Business Development	Transport for Cape Town	Daniel Chatman, Aaron Golub	5/27/2015
Dawie Bosch	Manager, Business Development and Integration	Transport for Cape Town	Daniel Chatman, Aaron Golub	5/27/2015
Eddie Beukes	Principal Professional Officer, Transport System Planning	Transport for Cape Town	Daniel Chatman, Aaron Golub	5/27/2015
Thabang Molefe	Chairman	Transpeninsula	Daniel Chatman, Aaron Golub	5/28/2015
Anonymous		CODETA	Lisa Rayle	10/7/2015
Henry Williams	Chairperson	Route Six Taxi Association	Lisa Rayle	10/9/2015
Brett Herron	Councillor and Mayoral Committee Member for Transport	Lisa Rayle	City of Cape Town	9/13/2016
Andrew Kerr	Senior Research Officer (creator of TaxiMap)	University of Cape Town	Lisa Rayle	9/13/2016
Thabiso Botha	Consultant	ODA	Lisa Rayle	9/14/2016
Sipho Afrika	Director of Contract Operations	Transport for Cape Town	Lisa Rayle	9/15/2016
Alastair Rendall	Principal	ARG Design	Lisa Rayle	9/22/2016
Abdul Bassier	Director of Regulations	Transport for Cape Town	Lisa Rayle	9/26/2016
Philip van Ryneveld	Consultant (Former CFO for City of Cape Town)	Hunter van Ryneveld	Lisa Rayle	9/27/2016
Claire Holderness	Professional Officer, Transport System Planning	Transport for Cape Town	Lisa Rayle	9/28/2016
Maddie Mazaza	Director of Planning	Transport for Cape Town	Lisa Rayle	9/28/2016
Kapil Singh	Senior Professional Officer, Transport System Planning	Transport for Cape Town	Lisa Rayle	9/28/2016
Babalwa Nyoka	Head of Surveys	Transport for Cape Town	Lisa Rayle	9/29/2016
Steven Otter	Head: Communications	Transport for Cape Town	Lisa Rayle	11/14/2016

## Minibus taxi industry interviews

My interviews focused mainly on decision-makers within the City of Cape Town, and only a few individuals from the taxi industry. In order to gain more information on the taxi industry

from hard-to-reach members, I also used interviews conducted by Herrie Schalekamp, a researcher at the University of Cape Town. For his dissertation, Schalekamp interviewed 38 individual taxi owners, representing eight taxi associations in Cape Town. I decided to draw on his interviews because it would have been difficult and impractical to conduct my own with the same population. In order to gain access to these individuals, Schalekamp spent years building relationships to establish trust, and even then most of the subjects were reluctant to participate. Schalekamp published the interview transcripts, which contained information useful for my research, such that I did not find it necessary to interview the same individuals again. (There were two exceptions: when I needed to gain permission from the taxi associations in Mitchell's Plain and Khayelitsha, I spoke to association leaders at length and used the opportunity to ask questions about their business and perspectives.)

In addition to Schalekamp's interviews, one other event allowed me access to information about the minibus taxi industry. From May 2015 to June 2017, Schalekamp led a professional development program for minibus taxi owners who were going to be affected by MyCiTi Phase 2. The purpose of the course was to educate taxi operators on basics of corporate governance and prepare them to manage operating companies that would contract with MyCiTi. I had the opportunity to sit in on one of these sessions, attended by about thirty individuals from the Mitchell's Plain and Khayelitsha taxi associations. Some of the information in this chapter comes from what I learned listening to discussions in that course.

## 4.2 Minibus taxis: emergence and workings of Cape Town's informal transport

In Cape Town, as in all of South Africa, informal public transport comes in the form of the minibus taxi, a vehicle with 14 passenger seats. Minibus taxis mostly follow a designated route for which they are licensed, but deviate from them as needed. Minibuses serve both intercity and intracity travel. Taxis are organized into taxi associations, which vary in size and have semi-official authority over a given area or set of routes in the city. As will be discussed in more detail later in this section, associations usually manage competition between operators within the area, operate taxi ranks, and provide political representation for members. In the Cape Town context, taxi "operator" usually refers to the owner, who may or may not also drive the vehicle.

Today, from the passenger's point of view, minibus taxis work the same way they have for years. To use a minibus taxi in Cape Town, one can either go to a taxi rank, where taxis and passengers queue, or flag one along one of the more than 500 taxi routes in the city. The passenger has to know their destination and be sure they board the correct taxi. Taxis do not follow a schedule, but depart from the taxi rank when they are full, or sooner if the driver expects to pick up passengers along the route. Thus the waiting time is not always predictable, although during peak times the volume of vehicles departing is so high wait times are very short. During off-peak times passengers may have to wait much longer.

Figure 4.1: Minibus taxi rank, Dunoon, Cape Town



*photo: City of Cape Town*

Picking up a taxi along the route is less predictable, since passing vehicles may already be full.

Passengers are normally guaranteed a seat. Although it is illegal, occasionally taxis will pick up passengers in excess of the number of seats, using a plank that creates an additional seat in the aisle between other seats. The taxi may employ a *gaardjie*, who alerts the driver to potential passengers on the road, opens the sliding door for them, and collects fares. If there is no *gaardjie*, the passenger in the front seat usually collects fares from the other passengers. Fares are paid in cash and are a fixed amount based on distance; the passenger will inform the driver of their destination initially and pay the fare accordingly. Drivers are known to sometimes give discounts in off-peak times to fill up their vehicles (Woolf and Joubert 2013). Passengers can alight anywhere along the route, or continue until the terminal destination, usually another taxi rank. To stop along the route, the passenger verbally requests a stop.

### **Evolution of policy toward public transportation**

As in other countries, informal services in South Africa arose when formal, government-subsidized transit failed to fully meet demand. Also as in other countries, South African's recent BRT initiatives can be understood as a continuation of the government's efforts to formalize the informal transport industry that go back decades.



Figure 4.2: Minibus taxi terminal, Mitchell's Plain, Cape Town



*photo: City of Cape Town*

### **An era of regulation and public subsidy (1930-1977)**

Between 1930 and the 1970s, public transport South Africa remained fairly closely regulated and, towards the end of this era, publicly subsidized. Given that Apartheid policies enforced residential segregation, much transport policy was motivated by the need to transport non-white workers long distances from townships to employment in white areas (Wilkinson 2010). The government subsidized commuter rail, and legislative acts from the 1950s through 1970s directed funds to subsidize operations of public bus services, which were contracted through private companies (Wilkinson 2010). Along with these subsidies, government involvement, such as fare regulation and prohibition of unpermitted vehicles, was necessary to support contracts between private or municipal bus operators and national and provincial transport departments.

Government-subsidized public transport evidently fell short of meeting demand, however, since by the 1970s independent shared taxis were serving enough travelers to attract the attention of the national government (Bassier 1989; van Ryneveld 1989). These shared taxis were known as “kombis,” after the vehicle usually used, a type of Volkswagen van. In a 1974 report, the government described the kombi taxis as operating in a way distinct from “white” taxis:

“Non-White taxis provide both line-haul and city distribution services in urban areas, and fares can be kept at reasonable levels on account of the relatively

high occupancy of the vehicles. In fact, Non-White taxis operate to a large extent as jitneys, i.e., small-size buses which follow a fixed route and are hailed by passengers. This means however, that they often contribute to traffic problems along busy bus routes" (Report of the Driessen Committee, 1974, quoted in Bassier (1989, p. 2-2)).

Hemmed in by the apartheid government's restrictions on the growth of black businesses, legally permitted to carry only five passengers, and subject to frequent police harassment, kombi taxi numbers remained limited in number during most of the 1970s (Khosa 1992).

### **Deregulation and the growth of minibus taxis (1977-1990s)**

By the late 1970s, several forces came together to loosen the regulations on public transport. The national government's 1974 report had explicitly recognized the importance of taxis and stated they "must be regarded as a necessary adjunct" to conventional bus services (Bassier 1989; van Ryneveld 1989). This report likely influenced the 1977 Van Breda Commission, set up by the government to respond to the 1973 oil crisis, and which concluded the country "had reached a stage of economic and industrial development which enabled it to move towards a freer competition in transportation" (Dugard 2001, p. 37). The Commission's output, what became the 1977 Road Transport Act, stopped short of permitting minibus taxis outright. However, it did increase the number of passengers permitted in "shared taxis" from six to eight, a move that Van Ryneveld (1989) suggests encouraged shared taxi operators to begin using larger 9- or 10-seater vehicles.

In the early 1980s, as public transport subsidies put ever greater strain on the national budget, arguments for deregulation grew louder (Wilkinson 2010). Black-owned minibus taxis continued to slowly increase in number (Khosa 1992). According to Wilkinson (2010), some officials began to come around to the idea that minibus taxis could provide both cheap transport and "an outlet for black economic aspirations" (p. 389). Expert reports in the mid-1980s concluded minibus taxis offered essential and affordable transport, and should be encouraged (Khosa 1995). Dugard (2001) noted that the business community at this time pressed for more free market reforms in all sectors, echoing the market liberalization occurring in the U.S. and U.K. A debate arose over whether or not to lift regulations on minibus taxis.

Despite calls to ban minibus taxis entirely, the deregulation argument prevailed. The National Transport Policy Study and subsequent 1987 White Paper on National Transport Policy essentially legitimized the minibus taxis (van Ryneveld 1989; Khosa 1995; Walters 2013). They recommended allowing 16-seater minibuses with only minimal entry requirements—vehicle fitness, valid driver license, proof of insurance (Khosa 1992). The recommendations were accepted in the 1988 Transport Deregulation Act, which legalized minibus taxis.

The 1988 Deregulation Act ensured that minibus taxis, operating in near-free market with open competition, had dramatic consequences. There was no restriction on the number of taxis, and minibus taxis soon flooded the market, resulting in oversupply. Although taxi

permits were technically required, enforcement was no longer a priority. Permits were “issued like confetti” (Dugard 2001). Taxi licenses exploded, in Johannesburg from 401 in 1984 to 15,160 in 1989 (Khosa 1992). The number of taxis probably increased much more, since many operators didn’t bother to obtain a permit at all; Khosa (1992) reported that in 1992, an estimated 30-60% of taxis operated outside legal parameters.

As the government retreated and left the industry largely to its own devices, self-regulation methods to control supply became increasingly violent. In what became known as the “taxi wars,” competing taxi associations battled over routes and over governance of taxi association “mother bodies,” often using violence to assert and enforce control. Throughout the 1990s, the taxi wars were responsible for about 100-300 deaths nationwide each year, according to statistics compiled by the South African Institute of Race Relations and the South African Police Service (Dugard 2001). Most deaths were targeted killings of taxi operators, but innocent passengers or bystanders were not infrequently caught in crossfire. The violence only increased after Apartheid ended in 1994, as taxi association politics was often intertwined with national post-Apartheid politics (Dugard 2001).

Khosa (1992) and Dugard (2001) attributed the violent taxi wars to oversupply created by deregulation. For example, a new operator might get a license and then find there is no business, and then poach passengers from other routes. Disputes erupted over taxi rank space, access to routes, and prices. Associations attempted to reduce such conflicts among their members by employing a queue marshal or rank manager to ensure drivers get equal business. But associations would periodically have to fight with “pirate” taxis that ignored self-regulation and codes of conduct, to battle rival associations over territory, or to fend off unlicensed operators attempting to poach passengers (Khosa 1992). By the late 1990s, many taxi operators were reportedly also engaged in gang and drug-related activities (Dugard 2001). Since then, a low-level state of conflict has persisted within the taxi industry.

### **Early steps toward formalization**

In addition to the taxi violence, deregulation had not led to more affordable transport, and workers still faced long commutes (Khosa 1998). Deregulation had increased the number of taxis, so theoretically passengers enjoyed greater service frequency and probably more direct routes, but at the cost of greater congestion and much reduced safety—although empirical evidence of the effects on service is not available. The violence and chaotic road conditions were obvious to all, however, and eventually prompted a redirection toward regulation (Khosa 1998).

As Khosa (1998) and Walters (2013) emphasized, the transition to post-Apartheid in the 1990s brought intense policy debate as well as a more inclusive political environment in which the historically marginalized taxi industry gained a seat at the table. A national transport forum, convened in 1992, wrote, “the transport industry should be used as an instrument of transformation. Emphasis should therefore be placed on the creation of new businesses and empowerment as a tool in the economic process” (National Transport Policy Forum 1994, p. 2). The public transport industry became recognized as a potential means

of black economic empowerment; the 2000 National Land Transport Transition Act stated “negotiated service had to be majority black owned within two years” (Walters 2013).

**Taxi recapitalization: an attempt at public investment for taxis** The 1990s debates produced a framework for formalizing the taxi industry. The National Taxi Task Team, convened in 1995, recommended that taxi associations be officially registered and recognized. It also proposed a program called taxi recapitalization (Khosa 1998). According to Walters’ (2013) overview of the program, the stated goals of recapitalization (known as “recap”) were to: improve safety and reliability of industry, reduce total number of vehicles to 85,000 (from about 120,000-140,000), upgrade vehicle quality, address economic sustainability of the industry, and effectively regulate the industry. The program’s rationale was that public investment was needed in the sector because private operators were apparently not investing adequately in their own businesses (Venter 2013).

In 2006, the DoT and SANTACO (South African National Taxi Council) agreed to a program that provided taxi operators a one-off compensation of R57,400 (8,165 USD) to either acquire a new vehicle or exit the industry. The old vehicles were physically destroyed. To qualify, operators were required to adopt more formal operating practices, including: convert from radius-based operating permits to route-based licenses, pay drivers minimum wages, regulate driving hours and leave conditions, have passenger liability insurance, and pay income taxes (Walters 2013). A year later, more than 42,000 taxis had been scrapped, and R2.13 billion (300m USD) paid out (Walters 2013). Still, annual government expenditures on taxi recap were never more than a tiny fraction of the amount spent on formal public transport modes (see Section 4.2). Of the formalization requirements, today only the route-based license system is in effect. My interviews confirmed the requirements for driver pay, maximum driving hours, insurance and income taxes were not enforced. Venter (2013) argued that although taxi recap succeeded in replacing a number of vehicles, it failed to fundamentally transform the industry’s informal mode of operation.

## Minibus taxis and informality

Although by 2010 the minibus taxi industry was officially recognized and regulated by the government, it continues to sit toward the informality end of the spectrum. We can see this by examining the dimensions of informality discussed in Chapter 2.

### Relationship to government

**Regulation** The government regulates the minibus taxi industry but it is not uncommon for regulations to be ignored or unenforced. Officially, taxis are required to hold an operating license that specifies a route on which it is allowed to operate. To obtain an operating license, the applicant must provide business registration, proof of insurance, vehicle registration, and a letter of support from the taxi association they intend to join, along with passing a vehicle inspection. Drivers caught transporting passengers without the proper license can be fined

and their vehicles impounded. The Provincial Operating License Board is responsible for granting licenses and, through the number of licenses granted, can ostensibly control the number of vehicles on each route. Municipalities can recommend that the province approve or reject additional licenses for a given route based on an analysis of current supply and demand. However, according to Abdul Bassier, Director of Regulations for Transport for Cape Town, these the supply and demand criteria aren't always taken into account:

The law requires for [the province] to [consider supply and demand data] if the City—if the planning authority directs you. If it doesn't support it—then [the province] cannot issue a licence. Then they shouldn't be able to issue a license, but sometimes something slips through. It's a problem (Bassier 2016).

Bassier and other interviewees suggested the issuing of operating licenses is constrained not by the Provincial Board's limits, but by taxi associations, whose support is needed for each new license applicant. "We mustn't fool ourselves; at the end the industry actually regulates themselves" (Bassier 2016). A former taxi owner and driver, Thabang Molefe also indicated self-regulation, not official enforcement of licensing, was what limited supply:

Molefe: You're not being allowed to come into the rank without the permit.  
 Interviewer: So the associations are enforcing that. Molefe: Yeah. Interviewer:  
 And theres enough enforcement by the police? Molefe: Mostly the associations.  
 Because, look, law enforcement we all know, it's not there sometimes... The  
 people who had the most effect on the operation is the association (Molefe 2015).

Taxi associations often respond to current demand conditions by dynamically regulating supply. At each taxi ranks, an association might employ a "rank marshal," who directs and passengers into queues at the taxi tanks. Rank marshals typically give preference to legal taxis, only admitting illegal vehicles into the rank to handle any excess passengers. Babalwa Nyoka, Head of Surveys for TCT, explained:

They are called rank marshals. I call them mafia because they are there to ensure that no illegal operator operates. Unless the line is so long; then they'll promote an illegal to take a load because people are complaining the queue is long. But if [legal] vehicles are there, they get preference. So if a [legal] vehicle is dropped off at Waterfront, it will not stand behind an illegal van (Nyoka 2015).

Bassier (2016) added that the extent and style of self-regulation varies considerably among different taxi associations. Whether taxi supply is controlled by provincial regulation or taxi associations' self-regulation probably varies by route and association.

It is widely recognized that government law enforcement of operating licenses is inconsistent and an unknown but not insubstantial portion of taxis operate without the required license (Nyoka 2015). The drivers of these taxis, colloquially called "pirates," might operate illegally simply because the cost of obtaining a license is too high. Aside from the operating

license fee itself (R300, or 21 USD, in 2016), an applicant incurs the expenses of registering and insuring the vehicle, no small barrier to new entrants. In Schalekamp's interviews, several respondents said they started out their minibus taxi career as pirates, and only obtained an operating license once they had started earning income and had established themselves in the industry. Molefe said of his own experience, "I started driving a taxi when I was 16 years old, without license, without PDP [professional driving permit], nothing. Just dodge the traffics [traffic police], run away, leave the vehicle with the passengers and run away with the key" (Molefe 2015). In addition to pirates, those in the taxi industry report that many vehicles, although licensed, earn extra money by encroaching on routes for which they do not hold a license.

It's hard to know the extent to which taxi operators pay taxes for which they are legally liable. To obtain or renew an operating license, an operator must present a tax clearance certificate from the SA Revenue Services (SARS), which requires them to submit their financial reports and income. Businesses of all types in South Africa must pay corporate income tax, which is assessed at a nonzero rate for businesses earning more than approximately R74,000 (about 5,200 USD) per year (sars.gov.za). Presumably all but the smallest taxi operators exceed this threshold. Employers are required to pay payroll taxes, which include withholding for employees' personal income tax. All income-earning individuals, no matter how small their income, are required to file a personal income tax return (sars.gov.za). (Passenger transport businesses are exempt from the value-added tax (VAT), which is significant because Stats SA considered registration for VAT an official indicator of a "formal" businesses. It's unclear whether Stats SA would consider VAT-exempt businesses that are also unregistered as informal or formal.)

According to Venter (2013), operators commonly do not pay taxes, or at least the substantially underpay. In interviews, taxi operators made no mention of taxes when discussing their income or finances. Many of Schalekamp's interview respondents said they kept little or no records of their businesses' finances, implying these operators may not file taxes. If they do file, they may under-report their earnings, although if they deposit income in a commercial bank it would draw attention from SARS (Schalekamp 2015b). Interview respondents' account of payment systems for drivers—such as the daily target system—leaves out any room for income or payroll taxes. Employees would have little motivation to independently report income for tax purposes.

**Government recognition** Government policy has come to acknowledge the taxi industry's legitimacy to varying degrees, beginning in the 1970s. As discussed in the previous section, a national government report in 1974 recognized taxis as "a necessary adjunct" to conventional bus services (Bassier 1989; van Ryneveld 1989) and the 1988 Transport Deregulation Act legalized 16-seater vehicles. Provincial agencies grant operating licenses and officials at all levels recognize taxi associations as legitimate organizations, national public funding has flowed to the taxi industry through the Taxi Recapitalization Program, and the City of Cape Town, like other municipalities in South Africa, provides taxi rank facilities.

However, taxi operators do not necessarily perceive government recognition as genuine. Khosa (1995) argued government policy with respect to the taxi industry has never escaped a climate of opposition and distrust. The series of deregulatory policies in the 1980s legalized minibus taxis and recognized SABTA as the industry's official representative. However, according to Khosa (1995), those within the industry did not believe deregulation was about improving transport or supporting legitimate businesses; they believed it was aimed at appeasing the black community or, worse, stoking destructive forces within it. Similarly, recap, intended to upgrade taxi vehicles, met a skeptical reception. In Schalekamp's interviews, operators said of recap: "Maybe [it] is a government scheme to root people out, to kill the industry." And: "The plan is to get rid of us." (p. 118). As another interviewee pointed out, what was supposed to improve operations actually resulted in business becoming "indebted to financial institutions" (p. 119).

Schalekamp (2015a) reported that many operators expressed desired for recognition by the government but did not see it as forthcoming. "There was a common perception that government officials were hostile to paratransit operators" (p. 116). Some interviewees described the government's approach as paternalistic: "Government treats us as small boys" (p. 120). They felt government officials did not listen to the taxi industry's concerns. "You know, the taxi industry is not being taken seriously... our problems just get bigger and bigger" (p. 116). In my own meetings with taxi operators, I perceived a desire on their part to be recognized as legitimate business owners who had worked hard and understood their market. One of Schalekamp's interviewees articulated this view: "the City must respect the local industry's knowledge; I'm unhappy about the amount of money that is going to consultants" (p. 216).

Taxi operators' perception that government officials intend to "get rid of us" finds some support in official documents, though in more diplomatic language. The national Public Transport Strategy of 2007 proclaimed the new transport networks would "radically transform public transport service delivery from an operator-oriented, low quality system for captive users - to a user-friendly, high quality system" (Department of Transport 2007, p. 5). It's not hard to see that the "operator-oriented, low quality system" referred to minibus taxis. The City of Cape Town's 2010 Business Plan for MyCiTi made it clear the taxi operators would be folded into the new system (City of Cape Town 2010). Thus government recognition of informal transport, while perhaps stronger than in many other countries, appears to be neither full-fledged nor permanent.

**Public investment** The taxi industry has received a small amount of public investment through the provision of taxi ranks and through the taxi recapitalization program, but the amount of funding made available to the taxi industry pales in comparison to public spending on more formal commuter bus and rail. Between 2006 and 2016, the national government spent an average of R430 million (29m USD) annually on taxi recap, mainly on one-off vehicle upgrading, a capital investment. In comparison, during the same period the national government allocated on average R8.7 billion (600m USD) per year for capital improvements

to commuter rail (both PRASA and Gautrain), and R3.5b (240m USD) per year for capital spending grants to BRT systems (Hunter van Ryneveld 2014). In addition, the City of Cape Town spends well under R100m (6.9m USD) annually on capital improvements to its public transport interchanges, used by both taxis and other public transport modes.

On operating costs, the government subsidizes rail and conventional buses but not minibus taxis. From 2006 to 2016, the national government's operating subsidies averaged R3.9b (270m USD) annually for conventional buses and R3.3 (230m USD) for commuter rail (Hunter van Ryneveld 2014). Minibus taxis did not receive any direct operating subsidies. The lack of public subsidies for taxi services has long been an issue for the taxi industry (Walters 2013). In fact, the promise of subsidies is one motivation for many in the taxi industry to now consider cooperating with formalization initiatives (Schalekamp 2015a).

### **Private sector provision and the profit motive**

That minibus taxis are private sector businesses driven by the profit motive is self-evident. People enter the taxi business to earn profit and drivers are motivated by fare revenue. Earnings vary considerably from operator to operator, but without public subsidies, unprofitable operators do not stay in business long.

In contrast to the City's multiple goals for MyCiTi, the minibus taxi operator's main goal is to maximize profit, and the primary relationship between informal transport providers and users is through market competition. It's no surprise that, in both my interviews and in Schalekamp's, taxi operators said their motivation was making money. More specifically, the majority of actors in the taxi business appear to be focused on short-term profit as opposed to long-term earnings.

For Molefe, short-term profit was a matter of personal necessity, especially when he started in the business.

I said [to my brother], 'Can you just give me a driver's job? I've got nothing.' And I had a child. My girlfriend at the time, who is my wife now, was expecting a child, so I decided, no no no, I must make a plan here. I had no money. I needed to get a permit, get a vehicle (Molefe 2015).

Later in his career, Molefe had expanded his business and achieved a level of financial security, and one might think he began to focus more on long-term sustainability. For example, he and others in the taxi business well understood passengers widely complained about the quality of service, driver behavior, and safety. He could have worked to improve customer service in order to attract more passengers to taxis, or at least forestall losing passengers to private cars, which was occurring as incomes rose and more people were able to afford cars. Instead, his taxi operations did not change, because his drivers, who made decisions about actual operations, were still concerned with maximizing daily profit. The interviews suggest this is a general pattern among taxi operators. When they become sufficiently successful to stop worrying about day-to-day income, operators tend to look to expand to adjacent



businesses, like maintenance services and supplies, or different industries altogether, like real estate, rather than focus on increasing passenger demand for taxis.

Some interviewees attributed the taxi industry's lack of long-term strategy to "culture" and unimaginative thinking. However, the cause is more likely incentive structures and a collective action problem. Because many taxi associations place limits on the number of vehicles a single owner can have, owners have no incentive to increase demand for taxis generally. Instead, they look to expand their businesses in other ways. The discussions in the operator education course suggested operators did want to improve their service, but each operator is too small to change the behavior of the whole.

The profit motive has consequences for operators' behavior, as van Ryneveld (2016) recognized: "The point is the more people you carry the more money you make and the taxi driver has an incentive to be really entrepreneurial about how they go about the business for the day." That means providing a fast and convenient service. This is not to say taxi operators only care about money—like anyone else, individuals in the business have personal motivations that go beyond money, such as achieving status and providing for family. "I wanted to be successful in life so I could assist, partly, some of my family members." The point is that these motivations are aligned, not in conflict, with the profit objective. This is a notable contrast with the wide-ranging and sometimes conflicting goals the City had for MyCiTi.

### Relationship to labor

Taxi businesses generally do not conform with employment regulations, particularly minimum wage laws. As discussed in Section 4.2, taxi recap did not succeed in imposing minimum wage or other employment regulations. Earnings bear no relation to official minimum wage; instead, drivers earn according to how many passengers they serve, on either a target or commission basis. In the more common target system, the driver must pay the owner a daily target amount, then is allowed to keep any extra revenue above the target. The target is negotiated between the owner and driver, and may vary by route, by owner, and even by driver. In the commission system, vehicle owners expect drivers to make a certain amount, based on an estimate of how many trips are expected to be made in a day, accounting for operating expenses (except fuel). The driver is then is paid a percentage (typically 30%) of that amount (Woolf and Joubert 2013; Khosa 1992). In response to allegations that taxi operators did not comply with minimum wage, the chairperson of Wynberg Taxi Forum, Amin Carlsen, told the media outlet *Ground Up*: "There is no basic salary. We are not subsidized by government like Golden Arrow buses, so we cannot pay taxi drivers in the manner prescribed by the Department of Labour" (Chiguvare 2016).

For those with low levels of education and qualifications, the taxi industry offers a low barrier of entry to work (Woolf and Joubert 2013). Few skills are needed to join the industry; one only needs to know the correct language and be familiar with taxi lingo, although it helps to already know someone in the business. Taxi employees might get their start as a *gaardjie*, or washing taxis, or filling in for absent drivers. Some might move up by working as a rank

marshal, who manages vehicles at taxi ranks. The goal is usually to be a driver, and then an owner, which promises profit if one can scrape together the initial investment (Molefe 2015; Woolf and Joubert 2013). Woolf and Joubert (2013, p. 5) cited one interviewee: “it is really easy to operate a taxi business. Just get a permit and a vehicle, arrange with your unemployed brother-in-law to drive the taxi, and you are in this income-earning business.” Even though more specialized skills are needed to perform vehicle maintenance, this work is usually performed by drivers themselves (Molefe 2015) or “backyard mechanics” (van Ryneveld 2016).

Despite not abiding labor regulations, my interviews suggested the relationship between taxi owners and drivers was not necessarily exploitative. For some routes, at least, analysis by the City suggests that, for a single vehicle, a driver typically earned more than an owner. According to Nyoka: “Because the owner sets a target. I went on one of the surveys myself, Sea Point. I think the driver got R3500. He paid the owner R1000, paid 700 for petrol, the rest goes to him. We told some of the owners this and they just couldn’t believe it, that [the drivers] were earning more than them” (Nyoka 2015). In other words, the driver netted R1800 (147 USD) for the day with no additional costs. The owner took in R1000 (82 USD) and would then have to cover maintenance, depreciation, and licensing and association fees. Since Sea Point is a very high demand route, these amounts may be on the high end of the range for Cape Town, but the important point is that a typical owner with two vehicles would almost certainly earn less than their drivers from the taxi operation. An owner with several vehicles or who is also a driver would of course earn more. Actual numbers vary widely among operators and routes; R600-R1000 is typical in Cape Town, depending on demand (Kerr 2016; Schalekamp 2015b).

Taxi drivers also have a relatively large degree of autonomy. Van Ryneveld suggested another way to think about the relationship is that the driver is the entrepreneur, which might make the owner an investor.

Van Ryneveld: The drivers are not so much employees as entrepreneurs who hire the vehicle for the day – and that’s actually how it works. Interviewer: The owner is an entrepreneur too, right? They are the ones making the investment. Van Ryneveld: I would say that they both entrepreneurs but they’re doing different things and the one has some capital, buys a taxi and he/she is in a sense going to be more of an entrepreneur in choosing their driver right; making sure the driver is a good driver.... The point is the more people you carry the more money you make and the taxi driver has an incentive to be really entrepreneurial about how they go about the business for the day (van Ryneveld 2016).

Regardless of labels, the important point is Cape Town’s taxi industry, by and large, is not characterized by formal employment relationships.

### Organizational structure and business practices

It's not easy to describe the 'typical' taxi operation, since, far from having a standard structure or business model, heterogeneity is the norm in the taxi industry. This diversity itself characterizes the industry: it is highly atomized, consisting of a heterogeneous but well-organized constellation of operators, drivers, and associations.

**Heterogeneity and atomization** Taxi operators run mostly small-scale businesses. While some individuals own fleets of taxis (Khosa 1992), most own only one or a few vehicles (Woolf and Joubert 2013). According to my interviews, the largest operator in Cape Town owned at most about 50 vehicles. The size limit is by design: taxi associations often enforce limits on the number of vehicles owned by any one individual so that he or she does not gain too much power in the association (Molefe 2015). As discussed, owners hire drivers—or, if you prefer, drivers rent vehicles from operators—and each driver has autonomy over his or her work and schedule, provided he or she does not violate rules and norms of the association. Operators organize themselves into associations, to whom they pay regular dues in exchange for the association protecting their collective interests. The responsibilities of taxi associations vary and might include preventing over-supply, setting fares, managing taxi ranks, and political representation.

Despite all operators using essentially the same type of vehicle—almost always a white 14- 16-seat minibus—they have very different earnings, depending on their business strategy, demand characteristics of the route, operational decisions of the driver, and the organization of the taxi association. In preparation for negotiating compensation with existing taxi operators affected by MyCiTi, the City attempted to estimate their business value using financial models. Profitability among operators varied widely: “when we then calculated compensation based on actual profits people generate, you will see an individual one extreme his value is two, four million [rand] and the lower end operates the same type of taxi but in a different environment and a different model of running their business, get as little as 400 000 [rand]” (Bassier 2016). (In this case, value refers to discounted future cash flow.)

Different taxi routes have different demand patterns, and the smart taxi operator will tailor his or her business to them, resulting in different strategies. For example, a driver with a license to operate a route between Mitchell's Plain and the city center can provide either short trips within Mitchell's Plain or line-haul trips from the community to the CBD. Each driver must decide which strategy is most lucrative at a given time—often, they provide 'feeder' services to the main rank in the morning, then make a couple line-haul trips to the CBD. But not all need choose the same strategy. Mitchell's Plain drivers' operations would look quite different from those on a route like Sea Point that has relatively high demand throughout the route and throughout the day. Additionally, an operator might decide to offer contract services in off-peak hours—e.g., many retail stores that close late will contract with taxis to provide their employees safe transport home. As an example, Nyoka (2015) calculated 10% of taxis in the city center offered contract services. I learned from the operator education course that others serve intracity routes during the week and

long-distance services for travelers on the weekend. Furthermore, some operators and drivers work in the taxi business only part time, doing only a few trips a day (Nyoka 2015).

The same taxi operator (or driver) might use different strategies over the course of their career as their circumstances change. Thabang Molefe's story illustrates how this evolution might occur. When Molefe began in the taxi business, he was young and desperate for money. Until he could afford to purchase a permit, he drove illegally, and his primary concern, besides collecting fares, was dodging punishment from law enforcement and the associations. After he obtained a permit, he also purchased the cheapest vehicle he could, as fast as he could, even though it was old and would be expensive to maintain. From then on, his primary strategy was to grow and acquire as many vehicles as possible. He did so by working very long hours and saving his money. But after he gained experience, and after his association told him he couldn't grow any larger, he realized he "could make almost the same amount of money with fewer vehicles" as long as they were very reliable. So he shifted his strategy to purchasing new vehicles and keeping them well maintained, and using them to provide long-distance service where reliability is more critical.

Cape Town's 158 associations have very different organizational structures and decision-making cultures from one another (Botha 2015). Nyoka (2015) explained in relation to having to negotiate differently with each one:

Nyoka: You have your Khayelitsha, which is very tribal. Your black people believe in one person must take charge. Then you have Mitchell's Plain, your coloured people, who are more gang types...For the tribal side you can talk to one person—you can trust [someone] that he will relay the message and speak with authority that I have decided that the city can come and negotiate with you, and no one's gonna question that.... With the gangs, they have to go consult someone else before a decision can be made.

Interviewer: Less organized in some way.

Nyoka: Well, it's organized but there's more decision-makers. You have to keep more people happy, because if he's not happy the process won't go ahead.... Also in the way they organize themselves, in Khayelitsha there's many route associations but they have one big mother body, which is CODETA. In Mitchell's Plain you don't find the same thing. Everyone is their own boss.

In other words, the "tribal" associations tend to be very hierarchical, with the top leadership enabled to make unilateral decisions, while the "gang" associations tend to require more consensus among their members before making decisions (Botha 2015).

**Business practices: Cash and informal accounting** While taxi business operate differently from one another in many respects, transactions are always cash-based, with the exception of one or two very recent electronic fare payment pilot programs. Most taxi operators manage their business without formal bookkeeping and accounting (Molefe 2015; Woolf

and Joubert 2013). Bassier (2016) claimed that while most operators focused intently on revenue, they did not explicitly account for expenses.

Profit. Now that's a term the industry doesn't understand because all they know is turnover. They're unable to calculate profit. Very few of them. Why? Because they don't keep track of their costs.... It's those who run fleets maybe they will know and they employ a lot of drivers. I mean like the one guy would say typically in a public forum 'you know how my business works?' and this is a fleet guy, he says 'the driver comes in. He says, boss there's the money. The moment I get the money the wife walks past and says, 'the school kids need this' and they give some of the money. Then someone else asks and he gives the money. And then the driver says 'oh yes, the brakes require replacement.' 'Ok here's another R400.' So before he knows it he sits with no money.

Taxi operators, by and large, do not employ typical corporate accounting techniques. For example, Nyoka (2015) recounted difficulties in communicating these concepts when negotiating MyCiTi compensation packages with operators: "The really hard part was trying to explain the discount rate. There I had nightmares. We went around in circles; I had to explain why I couldn't give them a zero discount rate."

Reliance on cash and informal bookkeeping makes it more difficult to understand how to grown one's own business. Molefe (2015) believed he was able to grow fast because he diligently saved the money he earned, whereas other operators would immediately spend too much of their income.

Molefe: Yeah, they [the others] didn't save their money. Look, it's hard cash every day.

Interviewer: It's hard to save, but you took it to the bank all the time.

Molefe: Basically on a Friday, I make sure in the morning, the first thing that I do, the bank, then proceed working, then stop.

Still, heterogeneity is the rule and business practices and organization structure vary among associations. Interviewees highlighted the example of the Peninsula Taxi Association (PTA), perhaps the city's most formalized association, which went as far as to register a legal private company and pool members' resources in order to buy supplies like tires in bulk (Bassier 2016).

**Low access to finance** Taxi owners in South Africa have access to loans from major financial institutions, but interest rates are high. According to Schalekamp's interviews, the "Big Four commercial banks [in South Africa] provide finance typically at 15-18% interest" to those who have good credit. [p. 248]. However, Schalekamp noted some operators said they could not get a loan because of "credit blacklisting" (Schalekamp 2015a, p. 247). Bassier (2016) told me few operators have credit scores to qualify for those loans, in which case

they can turn to the government-backed SA Taxi Finance, which lends at a 24-27% annual interest rate. Many of Schalekamp's interviewees said the high interest rates and other lending practices contributed to a perception that banks were exploiting the taxi industry. In addition, interviewees said there were limited options for purchasing vehicle insurance. Apparently there is only one company that covers minibus taxis, and accordingly charges high rates.

With such high interest rates, many operators forgo finance and instead use their own savings or borrow from friends and family. This is how many operators got their start in the era before major banks offered loans as well. In Schalekamp's interviews, many operators recounted how they worked as "gaardjies" or taxi mechanics, or drivers for other owners, in order to save money to purchase their own vehicle. Molefe recalled how when he wanted to buy his first vehicle, he turned to his family. The seller wanted R60,000 for a minibus. "I didn't have sixty thousand. I only had forty-five [thousand]. So I went to my parents, asked them for the difference and they just plain out refused. They said, 'Taxi industry, we're not investing in it anymore because it's dangerous.'" He negotiated with the seller but still came up short R3000. "I was thinking, OK there must be a way to get the extra three grand. I come from the township. . . you can go strip somebody's tires or something, somehow. But my brother was not in favor of such things. He said to me, 'I'll borrow you the money. Don't tell anyone, don't tell my wife'" (Molefe 2015).

Limited access to capital has likely contributed to systematic underinvestment in vehicles and vehicle maintenance. Since passengers waiting for a taxi chose whichever vehicle arrives first, regardless of quality, owners have little incentive to use new or well maintained vehicles. Most operators have little means to invest in vehicle upkeep even if they wanted to perform regular maintenance (Venter 2013). Taxi recap, the government's only capital investment in taxis, did upgrade vehicles, but without sustained subsidies the effects were short-lived (Venter 2013).

**Self-organization and self-regulation** Given that government regulations are inconsistently enforced, the taxi industry relies on a high degree of self-regulation, which is mainly enforced through taxi associations. The most important function of the taxi association is preventing over-competition by managing the number of operators on a given route. Generally, to provide service on a particular route and to use a particular rank, an operator must join and pay dues to the corresponding association. In return, the association controls supply to ensure operators are able to earn a profit. This often means policing "pirates" and others who ignore the self-regulation and codes of conduct. Some taxi associations employed security squads to militate against pirates in their areas. As already mentioned, taxi associations also normally employ a rank marshal who manages the arrival and departure of taxis in the taxi rank in order to ensure drivers get equal business (Khosa 1992). Associations also advocate politically on the behalf of the industry. At the national level, the national taxi organization SANTACO engages with the government on issues such as subsidies for taxi operations (Walters 2013).

While self-regulation appears to prevent the worst of over-competition, the system is far from seamless. Some associations are more effective than others. As Bassier (2016) put it:

You take an association like PTA here in Town, who's now very successful: they run TPI, the bus company. They have good discipline and they know by keeping the numbers down their members make more money.... Another association, without mentioning names again; they make more money from membership fees, so the more members they sign up the more money, because that money goes into some people's pockets. So for them, allowing self-regulation isn't a good thing. They will just sign up more members and they will oversupply.

When usual self-regulation mechanisms fail, violent conflicts sometimes erupt as rivals compete for passengers. During the taxi wars, competition between associations and realignment within the industry resulted in widespread violence. Today, periods of stability are occasionally interrupted by infighting over routes and management of ranks (Walters 2013).

### 4.3 MyCiTi: Cape Town's BRT as transport reform

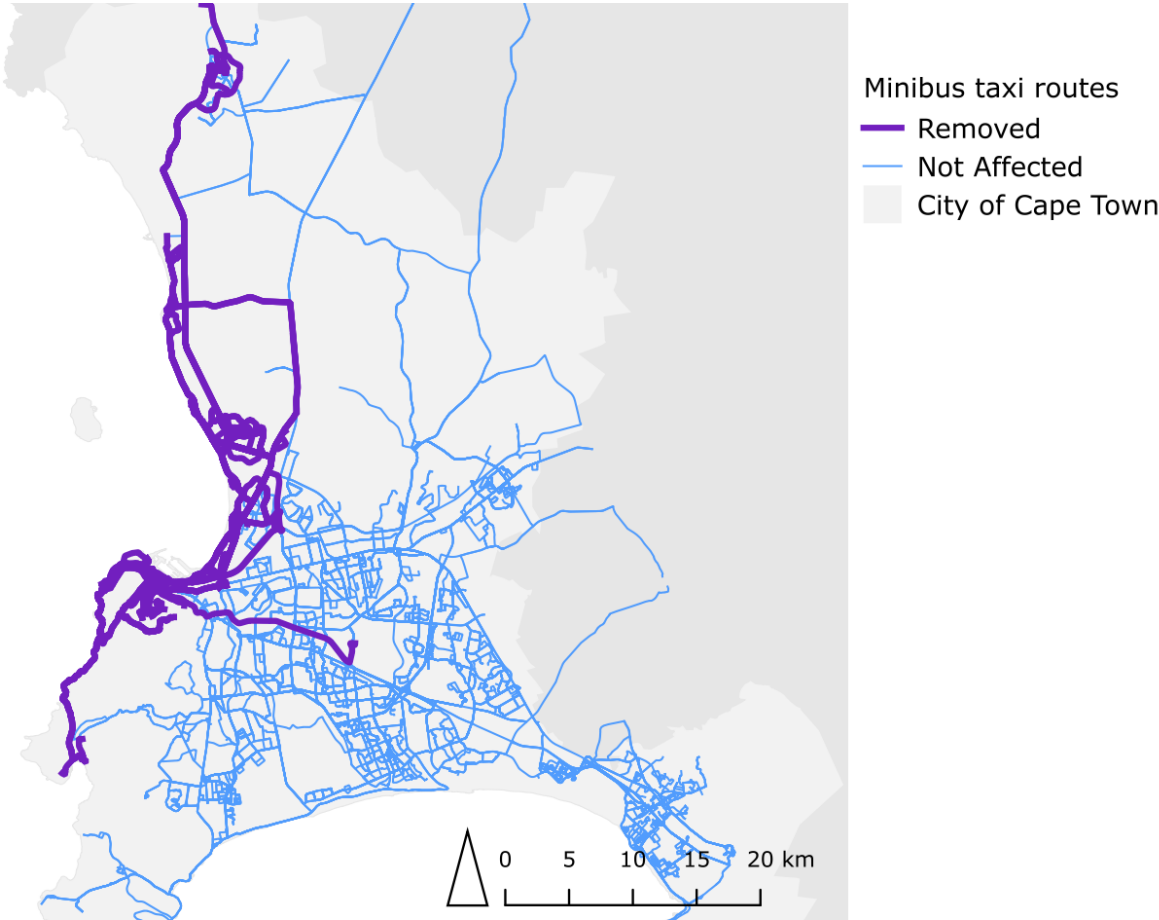
Cape Town's BRT was initially envisioned as both a replacement for the taxis and as a way to improve public transport generally. The idea grew out of a confluence local, national, and international movements going back to the 1990s, and gave leaders a way to simultaneously address multiple goals, including reducing car use, congestion, accidents, and crime (Wood 2015b). The BRT, named MyCiTi, was opened in 2010, just as the city hosted the FIFA World Cup. In addition to the new system, the transport reforms included two other key components. First, the reforms granted the municipal government more control over regional public transport and building professional capacity to manage that system. Second, they restructured the existing public transport industry by including incumbent operators as stakeholders in the new BRT system, while phasing out minibus taxis and Golden Arrow buses from the streets.

MyCiTi's Phase 1 design followed international standards for "gold standard" BRT (ITDP 2013). The trunk corridor featured exclusive bus lanes, high-floor articulated buses, enclosed stations with pre-payment and pre-boarding queuing, and cashless fare cards (City of Cape Town 2010).

In the corridors where the project's Phase 1 operates, the MyCiTi reforms have dramatically altered Cape Town's public transport. In this section of the city, which includes the city center and the corridor between the city center and Table View/Blaauwberg (also known as the West Coast; see Figure 4.4), BRT has replaced the majority of taxi and Golden Arrow services. The map in Figure 4.3 shows the taxi routes that were planned to be discontinued or altered to make way for BRT. MyCiTi, in contrast to relatively informal taxis, featured scheduled, subsidized, publicly managed but privately operated services on a trunk-and-

feeder network with large buses, fixed stations, electronic fare cards, and capital-intensive infrastructure.

Figure 4.3: Minibus taxi routes to be removed with MyCiTi reforms



At the time I began this research, in 2015, Phase 1 had been completed and was fully operational, while the city had recently launched a pilot stage of Phase 2 that consisted of scheduled express routes from the CBD to Mitchell’s Plain and Khayelitsha in the city’s Metro Southeast. However, in the Phase 2 section of the city, minibus taxis continued to operate as before; the new express service was added on top of existing taxi, train and conventional bus service.

By the time concrete plans for MyCiTi were underway, the idea of BRT had been “in the air” in Cape Town for at least a decade. Astrid Wood, who conducted over one hundred interviews with those involved in BRT in South Africa, reported that in the 1990s South African leaders were fascinated with, and visited, Curitiba, as much for its land use policies as its transport (Wood 2014a). In 2003 provincial leaders proposed a BRT project for



the Klipfontein Corridor in Cape Town based on the successes of the Bogotá and Curitiba systems, although it was never implemented (Wood 2015b). Wood (2015b) attributed the beginning of BRT in its current form in South Africa to a workshop led by the well-known international transport expert Lloyd Wright in July 2006. The National Department of Transport had invited Wright to lead the workshop, in which transport professionals from around the country learned about the technical aspects of BRT. Two local leaders, then-Mayor Helen Zille and former City Chief Financial Officer Philip van Ryneveld, also met with Wright and came away as strong advocates for BRT.

National officials quickly turned on to BRT. The Department of Transport's 2007 Public Transport Strategy said that BRT, or what the document called "Integrated Rapid Public Transport Networks" (IRPTNs), was the "only viable option that can ensure sustainable, equitable, uncongested mobility in livable cities and districts" (Department of Transport 2007, p. 4). The Strategy specifically envisioned trunk-and-feeder networks, with physical and fare integration, all planned and managed by a metropolitan authority. Not coincidentally, by 2007 government leaders were looking ahead to South Africa hosting the 2010 FIFA World Cup, which provided motivation to move decisively on building the new transport networks (Department of Transport 2007).

Importantly, the national government provided municipalities with the funding, legal backing, and technical road map needed to implement BRT. The government allocated funding to municipalities to cover the capital costs for BRT construction and municipal government capacity-building, through the Public Transport Systems Infrastructure Grant (PTISG) (Walters 2013). The PTISG had already been in use since 2005; in subsequent years the treasury dramatically ramped up funding allocations, from R319m (26m USD) in 2008/09 to R1.6b (200m USD) in 2011/12 (City of Cape Town 2012). The national government also provided funding for operating costs through the Public Transport Operating Grant (PTOG), which was already in use for subsidizing conventional bus service. The Public Transport Action Plan, Phase 1 for 2007-2010, laid out a plan for implementing the IRPTNs.

Meanwhile, the 2009 National Land Transport Act (NLTA) devolved key responsibilities for transport planning to the municipal level. In particular, municipalities would be responsible for negotiating and managing transport operator contracts, in addition to preparing integrated land use and transport plans (Republic of South Africa 2009). This act continued a years-long trajectory of devolving authority over transportation to municipalities, as discussed in Section 3.4.

Empowered by these national policies, and motivated to open the new service in time for the World Cup, the City of Cape Town began BRT planning in 2007, building on earlier plans for an integrated transit network. Three years later, MyCiTi began operating a special service to carry visitors to the new World Cup stadium. Regular service on the Phase 1 routes began in 2011. Additional feeder routes were later added, and by 2015 Phase 1 was complete with 28 routes, 35 full stations, and more than 300 bus stops. By then the City was planning Phase 2, the final version of which the City Council approved in 2017.

Prior to 2007, the City of Cape Town had limited responsibilities in transportation—until then it mainly was responsible for local streets, infrastructure such as taxi ranks and parking.

Table 4.2: Timeline of Cape Town BRT planning and implementation

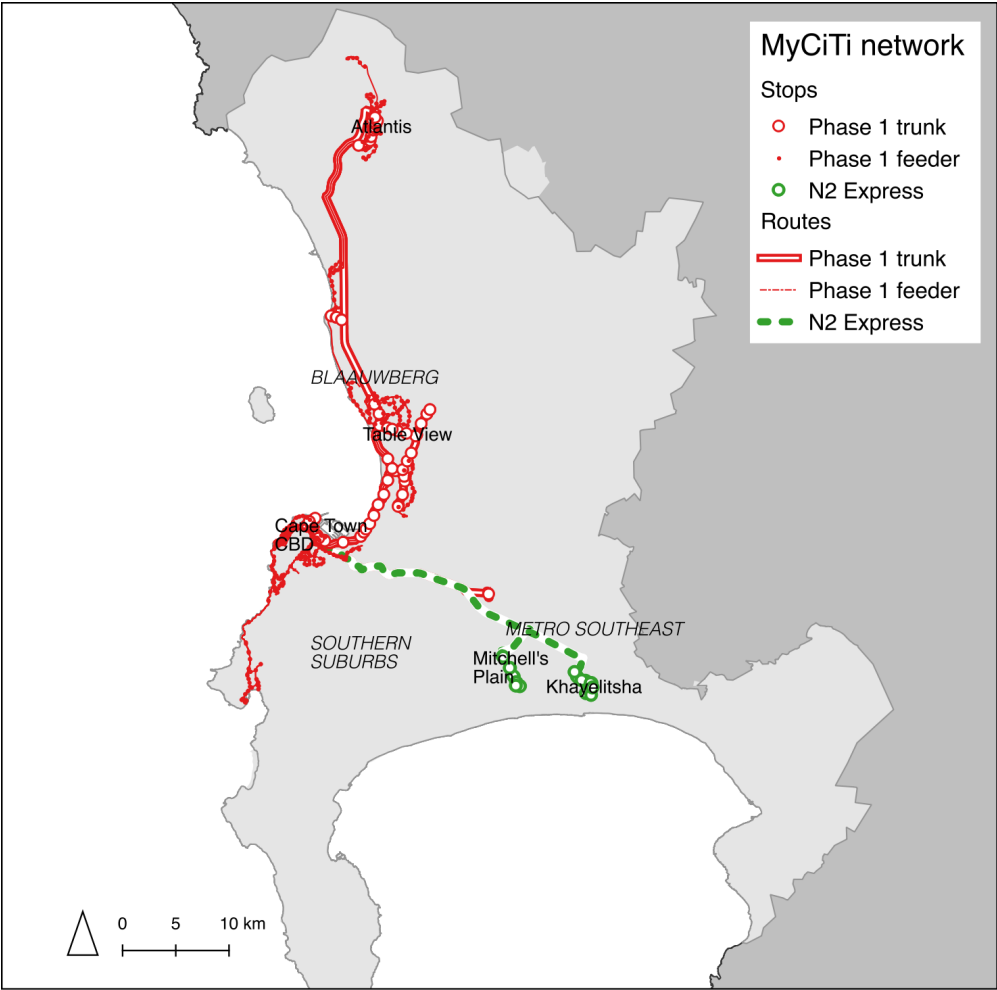
1990s	Cape Town officials visit Curitiba, discuss of integrated land use and transport planning
2003	Proposal for BRT in Cape Town's Klipfontein corridor
2005	National Public Transport Infrastructure and Systems Grant (PTISG) established
July 2006	Lloyd Wright leads a BRT workshop in Johannesburg
2006	Cape Town Integrated Transport Plan 2006-2011 names "Integrated Rapid Transit" as the top implementation strategy
2007	National Public Transport Strategy and Public Transport Action Plan, Phase 1
2007	Public Transport Implementation Framework, scoping study on BRT for Cape Town
2009	National Land Transport Act devolves transport responsibilities to municipality
May 2010	Special MyCiTi operations begin for FIFA World Cup
July 2010	Business Plan for MyCiTi Phase 1A
May 2011	Regular MyCiTi service begins
2013	City of Cape Town establishes transportation department, Transport for Cape Town
late 2013	Major Phase 1 expansion with additional routes added
July 2014	N2 Express service launched with two main routes
August 2015	Phase 1 complete with 44 routes, 42 stations, and 350 bus stops
mid-2016	Two additional N2 Express routes added
2017	City of Cape Town council approves MyCiTi Phase 2

However, after the NLTA devolved more authority to municipalities, the City began building out its transportation planning and management capacity. In 2013, it established a dedicated transportation department, called Transport for Cape Town (TCT), responsible for MyCiTi planning, operations, and contract management. Authority to manage conventional bus (Golden Arrow) contracts were also to be moved from the province to the City. However, the City still lacked authority over other modes of public transport: the train fell under the national government entity Metrorail, and minibus taxi licenses were still the responsibility of the province.

The most obvious of MyCiTi reforms was the change in physical design and operating characteristics. Like the majority of BRT networks, MyCiTi uses a trunk-and-feeder configuration, with the Phase 1 "trunk" serving the Blaauwberg corridor from the city center to Table View and Dunoon and Atlantis, and the route from the city center to the airport. These trunk corridors use segregated BRT lanes and high-capacity buses, which load and unload only at stations designed with pre-boarding. The feeder services operate mainly on

regular streets without designated lanes and are served by smaller buses. The feeder routes are designed to collect passengers, who then would transfer to the trunk routes. Unlike taxi service, all MyCiTi services run on fixed routes with fixed schedules, and drivers are permitted to stop only at designated stops. The MyCiTi network covers the same areas as the original taxi network, and many of the feeder routes were designed to follow former local taxi routes. The MyCiTi network differs from the minibus taxi network, however, in that there fewer direct routes.

Figure 4.4: The MyCiTi BRT system in 2015



Plans for Phase 2 of MyCiTi, approved by the city council in 2017, showed trunk routes connecting the city center with the Metro Southeast and Southern suburbs. When I conducted this research in 2016, the city was conducting a pilot service in the Phase 2 area: the “N2 Express,” which runs along the N2 highway between the city center and terminals in Mitchell’s Plain and Khayelitsha. The N2 Express might be considered “BRT light” in that

it exhibits some characteristics of full-scale BRT, but also some of conventional buses. It offers scheduled express service along a route between each of the two communities and the city center with no intermediate stops. The large, low-floor articulated buses allow pre-boarding at the terminal Civic Centre and Mitchell's Plain stations, but the buses also make a few stops within the Mitchell's Plain and Khayelitsha communities with no pre-boarding or special infrastructure. For most of its route, the N2 Express does not have a dedicated BRT lane, but it does use an exclusive public-transport lane along the N2 highway that it shares with minibus taxis and conventional buses. The fare system, management, operation system, and branding are all the same as the MyCiTi Phase 1.

## MyCiTi motivations and goals

Official MyCiTi planning documents listed multiple motivations and goals: reducing travel time, creating a "high-quality" transport service, integrating all public transport into one system, improving affordability, reducing car use, and transforming the minibus taxi industry (City of Cape Town 2010; City of Cape Town 2009). One expects BRT to serve multiple goals; even so, the motivations and goals interviewees cited were surprisingly numerous and wide-ranging. Besides creating a high-quality and customer-oriented transport service, stakeholders expressed several other motivations, enumerated in the following paragraphs.

**1. Attract car users to MyCiTi and reduce congestion.** The DoT intended BRT networks to reduce travel time in order to make public transport "car-competitive. This means a door-to-door total journey time of under 60 minutes in metropolitan cities" (Department of Transport 2007, p. 6). A number of interviewees stated a primary goal for MyCiTi was attracting car users, and thus reducing congestion. Maddie Mazaza, who was working as a planner for the City at the time, recalled that, early in the planning process, the City adopted a slogan reflecting the idea that public transport should receive priority over private cars. Alastair Rendall, principal at the design firm ARG, was part of the small design team for Phase 1. He recalled:

I think that's why in my view the quality of our stations is rather at a high end. You have the finishes, the look and feel of it, the lighting, and the lighting was another aspect—it had to be light and bright and attractive because we wanted to get people out their Mercedes Benzes and into the buses. That's why the buses are at the specification level that they are (Rendall 2016).

**2. Lower transport costs** At the time of my interviews, the most vocal political champion for MyCiTi reforms was the Mayoral Committee Member for Transport, Councillor Brett Herron. He said the high cost of transport for poor residents had motivated him to support MyCiTi.

Part of that vision is to reduce the cost of travel. We did a transport development index last year, a rather crude one but we are refining it this year. The results are quite horrifying, although not surprising—in terms of direct cost of transport to the poorest of our residents; the low-income groups, and so that has to be a priority (Herron 2016).

**3. Reform (or replace) the taxi industry** The Department of Transport's Public Transport Strategy, envisioned the transport networks would "radically transform" public transport from an "operator-oriented, low quality system for captive users" to "high quality system" managed by the government (Department of Transport 2007, p. 5). The City of Cape Town's early documents were more vague about the fate of minibus taxis. Its Integrated Transport Plan (ITP) for 2006-2011, one of the early plans that developed concepts for BRT, envisioned "a world-class sustainable transport system that moves all its people and goods effectively, efficiently, safely and affordably" (City of Cape Town 2009, p. 12). It did not explain how minibus taxis would fit into the "integrated transport system." But Schalekamp and Behrens (2010) claimed the City also saw BRT as a mechanism to formalize the existing transport sector, replacing the fragmented and loosely regulated paratransit services with a unified and more easily coordinated operational structure, thus bringing the sector under greater state control.

Although it was not always stated as such in official documents, interviewees acknowledged that many were motivated by a desire to bring the minibus industry under greater control, whether replacing or reforming it.

I think there was concern about just the somewhat chaotic nature of the taxi industry and it's been the bane of many people's lives including a lot of motorists. They cause a lot of accidents and safety standards, the ability to control them, the fact that unfortunately they are linked to the drug and gang industries and so forth. There was an idea that we could solve a number of problems in one go (Rendall 2016).

Bassier recounted how, as an engineer, he had been studying the minibus taxis for decades. "So it was quite exciting when the BRT or the MyCiTi project came.... It was an interesting opportunity at formalizing the minibus taxi industry" (Bassier 2016). For Bassier, working on MyCiTi reforms was an opportunity to further a personal career goal.

**4. Improve customer service and user experience** Interviewees understood how users had poor opinions of service provided by existing public transport – not just taxis but also Metrorail and Golden Arrow. Several said they viewed MyCiTi as a way to improve standards and status of public transport. In Bassier's words: "It's about bringing dignity to public transport and for me it's important those who use public transport do so in an environment that's dignified and that it's a pleasant experience" (Bassier 2016).

**5. Add capacity to oversubscribed public transport routes** The need to add capacity to meet travel demand was a motivation for the N2 Express, although not Phase 1. According to TCT planner Peter Grey, the N2 Express was initially seen as kind of a “top-up to the rail service” (Grey 2015). The 2012 MyCiTi Business Plan described the motivation this way:

The N2 Express service is a short-term intervention to relieve pressure on existing services, such as rail, between the metro south-east and the central city. It will also allow certain innovations and lessons learned from Phase 1A to be tested in the south-east prior to their adoption as part of Phase 2 (City of Cape Town 2012, p. vii).

Interestingly, this was the only statement I found expressing a motivation that has to do directly with responding to unmet travel demand.

**6. Prepare for the 2010 FIFA World Cup** Political leaders both at the local and national levels were highly motivated by the need to have respectable transit running for the World Cup events. Most interviewees acknowledged the World Cup was the catalyst for MyCiTi coming to fruition at the time it did. Mazaza (2016) recalled how years of inchoate BRT plans finally came together when the national government directed cities to build BRT in time for the World Cup. “So until 2007, we cleaned up and firmed up on the plans because we were given okay, you have the opportunity to implement a system that meets the requirements of FIFA.”

The target at that time [of planning the first trunk line] was to provide one of the primary trunk routes from the CBD to the stadium and back again, plus the airport for the FIFA World Cup. . . . I keep on saying that were it not for FIFA 2010 we would probably still be debating whether to go for this thing or not (Rendall 2016).

**7. Universal access** The physically disabled received consistent attention. The 2006-2011 ITP set a goal of providing a “public transport system that is accessible to special categories of passengers including persons with disabilities, the aged, pregnant women and those who are limited in their movements by children” (City of Cape Town 2009, p. 15). Explicit goals for serving those with physical limitations also appear in the MyCiTi business plan (City of Cape Town 2010).

Designing for physically disabled users, previously ill-served by other public transport modes, was “an absolute must,” according to Rendall (2016). “National transport and also the City of Cape Town— just in terms of their constitutional principles— that it should not be discriminated between any potential users of the system, so they must make it accessible to all.” Holderness said universal access requirements heavily influenced the design team. “I think people on the team were very pro universal access and we had a consultant specifically on that which was excellent, it really helped drive the agenda” (Holderness 2016).

**8. Devolution and consolidation of authority at the municipal level** Some were working toward a long-term vision for City's role in transport planning and provision. Herron (2016) saw consolidation of authority as necessary for achieving "integrated transportation":

What I would really like to see is for the City government to be managing all public transport. When I say that buzzword 'integrated' I'm talking about the City taking control of the scheduled bus service that's not MyCiTi, Golden Arrow, and ultimately the Metrorail service, so that we can create one network with one ticket and one timetable for our residents and users.

Through his work as the former Chief Financial Officer for the City of Cape Town, van Ryneveld had concluded local control over transportation was necessary in order to coordinate land use and build stronger cities.

I developed this argument that we needed to devolve [responsibility over] the built environment, so we needed to consolidate these functions at city level. So that was really my interest and I started pushing for the idea of a transport authority and so on – an authority being consolidated (van Ryneveld 2016).

For van Ryneveld, the transport authority was part of a larger personal goal: "If I was to say what has my career been about, it has actually been about that building of city governments."

**9. Social/racial integration** Some interviewees were motivated by furthering social and racial integration. Mazaza said it was a primary concern in the very early stages of BRT planning, when the city was still considering the Klipfontein corridor, even though its prominence declined later on. "One key objective was to make sure that we start connecting people who were separated by Apartheid using transport infrastructure to separate communities. It's sitting silent [now] but it was very big when we started" (Mazaza 2016).

**10. Spur urban redevelopment** The MyCiTi Phase 1 route passes by land with development potential and Holderness (2016) suggested one of the motivations for placing numerous stations in the industrial areas in Paarden Eiland was to catalyze "urban regeneration."

For Bassier, urban development was a sign of MyCiTi's success:

I think what MyCiTi has brought not withstanding – warts and all – it has given confidence back to road-based public transport. That's for sure. I read the newspaper the other day; you can see the confidence developers are now developing, where they advertise developments close to a MyCiTi route (Bassier 2016).

**11. Job creation** While never it was never claimed as a primary goal of MyCiTi, the City tried to create jobs during MyCiTi construction by hiring locally. According to Otter (2016), in public meetings local leaders said jobs were a priority, and the so the City sometimes hired a “small subcontractor with local workers [to] build local bus stops” rather than simply choosing the lowest bidder.

In addition to these multiple motivations and goals, official planning documents stated several specific objectives for MyCiTi, some of which addressed accessibility to the network and travel time. The Department of Transport's (DoT) 2007 Public Transport Strategy, aimed to have IRPTNs in at least twelve cities by 2014, and set goals of bringing at least 85% of a city's population within one kilometer of a IRPTN trunk or feeder corridor and shifting 20% of car work trips to public transport by 2020 (Department of Transport 2007). The City of Cape Town's five-year Integrated Development Plan (IDP) of 2006 set specific targets for travel time reductions: it aimed to reduced average commute times during peak period, by public transport, from a baseline of 45 minutes in 2007 to 40 minutes in 2008 and 35 minutes in 2012 (City of Cape Town 2007).

What's important about these goals for MyCiTi is there number and scope. MyCiTi was expected to provide a way to get from point A to point B, and to do it better and for a wider range of people than previously served by public transport. But it was also supposed to fulfill larger social, economic, and political goals. This vast array of aims stands in contrast with taxis' relatively straightforward goal of generating revenue.

## Serving multiple types of users

Not only was MyCiTi intended to serve many goals, it was also intended to serve many types of users. Official documents imagined BRT would not just improve service for the public transport-dependent, but also attract car users. The City of Cape Town's Integrated Transport Plan (ITP) for 2006-2011 set a goal of creating a “good quality transport system that provides for basic mobility for the economically disadvantaged but also provides a competitive alternative to the private vehicle with reference to convenience, comfort, network coverage and geographical accessibility” (City of Cape Town 2009, p. 15).

Planners of public transport systems typically face trade-offs between serving ‘choice’ riders, who could otherwise use private cars, and ‘captive’ riders, who depend on public transport to get around. For example, attracting choice riders requires focusing on fast, comfortable service on high-volume routes that can compete with private car commutes. In contrast, for captive users affordability and coverage are often more important, since they must use public transport for all travel.

Officially, the City did not distinguish between different types of users, but instead tried to provide a one-size-fits-all service for all types of users. The national Public Transport Strategy envisioned that BRT would expand beyond just serving “captive users” to serving “both public transport users and for current car users” (Department of Transport 2007, p. 5). In my interviews there was no consensus about which user needs would receive priority when trade-offs arose. For example, Mazaza (2016) said early in MyCiTi planning captive



users were the priority: “We were trying to be more biased to the captive because the quality [of public transport] is not good. Safety is a problem. If we start addressing the bigger percentage of the captive group we can go a long way.” However, Holderness suggested choice users were more important to Phase 1 planning: “The idea was definitely inspirational that our passengers—that’s who our client was, was our car drivers, so it was designed from that perspective” (Holderness 2016). Some decisions in Phase 1 catered to choice users. For example, the City spent more on high-end station design in order to attract car drivers (Rendall 2016), instead of spending the money on greater network coverage that would have benefited captive users. However, the N2 Express was launched mainly to help captive users.

### Choice of the Phase 1 service area

The choice of the Blaauwberg corridor for the first BRT trunk route highlights how multiple objectives competing with simply serving travel demand. The 1990s-era Klipfontein BRT study had outlined nine possible corridors. Of these, for MyCiTi Phase 1, the City chose to focus on the Blaauwberg corridor. When I asked interviewees why choose Blaauwberg first, I heard many different explanations, including the following.

- The area had relatively few taxi associations, so negotiations with the industry would be easier and encounter less resistance.
- The route could be aligned to utilize an abandoned rail line through the Paarden Eiland industrial area, making land acquisition easier in one of the densest sections of the corridor.
- The Blaauwberg corridor contains communities of a range of incomes and of all races, offering an opportunity to appeal to middle-class car drivers while also serving poor communities and not appearing to favor any particular community.
- Metrorail did not serve the area so MyCiTi would not have to compete with other fixed mass transit.
- The route aligned well with connecting the new stadium and the airport, allowing it to serve visitors for the World Cup.
- The route offered an opportunity to connect the far-flung Atlantis township, which was previously transport-disadvantaged.
- The corridor was identified as a “growth area” where future development was likely.

Of these reasons, only the last three are directly related to serving transport demand, and even that demand was temporary, low-volume, or a future hypothetical. In fact, the Blaauwberg corridor is much lower density than other proposed routes. Much of the Phase 1 trunk route passes through undeveloped land, which is partly why planners expected it

to receive future growth. Evidence suggests the City chose the Phase 1 corridor because it was politically expedient: resistance from the taxi industry and homeowners was expected to be low, and the route could be constructed quickly and relatively cheaply. Indeed, Beukes (2015) considered the Phase 1 “kind of like a little incubator for us to test these ideas out” before extending them to the rest of the city.

Phase 1 may have been considered a demonstration project; however, the choice may not have had the desired result, since the lower-demand corridor predictably generated lower ridership and poorer cost efficiency than would have a high-demand route. Mazaza, who had been involved since the Klipfontein study, justified the choice of the Blaauwberg corridor (also known as the West Coast). However, she added, “the only disadvantage was BRT always performs better when there are numbers, and unfortunately on this West Coast corridor, numbers are not as robust as was planned in Metro South East, Khayelitsha, [and] across the city” (Mazaza 2016).

## Demand management versus demand response

Notably, the long list of motivations and goals expands far beyond the transportation-specific goals of responding to travel demand. In fact, the City’s strategy in some ways is to not cater to demand, but to manage demand. Instead, in the longer term, rather than shape the MyCiTi system to serve demand, the city hopes to shape demand to fit the MyCiTi system by changing land use. In interviews, MyCiTi planners discussed how inefficiencies in BRT arose from Cape Town’s spread-out and segregated land use because it concentrated demand at peak times, in one direction, and in certain stations, leaving excess capacity elsewhere and at other times. Planners’ solution was, in the short term, to modify operations by using express buses, while in the long term modifying land use. Eddie Beukes, a transport demand modeler for TCT, explained.

We can’t ignore the long term [land use] problem. We have to address the underlying structural problems by trying to create bidirectional flow. In terms of land use, we have a new scenario that I’m working on right now. We developed it using genetic algorithms, trying to optimize land use to bring down costs” (Beukes 2015).

In response to the peak-demand problem, planners used higher peak-period fares to encourage people to travel at other times. That meant the fare structure would have to serve two purposes, as van Ryneveld explained: “a) it’s got to be affordable to get people across but b) we want to use the fare to incentivize spreading of the peak” (van Ryneveld 2016). Affordability alone could not be the objective – fares had to serve both affordability and demand-management.

## Changes in institutional and organization structures

### Minibus taxi industry formalization as part of MyCiTi reforms

Formalization was a critical objective in the MyCiTi implementation. It was widely acknowledged that existing minibus taxis must be removed; if allowed to compete with the new BRT, they would undermine any congestion benefits and would leave BRT with too small a market share to be financially viable. Rather than simply prohibit the existing taxi operators and replace them with BRT, a strategy that would have generated intense opposition and likely violence, city officials opted for a cooperative approach in which they worked with the operators to incorporate them into the new system. The City's MyCiTi 2010 business plan called for gradually phasing out existing taxi services by incorporating operators as contractors and shareholders in the BRT's new operating companies, or by paying them to leave the sector (City of Cape Town 2010). Post-reform, operating a minibus would become illegal on routes served by BRT.

The taxi industry engagement process and agreement terms have been detailed in Schalekamp and Behrens (2010) and (2013). To summarize, in order to induce cooperation, the national minister of transport promised taxi operators "would not be worse off" with BRT and the City followed suit. As such, the city offered each taxi operator in the affected area a compensation package equal to the estimated value of his or her business, in return for scrapping all vehicles, invalidating operating licenses, and ceasing operations. The operator could then either keep the cash compensation and exit the industry, or receive the equivalent amount as shares in one of the new vehicle operating companies (VOCs) that would provide contracted BRT services. Former taxi drivers and other taxi industry employees would receive preferential hiring consideration in VOCs and other contracting companies. The City would assume the bulk of the risk in VOC contracts so that it could determine routes and schedules and so that operators would not be worse off (Schalekamp 2015a).

For Phase 1, the compensation agreements applied to those operators who belonged to one of the eight taxi associations in the area now served by MyCiTi, which included the entire city center, the Blaauwberg corridor, and Sea Point/Hout Bay. Routes with one end in the MyCiTi area but the other end outside were not affected. Taxi routes that partially overlapped with MyCiTi routes would be modified such that operators were prohibited from operating on the affected part, and operators compensation proportionally (Schalekamp 2015a). By 2015, 337 affected operators turned over their operating licenses to the city in exchange for compensation, the majority of which have become shareholders in one of the four new VOCs formed (City of Cape Town 2015). A small number of operators chose not to cooperate and continued operating, now illegally. As before, some pirates continued operating illegally.

A complicating factor was that a small number of taxis that primarily operated outside the MyCiTi area were technically licensed to also operate within the city center, a fact the City initially overlooked. After MyCiTi opened and the affected taxis were removed, the dearth of taxis made the city center suddenly much more lucrative, and this overlooked

group of taxis shifted from their primary routes to fill the vacuum. Because these operators were not part of the compensation process and retained their licenses, the City had no legal means to prevent them from operating.

Because it was a pilot phase and taxi negotiations in Phase 2 were incomplete, the City made no effort remove taxis before launching the N2 Express and taxi operations continued as before. In Mitchell's Plain, taxis and MyCiTi serve essentially the same route. In Khayelitsha, though, MyCiTi and taxis serve different points within the township—the main taxi terminal is located at the north side of the community, at Site C, while the MyCiTi hub is located at the opposite end of the township, at the Kuyasa train station—such that taxis and MyCiTi do not directly compete.

### **Golden Arrow reform as part of MyCiTi**

While the City devoted most of its industry transformation resources to formalizing the taxi industry, the MyCiTi plan also involved ending conventional bus service provided by Golden Arrow. Like the taxi operators, the Golden Arrow company would be folded into the MyCiTi system as a shareholder in one of the new VOCs, a transition that as of 2017 was still in process (Transport for Cape Town 2015). The MyCiTi service would differ substantially from Golden Arrow service. Rather than broadly serve generic travel demand, Golden Arrow operated hundreds of routes, many of which served specific demand niches, such as transporting students to and from one neighborhood to a specific school, and ran only a few times a day. With the MyCiTi roll-out, these Golden Arrow routes were removed. In contrast, MyCiTi ran much more frequent buses along a much smaller number of routes.

### **MyCiTi vehicle operating contracts**

For a system like MyCiTi that depends on contracted services, contract structure is critical. In general, transport service contracts may be structured in one of two main ways (Hensher and Stanley 2010; Walters and Jansson 2008). In a service-based contract (often used in competitive tendering), the government authority specifies service characteristics like routes and schedules, and pays the operator for the amount of service provided (e.g., per kilometer), regardless of how many passengers are carried. Operators can be penalized for failing to meet performance indicators like on-time arrivals. This type of contract incentivizes operators to be on time and maintain specified quality standards, but not necessarily to attract passengers. The government takes on the risk of ridership being lower than expected. In a performance-based contract, operators are paid based on the number of passengers. In this case the operator has more discretion over matters like routes, schedules, and service quality. The operator also carries more of the ridership risk and is incentivized to attract more passengers.

MyCiTi used service-based contracts, in which VOCs were paid based on kilometers of service provided, rather than number of passengers. According to Siphon Afrika, Director of Contract Operators for TCT, the City chose this type of contract because it wanted to

ensure high service frequency and predictability, in order to “create a culture of traveling” on public transport (Afrika 2016).

With a service-based contract, the operators’ only incentive is to fulfill contract obligations – make sure buses are on-time, vehicles are maintained according to schedule, and so on. The operator need not worry about passenger needs, because it is paid the same amount regardless of number of passengers. Afrika explained, “We as a government, we’ve taken almost all the risks because if the bus is empty or full they [the VOCs] get their money. There’s nothing that really pushes them to perform” (Afrika 2016). In other words, the City was willing to take on more ridership risk to ensure a reliable and frequent service. Because VOC contracts are service-based, it is up to the City to understand user needs and design service requirements accordingly. Therefore, the relationship between the City and users is critical.

As formalization, the MyCiTi reforms were at least partially successful. I identified major shifts in all four dimensions of formality: relationship to government, relationship to labor, and organization structure and business practices.

### **Relationship to government**

MyCiTi is a hybrid public-private endeavor. The City’s transport department, TCT, plans and manages the system, while funding comes from the national government and local tax revenue. TCT contracts bus operations to the privately owned VOCs, whose shareholders include former taxis owners as well as the conventional bus company Golden Arrow. Other MyCiTi services, like station management and fare collection, are also contracted to private companies.

**Regulation** Prior to MyCiTi reforms, government regulations on service supply and quality existed but were weakly enforced, and the industry relied heavily on self-regulation to avoid oversupply. With MyCiTi, the addition of operating contracts brought former taxi operators who became shareholders in VOCs under much closer government oversight than they had been before with operating licenses. TCT can impose penalties on VOCs for failing to meet performance criteria standards, including: not complying with the schedule, not following the route, break-downs resulting from improper maintenance, not displaying the correct destination information, not using authorized stops, speeding, and dirty or otherwise unsatisfactory vehicle conditions (Transport for Cape Town 2015). Siphon Afrika explained TCT relies on monitoring and user reports to enforce contracts and impose penalties violations. “We do random checks; for example I’ve got monitors on the ground.... And also there’s a schedule. People know the timetable. The commuters know the timetable. They complain and we investigate” (Afrika 2016).

When MyCiTi operation began, the City also stepped up enforcement against illegal taxis. Molefe (2015) suggested enforcement in general has intensified in recent years: “Now, things are getting much stricter, vehicles are being impounded. If somebody’s caught without

a license, you have to go pay a fine for giving someone without a license your vehicle to operate... They're clamping down."

Where MyCiTi reforms imposed new government oversight, they also disrupted taxis' self-regulation mechanisms. In a couple areas within the MyCiTi area, such as Sea Point, taxis continue to operate, partly because the City realized they could not provide enough capacity with MyCiTi to meet demand and because the removal of legitimate taxi associations also removed self-regulation. In the words of Peter Grey, Senior Planner at TCT, "We take out the kingpins, all the illegals come flooding in" (Grey 2015). That is, previously taxi association leaders would enforce the rules and hierarchy that supported self-regulation: rank marshals would prevent unlicensed taxis from entering taxi ranks, but then legitimate association members left to join the MyCiTi operation. "So you have someone who self-appoints himself as marshal, because he gets paid the 10 rand per vehicle" (Nyoka 2015). Since the self-appointed marshal does not work for an association, his incentive is to admit as many vehicles to the rank as he can, regardless of whether or not they are licensed and whether or not they create oversupply.

**Government recognition** MyCiTi reforms forced an increase in government recognition of the taxi industry. Whereas prior to MyCiTi, government recognition might have been characterized as begrudging and uneven, with MyCiTi the City recognized taxi operators as legitimate and necessary partners. The City's decision to engage with the taxi industry and promise operators they would not be worse off shows officials acknowledged the political importance of the industry and understood MyCiTi had little hope of success without changes in taxi operations.

The fact that planners designed many of the feeder routes to mimic minibus taxi routes signals acknowledgment of the industry's ability to identify demand. In my interviews, city staff recognized taxi operators often knew more about their own routes than they did. In fact, as efficiency shortcomings of the Phase 1 feeder system become more and more evident, City officials increasingly accepted the importance of taxi services. "Well, I wouldn't replace all the taxis because not just for the sake of competition, but also for the benefit for the passengers. I sometimes feel guilty that we have replaced taxis but we not able offer and equivalent level of service in frequency and reach" (Bassier 2016).

**Public investment** Public investment in transportation clearly increased with the reforms. Whereas minibus taxis received negligible public funding, the national government has granted R3.5b (240m USD) per year for capital spending on BRT systems. National operating subsidies for BRT averaged R700m (48m USD) per year, beginning in 2013, while the City of Cape Town contributed roughly R230m (16m USD) in operating subsidies to MyCiTi (Hunter van Ryneveld 2014; Transport for Cape Town 2015).

While increased public investment supports high-quality infrastructure and vehicles, the increased expenditure in capital also reduces operational flexibility, with consequences for accessibility. Specifically, MyCiTi requires large investment in fixed infrastructure and vehicles,

which make the system less adaptable to user needs when compared with less capital-intensive informal transport. The question of high-floor buses versus low-floor buses illustrates this inflexibility. In 2009, MyCiTi planners had to decide which type of vehicle to use for main trunk route: buses with a high floor or low floor. At the time, high-floor buses were a common choice for BRT systems. They were cheaper and easier to maintain, but because the doors are several feet off the ground they would only allow boarding at BRT stations with a raised platform. Low-floor buses have doors close to ground level and so would allow boarding anywhere, not just at special stations. However, low-floor buses were more expensive, because the engine cannot be housed beneath the vehicle. Perhaps more importantly, high-floor platforms would physically prevent minibus taxis from poaching passengers from the BRT stations. MyCiTi planners chose high-floor buses for the trunk route due to their lower cost, less complicated maintenance, and ability to prevent encroachment from taxis (Rendall 2016; Transport for Cape Town 2015; Schalekamp 2015b). Meanwhile, for feeder routes planners chose shorter 9-meter low-floor buses because these would have to stop at regular bus stops without platforms.

Unfortunately, this choice of vehicles for Phase 1 reduced flexibility of future operations because trunk-route buses and feeder-route buses could not stop at each other's stops. The addition of the N2 Express complicated the situation further. By the time the N2 Express routes were added, low-floor buses had fallen in price as they became more popular for BRT systems internationally, and TCT chose low-floor for the N2 Express and all future Phase 2 routes (Transport for Cape Town 2015). However, the Phase 1 station platforms were already built for high floors, so the vehicles in each phase were not interchangeable, reducing operational flexibility. As TCT planner Kapil Singh put it,

We sit in a situation now where we have high-floor buses on these few trunk routes and everything else that's coming will be low-floor. Just in terms of the existing network we could optimize our operations a little bit better if we had the flexibility of being low-floor (Singh 2016).

Moreover, the larger trunk-line buses are too large to be re-purposed on many of the feeder routes.

In contrast, taxis use small vehicles that require no special fixed infrastructure. The small vehicle means a driver with a less-than-full vehicle could decide to modify the route slightly to pick up more passengers—for example, drivers sometimes use local roads rather than the freeway—without inconveniencing many passengers. Taxis can stop anywhere, not just at designated bus stops, and they frequently do. Nyoka (2016) suggested the ability to stop anywhere was likely one of the reasons passengers on the Sea Point route use taxis even when they have the option of MyCiTi. All taxis are small, and all are more or less the same size (14-16 seats), so vehicles can just as easily serve small streets in townships like Dunoon as line-haul highway commutes.

### Relationship to labor

In South Africa all formal transport sector employment, including MyCiTi, must conform to the South African Road Passenger Bargaining Council (SARPBAC) agreement between formal bus companies and employee unions, which covers wages, work hours, and benefits (van Ryneveld 2016). For example, under the agreement, a BRT driver in 2016 was guaranteed a minimum wage of R42.17 (2.89 USD) per hour and work hours could not spread over more than 14 hours in any given day. Any change in work schedule required at least one week's notice (SARPBAC 2017).

Compared to taxis, MyCiTi had higher standards for new hires. Many former drivers from affected taxi associations could not qualify as MyCiTi drivers because they lacked the proper driving license (Molefe 2015) or didn't pass the qualifying tests. After being offered only lower level jobs like station attendant or cleaner, many of these former drivers quit and went back to the taxi industry. According to Nyoka (2015), "most of them didn't pass the medical tests to drive and had to clean instead. That didn't go well. They said, I'll just go find another taxi to drive on another route." Molefe (2015) said former Golden Arrow drivers were more successful as MyCiTi drivers—presumably because they were already qualified for and accustomed to formal employment.

Whereas in the taxi system drivers had a large degree of autonomy and were incentivized to maximize fare revenue, MyCiTi drivers must meet specific performance criteria, such as keeping vehicles on schedule. MyCiTi drivers and station employees can be reprimanded if customers lodge complaints about their behavior (Afrika 2016).

In contrast, taxi drivers do not have formal labor agreements. They often work long hours: a driver working a typical 4AM to 7PM day would have a 'spread-over' of 15 hours, which would be prohibited under SARPBAC. Drivers usually set their own hours and can decide whether or not travel demand at a particular time of day warrants working those hours. Because each additional passenger means more income, they are highly motivated to seek out more passengers and find pockets of unmet demand. For former taxi drivers who did land jobs as MyCiTi drivers, the transition to MyCiTi was a big change. Afrika (2016) contrasted the taxi system with what was expected of drivers at MyCiTi:

Most of the drivers used to be taxi drivers. There's no discipline that side. Here there's discipline. There are rules and regulations, there's uniform here. There's behavior; they cannot talk to customers as they wish. There are rules; you can lose your job.

MyCiTi's formalized labor relationship would likely result in reduced flexibility, compared to taxis. The work hours requirements make it more expensive to optimize operations in response to demand. van Ryneveld (2016) explained, "Your formal sector has this total number of eight hours in a day.... It's much more formally structured and people have got to be brought back to the depot." Furthermore, according to the agreement schedules cannot be changed at the last minute to adapt to changing demand.



## Organization structure and business practices

**Consolidation and standardization** Whereas the taxi industry consisted of many heterogeneous, small-scale operators who joined together to form associations, which themselves have diverse organizational structures, the MyCiTi system is by design consolidated and centrally planned and managed, with services contracted to VOCs that have standardized organization structures and practices. TCT specifies schedules, routes, vehicles, fare collection technology, and performance quality measures. VOCs can differ in how they negotiate their contract and manage shareholders, but must comply with TCT's standards.

While centralized decision-making allows MyCiTi to take advantage of network and scale economies, its relatively complex decision-making structure also limits its ability to adapt. TCT determines routes and schedules, and changes require approval from and coordination of several departments, negotiations with VOCs, and a period of public notification, meaning any modifications take weeks to months. For example, it took the City more than a year to implement express buses in response to the realization demand was more peaked than expected (Transport for Cape Town 2015).

This lack of operational flexibility constrains MyCiTi's ability to adapt quickly to user demand. The most common complaints from residents related to service supply—specifically service coverage (e.g., “MyCiTi does not stop where I need to go”) and frequency (e.g., there are not enough buses on the N2 Express routes). With more operational flexibility and lower operational costs, MyCiTi could expand routes and add more buses, or redirect buses from less popular routes.

In contrast, the fragmented nature of the taxi industry allows more adaptability. Although official licensing laws and informal association rules prevent each individual operator or driver from operating outside his or her designated routes, almost every part of the city falls under some association's authority. If demand increases in a particular area, that association can allow more licenses to be issued there. Granting additional licenses takes time—operators must apply the provincial authority and get permission from the association—but in the meantime, if demand is high enough, the association may temporarily allow unlicensed taxis. The same self-regulation works in taxi ranks, where the marshal will give priority to licensed vehicles, then unlicensed ones can take any overflow demand. In this way, the taxi industry has a built-in mechanism to adjust supply to varying levels of demand.

**Corporate business practices** As part of the transition process to VOCs, the City former taxi operators to adopt more formal practices. For example, operators were trained in professional business management skills where they learned how to keep records and set up corporate governance structures. As the city official in charge of regulating the new VOCs, Afrika (2016) described how he expected the new companies to be organized:

There are specific things/characteristics that I want to see coming out of the company. For example, I want to see a board, specific requirements, I want to see the role of the CEO and the role of the CFO being clearly defined, as well as

the role of the Chairperson of the Board.... For me a structure of an organization creates the platform in which you can enable a company to perform so when the organization structure is stable, in other words there's no tension, there's direction.

VOCs thus have a management team that reports to a board, which is accountable to shareholders. Operators now part of VOCs no longer use cash; under MyCiTi, fare payments are electronic, and the companies use formal banks and accounting techniques. Molefe (2015) described the transition for him personally:

I've learned about that, I've learned about corporate governance, like I've said, I've learned about—how to read a budget, how to read—if make your own budget it's different from one that is, one that is credible— I've learned how to read financial reports.

In terms of access finance, the initial financial for investment in MyCiTi vehicles was arranged by the city and funded through the national grant, PTISG (Transport for Cape Town 2015). Going forward, the government will aid with financing but, as formal businesses, VOCs also in principle have greater ability to secure financing from private banks (although whether or not they do in practice is still unclear).

## **The planning process and understanding user demand**

My interviews helped illuminate the planning process behind MyCiTi, especially the ways in which planners understood user needs. The MyCiTi reforms changed who made decisions about transport provision—instead of taxi operators, decisions were now made by the City and its planners.

The MyCiTi reforms greatly changed the ways in which those decision-makers interact with users and learn about their needs and preferences. For taxis, travel demand is revealed through behavior in the market, which may potentially result in a better understanding of user needs. Taxi operators are more likely to be “on the ground,” closer to the community, and drivers who come from the same community as passengers may be more familiar with what they want in terms of transportation.

The taxi industry may understand user needs better than the formalized service can, because the market efficiently reveals demand and because operators more often interact personally with their customers. In the previous section I address how the market reflects travel demand. It does not, however, reflect all user needs and preferences, but instead privileges the need to get from point A to point B. It does not reflect preferences like comfort and safety. At the same time, because operators and especially drivers personally interact with passengers, they had a good understanding of user preferences or, more often, complaints. Taxi operators knew well that passengers complain about driver behavior and safety. In Schalekamp's interviews, even representatives of the taxi industry admitted that

most operators do not pay attention to customer service. As another example, operators knew that on weekends many people travel to visit family out of town, in the Eastern Cape, and so they offered long-distance taxis to the Eastern Cape on Thursdays and Fridays, with the return trip on Sundays.

Taxi operators do have a good understanding of travel demand and user preferences, but not necessarily because of a positive relationship with the community. While some residents may be friendly with drivers, as discussed in the last chapter, most residents characterize their relationship with taxi drivers as oppositional. One user said about taxi drivers, “they do not represent the community.” Moreover, knowledge of users’ needs and preferences may not translate into acting on that knowledge, especially if the transport market is not competitive.

Under MyCiTi’s service-based contracts, in contrast, the responsibility for understanding user needs fall primarily with the government—not service providers. Information about travel needs comes to the City through methods such as household surveys, passenger surveys, community participation, and call center feedback. In my interviews, I found the City had a general knowledge of what citizens priorities and attitudes toward taxis. Early on, planners and officials understood affordability was of primary importance, and so they set fares at a level comparable with Golden Arrow, a reasonable benchmark for affordability (Otter 2016; van Ryneveld 2016). City officials and planners I spoke to were aware of the public’s opinion toward taxis, both from surveys and from word of mouth and personal experience. Specifically, they knew residents complain about driver behavior and unsafe driving. “We all know passengers are concerned about the behavior of drivers, the way they drive, how uncourteous they are, etc.” (Bassier 2016).

### **Travel data and travel demand modeling**

Prior to launching MyCiTi, the City’s main way of predicting volume, timing, and location of travel demand for BRT was through a standard four-step travel demand model. (The four-step travel demand model, a standard in transportation planning, aims to predict the volume and distribution of passenger trips through four steps: estimate number of trips generated and attracted for each zone given land use; match trip origins to destinations; estimate mode split; and assign each trip to the transport network.) Calibrated with previously collected household travel data, the model projected likely passenger demand for a new BRT system, which planners considered in designing MyCiTi’s stops, service frequency, and capacity. For example, stations were designed to accommodate the expected volume of passengers under the model assumptions (Rendall 2016). Like any model, the four-step model is only as good as the input data and underlying assumptions, and Cape Town’s model had several shortcomings that led to it overestimating demand for MyCiTi, especially on certain links.

According to the 2015 MyCiTi Business Plan (Transport for Cape Town 2015), several faulty assumptions led to the model overestimating demand. First, the model only represented the morning peak period, and extrapolated predicted demand to other times of the day using a “well-researched” expansion factor (6.7). However, “the actual revealed data showed a lower factor (5.75)” (Transport for Cape Town 2015, p. 60), meaning actual travel

demand was more concentrated in the morning peak than expected, resulting in excess capacity at other times of the day. Second, the model originally assumed all taxis, as well as Golden Arrow buses, would be removed from the MyCiTi area, and those passengers would switch to MyCiTi. In actuality, however, not all taxis were removed, so MyCiTi gained fewer passengers than expected. Third, the model assumed MyCiTi buses would be filled to capacity, but it turned out passengers preferred to wait for a seat on the next bus rather than having to stand for a long journey. This resulted in overestimating revenue per vehicle trip. Fourth, the model assumed MyCiTi service would be more reliable than it actually was. Reliability was below standard partly because the supplier retained to implement a real-time vehicle arrival information system failed comply with its contract.

City planners continued to collect data on passenger volumes after MyCiTi opened, though, and as they did their understanding of demand improved. Planners realized the initial model had overestimated demand and in response they adjusted operations. For example, the City implemented “short turns,” where, instead of traveling the entire route, the bus turns around early so as to increase capacity along the popular segment while decreasing capacity in the less-used segment. In response to the worse-than-expected peak demand problem, the City placed a cap on the number of buses during peak periods in order to encourage users to shift their travel to the peak “shoulders.” While this may have reduced peak-period demand, users would not experience it as a positive, but as more crowded buses and longer waits.

Another area where actual demand missed projections was in non-motorized modes. The Phase 1 design included bicycle lanes alongside the BRT lanes and bike-friendly infrastructure around stations. Planners included these designs assuming – or hoping – they would encourage bicycle use, even though there was little evidence to support that assumption. Holderness (2016) pointed out:

There was great support [from the city] for cycling which was great, but almost at the expense of pedestrians. So it became cool to put in the cycle lanes; it was quite glamorous and stuff, but the fact that all of our passengers are pedestrians kind of got a little bit lost.

With more accurate understanding of the demand for bicycling vs. walking, the resources spent on bicycle facilities could have been more efficiently directed to pedestrian infrastructure. In later planning phases it became clear bicycle use did not increase; indeed, in my user survey, only 0.4% of respondents used bicycles, essentially no increase from the 2013 CT HHTS. At this point planners did shift their focus to pedestrians.

### **Community engagement**

The City could also gain understanding of user needs from public engagement. On this task the City efforts were somewhat uneven. My interviews suggest City officials initially had a limited understanding of user needs, but they improved their understanding considerably over time.

Even before MyCiTi, when planning for the Klipfontein corridor in the 2000s, the City did user research. Mazaza recalled, “We did videos, we followed people around across the city, so we targeted passengers from Atlantis as well as Metro South East and put them on a bus, a taxi and rail, follow them into the CBD, how long it takes and they would explain the challenges of using public transport.”

However, whatever lessons the planners learned from these exercises, they apparently did not translate to strong community relationships during the first phase of MyCiTi planning. Initially, the City considered community engagement mostly as a market and public relations exercise. Carried out by the marketing department, not planning, it initially had little relationship with the technical decision-making. The former head of public engagement for TCT, Steven Otter, told me, “When I started [in 2014], we were more at a point of crisis management.” Public engagement was being done, but by “contractors that were more like marketing types” (Otter 2016).

The city’s weak understanding of user demand and needs is evident in mistakes planners made in MyCiTi stop placement. For example, planners I interviewed admitted the Phase 1 trunk line had too many stops in the area around Paarden Eiland, a mainly industrial area just outside the city center. According to van Ryneveld, planners located stops not based on based local demand, but on international transport standards that recommended potential destinations be within 500 meters of a stop to encourage walking. “They ended up with much more frequent stations that I think— than were appropriate” (van Ryneveld 2016).

When asked how station locations were chosen, TCT planner Claire Holderness explained:

This was the first time we were doing BRT, so it was based a lot on the advice we were given, and it was quite a theoretical guess that these were the optimal spacing of stations. But we wanted to create access for everybody but keep the mobility function and all those usual things.... Yes, so I think the stations – that the spacing of the ones that you’re talking about, were maybe not used that much and we’ve had to close down now (Holderness 2016).

In fact, these stops, which were full BRT stations that represented significant capital investment, weren’t actually closed, but instead some buses were made express buses that skip those stops. In any case, planners later realized they misjudged how many people would be willing to walk to these stations, and then adapted operations to the actual demand.

In another instance, MyCiTi planners had placed several Phase 1 feeder route stops in Atlantis in locations the community considered dangerous. Otter (2016) described the system planners’ approach this way: “You have your satellite image and say ‘oh this stop is 500 meters from this one, so that’s where we’ll put it.’” But he said there was a public “outcry” after the Atlantis stops opened.

I was in Atlantis and one of the local leaders said to me, ‘That is a drug den, right where you put your stop. I can assure you if you look at your figures, you’ll find no one is taking that bus.’ And we looked at the numbers and sure enough no one was (Otter 2016).

Planners learned of the problem through community meetings. Singh, who designed several MyCiTi routes and stops, recounted:

So what came out of various public meetings where delegates from the City would go out to and engage with the public in a school hall—what came out of that was that people in Atlantis preferred the more circuitous routes rather than the direct routes, so they wouldn't mind sitting on the bus for longer if it meant they had to walk a shorter distance to get to the stop (Singh 2016).

After learning about the problems in Atlantis, planners modified stop locations. Unlike the expensive trunk line stations, these were feeder stops that did not involve much infrastructure and were easier to move. The lesson affected future planning: in subsequent phases, planners solicited more feedback from community members about the location of stops, and earlier in the process. The improved community participation was evident in planning for the N2 Express. Singh (2016) told me how Mitchell's Plain residents helped planners choose stop locations for that route:

Singh: This particular intersection is close to a school and we figured that's why we would put [the stop] there — safe crossing and signalized intersections. The feedback was that we should definitely not have a stop there because of gang warfare and turf wars that happen there.

Interviewer: What would happen if you did put a stop there? What did they say would happen?

Singh: They didn't say they would do anything, but basically they said no one is going to use that stop because they know what happens there. It's not safe.

With this information, the planners chose a different stop location. In this case, the earlier community feedback helped the planners locate stops effectively the first time, without having to go back and move them.

Another misstep in Phase 1 planning illustrates how the City lacked knowledge of the communities it served. Having planned feeder routes in Dunoon, the City discovered, too late, that even the shorter 9-meter feeder buses could not fit on some of the neighborhood's narrow, winding streets (Schalekamp 2015b).

It also appeared many of the city planners and officials still had a better first-hand understanding of car users than they did of public transport users. In Holderness' (2016) words:

That's who our client was, was car drivers, so it was designed from that perspective. And, just on a personal note, I think that's also what made it slightly easier from a planning and design perspective to do because as professionals we're all car drivers so we understand our client really well.

By this, Holderness meant planners envisioned car drivers as the target user, and as car drivers themselves they found it easier to understand the target user's needs.

Later, though, planners began to take public engagement more seriously. "Since then there's been a real shift. I've started to implement community engagement far earlier in the process.... There's been tremendous buy-in from the technical staff" about public engagement (Otter 2016).

In addition, interviews also suggest that, even if the City undertook public engagement in order to understand user needs, this was secondary to engaging with the taxi industry. The city officials and planners I interviewed were generally more eager to discuss industry engagement than public engagement. Planners, who were not specifically responsible for either type of engagement, readily pointed to the City's successes in negotiating with taxi operators, but did not mention community participation until I specifically asked about it. Herron (2016) acknowledged this was true in the case of the N2 Express: "The biggest challenge for the N2 Express was not the public – they were very excited about it – it was getting the taxi industry on board." The City needed to direct so many resources to engaging the taxi industry, understanding user needs came as a lower priority.

### **Market research**

Between the 2010 and 2015, as it rolled out MyCiTi service, the City increased its efforts in market research, which improved its understanding of user needs. For example, the TCT's marketing department contracted studies on perceptions of MyCiTi to a market research firm, yellowwood, which between 2012 and 2014 conducted interviews with current and potential users. The firm identified priorities for improvement, including improving on-time arrivals and better communicating to passengers how they would receive financial penalties by not tapping out their fare cards (yellowwood 2014).

In 2015, the City conducted an experiment to better understand why or why not minibus taxi passengers in the CBD would switch to MyCiTi. Among passengers queued for taxis to Sea Point and Waterfront, the City distributed several hundred free MyCiTi fare cards with preloaded credit for about three trips, and then tracked usage of the cards (yellowwood 2015). However, it's not clear the experiment produced results the City could actually act on. For example, one of the experiment's findings was that people who continued to use taxis rather than MyCiTi said they preferred taxis because MyCiTi did not stop where they wanted to stop. This particular information did not result in the City changing any stops (Nyoka 2015).

Overall the interviews suggest a lack of information about user needs may have led to some key decisions early on that reduced benefits for users. However, after Phase 1 opened the City improved its understanding of user demand and that information influenced decision-making in later stages.

## 4.4 Expectations for how BRT reforms affected accessibility

MyCiTi and its accompanying reforms changed transportation provision in Cape Town in several ways that can be expected to affect accessibility. The reform introduced a new mode of transport, BRT, to an already complex transportation landscape. It introduced a new institution, Transport for Cape Town, and expanded the municipality's responsibility and capacity for public transport. It altered relationships between transport providers, users, and the government. And, in partially replacing minibus taxis, it at least partially formalized transport provision in the Cape Town.

With the replacement of taxis with MyCiTi, the previously existing direct, market-based relationship between transport providers and users dissolved. Instead, transport providers became accountable to the government through contractual, regulatory, and financial relationships. Contracted providers (VOCs in the Cape Town case) did not have a direct incentive to serve customers, but instead serve contracts with the City. In contrast with revenue-maximizing taxi operators, the City had multiple motivations and expected MyCiTi to serve multiple goals, each responding to the needs and preferences of different constituents or different actors within the government. Shifting from a single goal to multiple goals would have implications for the ability of public transport policy to serve accessibility.

As Cape Town's transport provision became more formalized, we might expect the changes in technology, institutional structure and relationships with operators to limit flexibility and constrain the City from responding effectively to user needs. In contrast, taxis' business model, informal organization, and business practices allow more flexibility in service, which enables them to respond more easily to demand.

Cape Town's reforms have placed more responsibility for public transport in the hands of the City. It follows that resulting improvements accessibility and equity in its distribution depend to a great degree on the municipal government's capacity, both in terms of (1) the ability of the civil service to plan, implement, and manage a BRT system and (2) the degree to which the process responds to the interests of various populations.

The changes in how transport providers understand and learn about user needs and preferences would also be expected to affect accessibility. Whereas taxi operators personally interacted with their customers and, through them, learned about their travel needs, the City relied on transportation professionals, most of whom were either not from Cape Town or were not public transport users, to learn about MyCiTi user needs. If these methods result in a poorer understanding of user needs, it may mean formalization leads to fewer accessibility benefits. Additionally, different means of gathering information may favor the needs of different populations, affecting distribution of accessibility benefits.

As discussed in Chapter 3, Cape Town's governance capacity can be described as moderate, and its specific capacity in transport planning and management changed over time. At the outset of planning for MyCiTi, the City of Cape Town had very little expertise in transportation planning, and relied heavily on consultants. But recent national reforms



have empowered the municipality to plan and manage BRT throughout the metropolitan region, backed by funding from the national government, which has allowed city staff to gain more experience in this area. Since the launch of MyCiTi, the City has increased its transportation planning and management capacity, especially with building out a new transport department, Transport for Cape Town (TCT). The City also has capacity to raise its own tax revenue and direct it to public transportation spending. A reasonable guess is that the City of Cape Town's ability to build capacity will enable it to successfully bring accessibility improvements through formalization.

In terms of the degree to which the government is accountable for delivering benefits in an equitable manner, Cape Town again ranks moderately. To maintain legitimacy, elected officials must be perceived as being fair to black and poor communities even if they are not their core constituency; any action perceived as preferential to whites carries political risk. In addition to political risk is the threat of violence. Violent acts against city-sponsored projects are not uncommon; for example, on several occasions residents have badly damaged MyCiTi buses and stations by throwing rocks. Whereas the vast majority of residents hold the government accountable through elections, the taxi industry has deliberately used the threat of violence to assert political power over city leaders, and as a result in the MyCiTi reforms the City has had to answer to the taxi industry as well as residents. Given the importance of tourism to its economic, the City has an interest in providing transport amenable to visitors. With these multiple competing interests, it's likely the City would try to deliver benefits to each of these groups, or at least would try to be perceived as delivering benefits to each group. Thus it seems reasonable to predict that the impacts of Cape Town's transport reforms will go mainly to white and coloured residents as a group, with relatively fewer benefits going to black residents.

## Chapter 5

# Measuring accessibility with a network model

How has Cape Town’s introduction of BRT and accompanying removal of informal transport affected the distribution of accessibility for residents? In this chapter, I explore spatial patterns in accessibility by formal and informal transport modes, based on travel time estimated by computational models of each system. To estimate travel times for minibus taxis, I use a custom-built routing model to represent minibus taxi services. I then compare accessibility measures before and after the introduction of BRT, for population groups defined by income, race, and location relative to BRT.

The model-based analysis is useful because it focuses our attention on the accessibility changes arising from differences in network configuration, service spatial coverage, travel speeds, and service frequencies between BRT and minibus taxi, and how those changes interact with land use. As discussed in Chapter 2, formal and informal modes typically differ substantially in these supply characteristics, and they are expected to substantially influence accessibility. Since the model explicitly represents the changes in network configuration and service frequencies, we can better isolate the accessibility impacts of those changes from other factors which might affect travel choice, such as affordability, reliability, or safety. Whereas the user survey in Chapter 6 focuses on travel time changes as experienced by individual survey respondents, who may or may not have made travel decisions based on travel time, the network-routing model analyzes potential travel time changes experienced by residents of each location in the city.

### 5.1 Hypotheses

The effects of BRT reforms will depend on location. In the MyCiTi Phase 1 area, transport reforms involved both the introduction of a BRT system, MyCiTi, and removal of most informal transport routes. The shift from informal transport to BRT has meant a shift from a point-to-point network served by small vehicles to a trunk-and-feeder network served

with larger vehicles. Based on the spatial distribution of service alone, we would expect the formalized system to improve accessibility for residents within a short walk of the main trunk route, who would now have direct and high-frequency service to locations served by the BRT. Accessibility might be reduced for those who need to access the trunk via a feeder route, because they would potentially now have more transfers and lower frequency service. However, with an exclusive bus lane, the BRT avoids congestion along the main route, and the extra time saved may make up for increased transfers. Thus it's difficult to know in advance whether or not accessibility will improve for those in the service area.

In terms of the distribution of accessibility, the Phase 1 trunk corridor serves communities of a range of incomes and races, although overall the area has a higher proportion of high-income and white residents than the city average (see Figure 3.4 in Chapter 3). Because higher-income residents are more likely to live nearer to the city center and therefore BRT routes, I expect to find accessibility in the Phase 1 area has become more unequal between income and racial groups.

In the N2 Express area, where BRT was introduced in addition to existing minibus taxis, I expect accessibility to have improved for all residents. The N2 Express corridor serves two large communities, one with a primarily coloured population and a range of middle- and low-income households (Mitchell's Plain), and one primarily black with a high concentration of low-income households (Khayelitsha). Here, Khayelitsha began with especially poor accessibility. I expect the changes brought by the BRT to have been particularly large for black and low-income households, simply because they began with a very low baseline.

## 5.2 Accessibility index methodology

### Measuring Accessibility

Since the 1990s, researchers have developed increasingly sophisticated ways of operationalizing accessibility (Handy and Niemeier 1997; Geurs and van Wee 2004; van Wee 2016). The literature now contains range of metrics that range from relatively simple measures of travel time to more complex measures of utility and welfare (Geurs and van Wee 2004; van Wee 2016). Accessibility measures can be infrastructure-based (i.e., how much accessibility does a person using a given piece of infrastructure have), location-based (i.e., how much accessibility does a person in a given place have), or person-based (i.e., how much accessibility does a given person have) Geurs and van Wee (2004). I ruled out simple infrastructure-based measures, like level of traffic congestion along a corridor, because they do not sufficiently reflect land use attributes and are generally not suitable for evaluating social impacts, like comparing accessibility of different groups (Geurs and van Wee 2004). I considered both location- and person-based metrics, finally selected a location-based cumulative opportunities approach, as described in more detail below.

### Location-based measures

The simplest group of location-based measures, what Geurs and van Wee (2004) call “distance” or “connectivity” measures, captures the degree to which two places are connected. For example, one might measure the travel time from a given location to the nearest hospital or map the area reachable from a given location for less than a given cost. One form, the widely used *cumulative opportunities* measure, counts the number of opportunities that can be reached from a given location within a given travel time; for example, the number of jobs reachable from a residential neighborhood within 30 minutes. The advantage of connectivity measures, according to Geurs and van Wee (2004), is their simplicity—they require relatively easy to acquire data, and are easy to interpret. A disadvantage is that they do not take into account differing attractiveness of various locations or differing preferences of individuals—for example, some people might travel to a more distant grocery store because the staff are friendlier. Cumulative opportunities measures, in particular, are sensitive to arbitrary cut-offs, such as when a grocery store 29 minutes away is valuable but one 31 minutes away is not. Further, they do not consider the demand, or competition, for destinations. A hospital can become full, and a job is for only one person. Connectivity measures also do not easily account for temporal variations in accessibility.

The relative ease of use and interpretation makes connectivity measures popular for both research and practical applications. Golub and Martens (2014) compared accessibility indices for automobile and transit modes across various proposed planning scenarios in the San Francisco Bay Area. They used a relatively straightforward cumulative opportunities measure: the number of jobs (or any other given activity) that can be accessed from a location within a given amount of time (e.g., 45 min) by a given mode. These authors’ contribution was developing several useful measures of access equity. They defined an access ratio as the ratio of accessibility scores by transit to accessibility score by auto for a given TAZ. They also defined “access poverty” as having an access ratio of less than 0.33. These measures allowed the authors to compare equality of accessibility for various transport planning scenarios. To calculate travel times, they used the travel times estimated by an already existing regional travel model.

In data-poor contexts, even travel times by different modes may not be available. Tiwari and Jain (2012) demonstrated a way to analyze accessibility while working with incomplete data on travel times before and after the completion of a BRT corridor in Delhi. In order to assess the impacts of the BRT on accessibility within the corridor, they constructed three measures: (1) change in travel time for users of different modes within the corridor, (2) change in the total number of people who can access a given destination, based on travel time savings, and (3) change in the total number of destinations that can be reached by different mode users, assuming they keep the same travel time. With these measures, the authors showed that accessibility within the corridor appeared to improve for BRT and bicycle users. However, a major drawback of this study is that it only considered travel within the BRT corridor.

Also widely used is the gravity-based measure, as described by Hansen (1959). The

gravity-based measure calculates accessibility from a given location to all other potential destinations, where closer or otherwise more attractive destinations are given greater weight. The metric can be expressed as

$$A_{im} = \sum_{j=1}^n D_j f(c_{ij}) \quad (5.1)$$

$$f(c_{ij}) = e^{-\beta c_{ij}} \quad (5.2)$$

Where  $A_i$  is the accessibility for zone  $i$  to all destinations  $D$  in zone  $j$  by mode  $m$ ,  $c_{ij}$  is the cost or impedance of traveling between zones  $i$  and  $j$ . Various impedance functions can be used; the most popular is the negative exponential form a distance-decay parameter  $\beta$ . The negative exponential form reflects the fact the deterring effect of distance diminishes with distance, which is consistent with individuals' perceptions of distance.

An advantage of the gravity-based model is that it can take into account the relative attractiveness of different destinations. Data needs are relatively modest, although El-Geneidy and Levinson (2006) cautioned the impedance factor should be estimated using recent travel data, in practice the measure may not be very sensitive to this parameter (Delmelle and Casas 2012). It can also be difficult to combine multiple modes into a single measure (El-Geneidy and Levinson 2006). Additionally, the metric does not have meaningful units, only relative values, so it is harder to interpret and values cannot be compared across studies. Like connectivity measures, the gravity-based measure does not take into account competition for destinations or temporal variations.

In a study relevant for the present one, Delmelle and Casas (2012) calculated accessibility measures for the BRT in Cali, Colombia. They used two measures of accessibility: (1) the percentage of population within walking distance of BRT stops and stations (using walking time bands of 5-min intervals, up to 20 min), and (2) a gravity-based measure to estimate accessibility to hospitals, libraries and recreational facilities. For the latter, each destination was assigned an attractiveness weight, based on the size of the destination (e.g, number of beds, acres of parkland). They then used ArcGIS Network Analyst to calculate travel time to potential destinations from each the centroid of each neighborhood polygon. They calculated walking time to the station, travel time by transit, and then walking time to destination, assuming constant walking and transit travel speeds, and omitting waiting time and transfer time. To show how accessibility is distributed, they presented results as the percentage of each income strata within each accessibility range. The authors also calculated accessibility measures for a potential extension of the BRT.

This method was able to effectively compare accessibility between income groups and different neighborhoods. A major limitation of this study is that it only considered one mode—BRT with walking as the access mode—when automobile and other forms of transit, including informal modes, are presumably options for many residents. The omission of transfer times would likely introduce errors because the trunk-and-feeder structure of BRT relies heavily on transfers, which might lengthen some trips much more than others. Further, as an evaluation of the BRT, the study would have been more useful if it had compared

current accessibility the situation before the BRT was implemented or with an alternative scenario.

### **Person-based measures**

Unlike location- and gravity-based measures, person-based accessibility measures can account for individuals' preferences as revealed by travel choices. A commonly used measure, the 'logsum,' is calculated as the denominator of the multinomial logit model, which represents the probability of an individual choosing any particular travel option as a function of the benefit, or 'utility,' provided by that option, compared to alternatives (Ben-Akiva and Lerman 1985). The logsum is the sum of exponentiated utility expressions for all alternatives, and thus represents the utility of the entire choice set (Ben-Akiva and Lerman 1985). The logsum measure has the advantage of being readily convertible to consumer surplus (Geurs and van Wee 2004). The disadvantage is that logsum measures derived from different model specifications cannot be easily compared or interpreted without using a factor to convert the measure to monetary terms, which requires more assumptions and may be subject to distorting income effects. This makes the logsum difficult to use when comparing different time periods or mode options. In addition, the measure requires sufficient travel behavior and transport supply data to estimate a logit model (Geurs and van Wee 2004).

### **Selecting an accessibility measure**

In their review and evaluation of accessibility measures, Geurs and van Wee (2004) recommended selecting a metric that reflects simultaneously the influence of transportation and land use systems, temporal variations in accessibility, and differences in individuals' needs and preferences. At the same time, robustness must be balanced with usability and ease of interpretation. El-Geneidy and Levinson (2006) suggested cumulative opportunities and gravity-based measures are suitable for comparing accessibility between places, while if the objective is between individuals, utility-based measures might be better.

For the present application, I needed a metric that would be sensitive to the transport system changes before and after Cape Town's BRT and reform of the minibus taxi industry, and that would reflect differences between population groups. My main interest is comparing accessibility between places and time periods, thus location-based measures like cumulative opportunities and gravity-based are appropriate. Moreover, they can be calculated using the data available: census, transport supply, travel survey data aggregated to small zones. Person-based measures are also suitable for assessing distributional impacts of transport system changes, and it would be possible to construct a utility-based measure using available individual-based travel survey data. However, because the available travel behavior data are incomplete, a utility-based measure would require additional assumptions that would introduce additional errors. On the one hand, given that Neutens et al. (2010) suggested person-based metrics are more conservative than place-based when assessing equity impacts, my choice of a place-based measure risks overstating the differences between groups. On the

other hand, the very high spatial segregation in South Africa means place-based indices will correspond more closely to individual-based indices than in contexts with less segregation.

With these considerations in mind, I chose to use a cumulative opportunities measure, which will capture the relevant relationships while also being relatively easy to interpret. With this measure, the accessibility score for each zone represents the number of opportunities of a given land use type reachable within a maximum travel time by a given mode. Formally, the accessibility measure is:

$$A_{i,lu,t_{max}}^{p,m} = \sum_Y F_{lu, Y = \{j | t_{ij}^{p,m} \leq t_{max}\}} \quad (5.3)$$

where  $A$  is the accessibility score and  $i$  and  $j$  are the origin and destination zones;  $m$  denotes the travel mode,  $p$  the time period,  $lu$  the land use type;  $F$  is floor area in square meters and  $t$  is the travel time.  $Y$  is set of zones reachable from the origin zone within  $t_{max}$  maximum travel time.

### Accessibility to what? Selecting land use activity types

Typically, formalized public transport like BRT is intended serve people's full range of travel needs, including accessing jobs, goods and services, and social opportunities. At the same time, as a fundamental need, access to employment is often the priority. In South Africa especially, the apartheid government initially began subsidizing rail and bus transit because businesses needed access to non-white workers living in distant settlements (Wilkinson 2010), and the long-haul routes provided the train and Golden Arrow bus reflect that commute focus. Although the government's objectives have now broadened, transporting residents to work is still a priority, in no small part because the land use pattern has changed little and still requires that residents commute long distances (Transport for Cape Town 2015). As discussed in Chapter 3, the city ostensibly intended the MyCiTi system to meet all types of travel demand, but the actual design, with a trunk-and-feeder network offering high-capacity service in the peak period, might be expected to favor commute trips. Cape Town's minibus taxis serve all types of travel, depending on the demand at the time of day in a particular place. Many operators provide long-haul commute services during peak hours, then provide shorter local trips during the day. Compared with more formal transport, though, we might expect informal transport's small vehicles and flexible routes to give it an advantage for local trips and non-work travel.

In order to represent a variety of travel needs, I considered accessibility to three different land use types: retail uses, office uses, and hospitals. I would have liked to analyze accessibility to employment more directly, but unfortunately in South Africa neither the government nor any other institution of which I'm aware collects data on employment location, and so data on the spatial distribution of jobs is not available. The best available source for land use data is the City of Cape Town's buildings database, which includes the total gross leaseable floor area by land use type. I obtained a dataset with the sum of each type in each traffic analysis zone in 2013. I decided to focus on retail, office, and hospitals for two reasons. First,

they represent a range of activity types (work, shopping, services and health). Second, of the land use types available in the dataset, these were the types with the most straightforward definitions and were the ones that I was most able to ground-truth via inspection. For example, the hospitals category clearly indicated locations of hospitals and health clinics that matched with a Google web search and with my personal knowledge of the city. In contrast, the category labeled as ‘places of instruction’ clearly contained schools that showed up in a web search, but also pointed to locations—perhaps small training programs or the like—that I was not able to identify.

Throughout this chapter, I assumed land use did not change over the five-year time frame. This is a reasonable assumption since five years is probably too short to observe significant land use changes in response to a transportation project. Further, I was interested mainly in the accessibility changes due to differences in travel time by different modes, rather than effects on land use. Over a longer time frame, however, one would expect land use change to become a factor.

**Measuring land use in the presence of informality** Measuring opportunities with land use data potentially under-represents opportunities in areas that have higher rates of informality since the city’s buildings database may omit informal businesses. Based on my knowledge of Cape Town, informal hospitals and health clinics are very unlikely—these are activities almost always provided by the government in a formal capacity—but informal retail and office uses are possible.

Representative data on informal non-residential land uses in Cape Town are not available; however, the government does collect data on informal work. Stats SA’s Labour Force Surveys define informal employment as (1) “employees working in establishments that employ fewer than five employees, who do not deduct income tax from their salaries/wages” and (2) “employers, own-account workers and persons helping unpaid in their household business who are not registered for either income tax or value-added tax” (Stats SA 2016). By this measure, 18% of Cape Town workers in 2015 were engaged in the non-agricultural informal sector, roughly the same as in the country as a whole. One might question whether government surveys actually capture the extent of informal work given it is inherently difficult to measure. Seekings and Natrass (2005), however, disputed the possibility that surveys significantly underrepresented the extent of informal employment in South Africa, based on their review of several studies from the 1990s and early 2000s. For example, a 2000 survey that specifically searched for informal activity in Cape Town’s Khayelitsha and Mitchell’s Plain townships had not found results significantly different from Stats SA surveys.

Informal employment may or may not be captured by the city’s buildings database; informal activities may take place in established storefronts, in makeshift storefronts, on the street, or in private homes. Based on observation, it is likely that at least some retail activity and service provision occurs in informal buildings—based on the proportion of informal sector workers, perhaps as much as 10-20% of these types of activities. To the extent that informal businesses exist, they are more likely in township areas, where residents are more likely



to be lower-income and nonwhite. Therefore the accessibility measures I calculated most likely underestimate accessibility to retail and possibly office locations for lower-income and nonwhite residents. It is worth noting, though, that informal retail and services are still less prevalent in South Africa than in many developing countries.

### Accessibility when? Selecting time frames

My analysis focused on accessibility during the morning peak period. Although the morning peak admittedly captures only a portion of the full accessibility picture, it is the most meaningful because travel in Cape Town is highly concentrated in the morning. According to the 2013 HHTS travel diary, 88.6% of trips for school and work began 5AM-9AM. Compared to other cities, Cape Town's travel demand is unusually highly peaked in the morning; TomTom's global Traffic Index suggests that whereas the vast majority of cities experience their highest road-based congestion levels in the evening peak, in Cape Town the morning commute is the most congested period (TomTom 2016). These data suggest there is a very high demand for travel in the morning, and that travel conditions in the morning are likely a limiting factor for Capetonians' ability to meet travel needs, especially for work and school travel.

Another reason to consider morning travel is that it is the time period for which the most data are available. The minibus rank surveys, from which I derived the minibus service frequencies and wait times, were conducted mainly in the weekday morning and evening peaks, with the most observations in the morning between 7AM and 9AM. Very little data on service frequencies are available for other times of day. Additionally, aside from the trip diary portion, the main HHTS survey only asked respondents about their travel in the AM peak. The City of Cape Town's data collection efforts, through the HHTS and rank surveys, have focused mainly on the morning peak, which reflects the City's concern with designing a service to meet the needs of commuters.

One might argue that my focus (and the City's) on the morning peak may overlook temporal variations in accessibility, which are especially important for non-work travel. In the Cape Town HHTS travel diary, 52.9% of shopping trips were in the evening peak period and 42.7% were during weekday middays. Yet since serving morning-peak commuters was a central goal of MyCiTi reforms, an assessment of progress toward this goal is certainly important.

In some cities, informal modes might operate during off-peak periods, when formal services designed for commuters might not. This is not exactly the case in Cape Town, however, because the minibus taxis typically operate for fewer hours each day than does MyCiTi. Although operation times vary by route and area of the city, typically taxis begin operations around 4:30AM, while the first MyCiTi routes begin at about 5AM. However, on most routes, taxis stop around 7-8PM, because it's perceived as unsafe to operate later. MyCiTi, in contrast, runs until 9-11PM, even in areas perceived as unsafe. Direct comparisons between MyCiTi and minibuses regarding time of day are complicated, though, because while minibuses might stop operations in the early evening, it's common for employees who must

end work later to travel home by minibuses chartered by their employer (although usually still paid for by the employee). This provides another reason for my analysis to focus on the morning peak: the minibus-BRT comparison is more straightforward.

In terms of longer time frames, I estimated a set of accessibility scores for two time periods: before MyCiTi (in 2010/2011), and after MyCiTi (2015/2016). Each time period spans two years because the data sources from which I drew vary slightly in their time coverage.

### **Accessibility by what modes?**

I calculated accessibility indices for minibus taxi and MyCiTi only. Other travel modes—car, conventional bus, and train—also contribute to the mobility picture but could not be included in the analysis due to data and resource limitations. I will elaborate on the role of these travel modes in the survey-based analysis (see Chapter 6), which does consider accessibility by all modes.

## **Data sources and pre-processing**

### **EMME/2 Travel Model Files**

I obtained information about the transportation network from ESRI shapefiles of street segments and intersection nodes in the taxi network, which the city originally created for its four-step travel demand model created by the EMME/2 software. Importantly, these included a street segment shapefile that defines the complete street network topology for the city. The street segment table contained information about each segment length, the street type, the transport modes which operate on that segment, and the segments to which it is connected. The street network is directional, meaning it provides a link from one intersection node to another. I visually inspected the street network files to ensure they accurately represent actual street network. The EMME/2 files also included a shapefile defining minibus taxi routes and a morning peak period headway for each. I was not able to verify how the route headways were defined and whether they were accurate; hence, I used other sources to define route headways where possible (see section 5.2).

### **Taxi rank surveys**

Data on minibus taxi supply comes from the City of Cape Town’s taxi rank surveys, which are typically conducted twice annually on a selection of taxi ranks. In the Cape Town context, taxi ranks are designated areas for taxi queuing, and are usually terminal points for routes. To conduct the rank surveys, fieldworkers stationed at a rank manually record each vehicle that arrives or departs, along with the time, the taxi license number, the number of passengers, the fare for that trip, and the vehicle’s origin (for arrivals) or destination (for departures). Data are collected during peak periods and sometimes throughout the entire day. Fieldworkers also record the queue length and waiting time for particular taxi

destinations at regular intervals. Queue lengths were determined by counting the number of passengers in line every 15 minutes for a period of 3 or more hours on a given day.

Data are available from 2011 to 2015, which makes these surveys useful for assessing changes in taxi supply over time. There are some limitations, however. Importantly, data are only available for a sample of taxi ranks and times, and information on how this particular sample was selected is not available. It's unclear whether or not the sample strategy changed between 2011 and 2015. Another limitation is that, although many records include origin and destination, there is no information on what specific route was taken, or whether the vehicle stayed on the designated route at all. Most routes are uniquely defined by their origin and destination, but some routes with the same origin/destination vary in their intermediate points.

To prepare these data for analysis, I first cleaned the origin and destination fields (many were misspelled). While fieldworkers were supposed to record vehicles' origin or destination, more than half the records are missing this information. However, upon inspection I could not find any systematic patterns in the missingness of origin and destination information. I then filtered only for arrivals during the morning peak period, defined as weekdays 6AM-9AM. After filtering, I was left with 35,209 observations, where each observation is a vehicle arrival. For queue length, the filtered data contained 3,149 observations, where each observation is a 15-minute interval.

### **Land use activities**

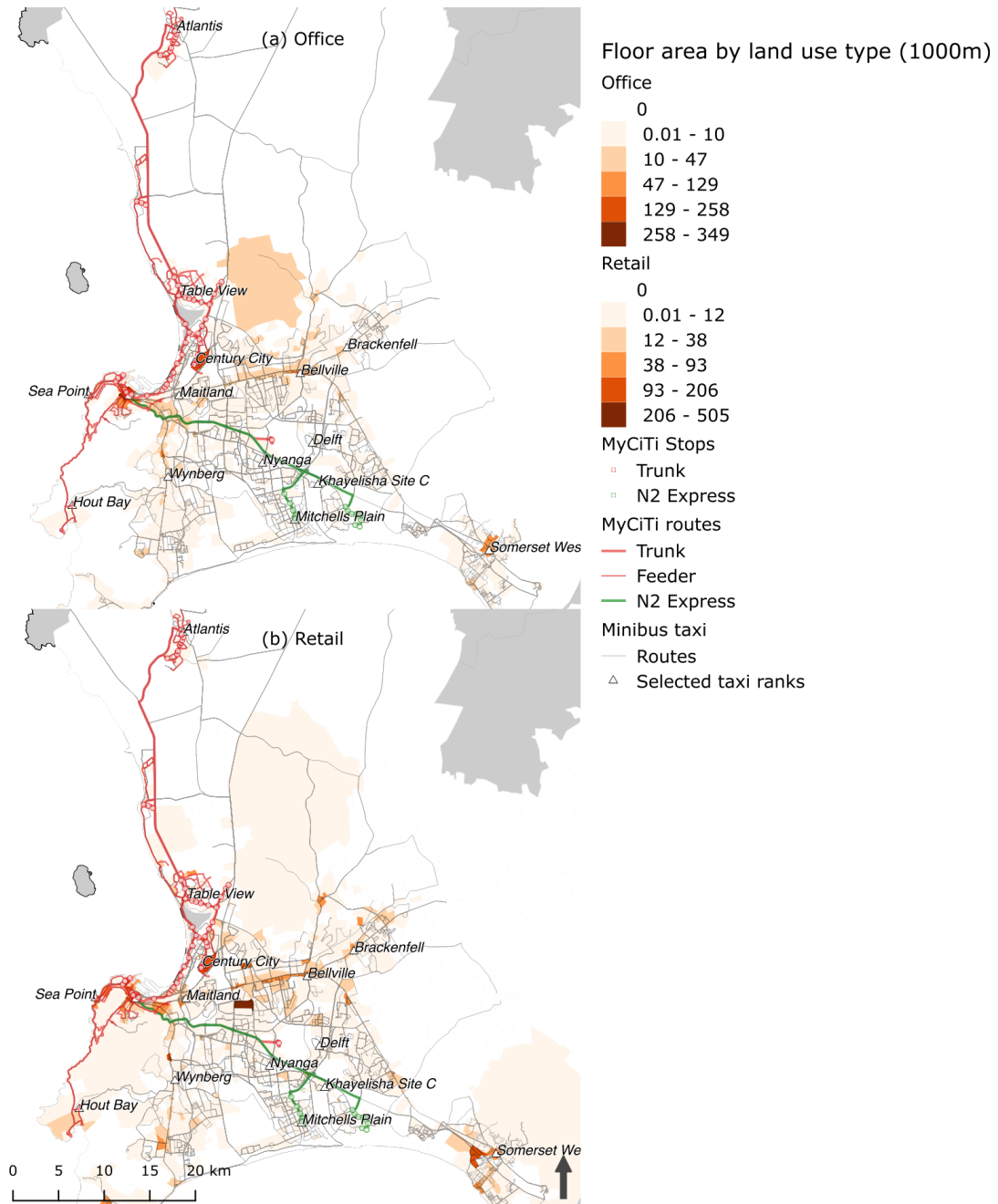
The accessibility analysis uses information on potential destination locations supplied in land use data collected by the City. The City made available the land use shapefile used in its travel demand model. This file holds the amount of non-residential leaseable gross floor area by type (e.g., office space, retail, warehouse, civic uses) in each TAZ in the year 2013. The data comes from a database of all buildings in the city.

Figure 5.1 shows the spatial distribution of office, retail, and hospital uses. Office uses are clustered in the city center, in the Century City development, and along a couple of the major arterials. Retail use is concentrated in these areas too, as well as in other zones with shopping centers, such as Wynberg, Mitchell's Plain, and Somerset West. As we would expect, hospital use is concentrated in the few zones with large hospitals.

### **Census**

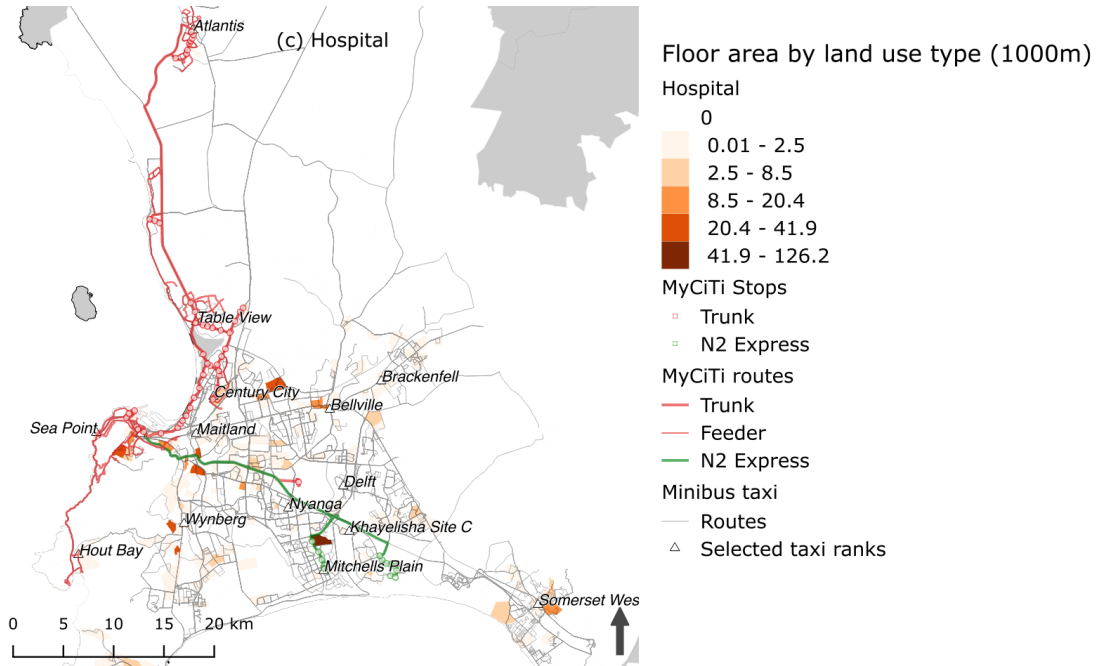
Population and socio-demographic data come from the national census, a household-based survey conducted by Stats SA every ten years. For this analysis I used the most recent data, collected in 2011. The census includes information about individuals, households, and dwellings, including basic demographics (age, gender, race, household size), socioeconomic status (education, employment status, household income, vehicle ownership), and housing characteristics (dwelling type). It notably does not include any information about employment location or travel to work. For this research, I used data at the smallest available

Figure 5.1: Land use activities by type



Source: City of Cape Town

Figure 5.2: Land use activities by type



Source: City of Cape Town

spatial unit, the Small Area Layer (SAL), which in Cape Town has an average population of 1,401 and an average area of 0.42 sq. km.

## Estimating travel times

In order to compute the accessibility score in Equation 5.3, I needed to estimate travel times by minibus taxi and MyCiTi between each pair of TAZs. Assuming land use remains constant, travel time estimation is the most critical and most complex element of the accessibility model. The travel time for each mode can be expressed as:

$$\hat{t}_{ij} = \sum_l t_{access,ij} + \sum_k t_{wait,ij} + \sum_k t_{in-veh,ij} \quad (5.4)$$

where  $\hat{t}_{ij}$  is the estimated total travel time from zone  $i$  to zone  $j$ ,  $t_{access,ij}$  is the access (walking) time required to reach the stop,  $t_{wait,ij}$  is the expected wait time, and  $t_{in-veh,ij}$  is the expected in-vehicle travel time. The travel times are summed over all the legs in the trip, denoted by  $k$  for transit and  $l$  for walking, where  $l = k + 1$ .

As I will discuss in the following sections, I estimated minibus taxi travel time using my own model, while MyCiTi travel times were supplied by Google Maps.

### Minibus taxi travel time model

My basic approach to estimating taxi travel time was to first construct a network graph representing the minibus taxi network, and then find the shortest path between each pair of zones. To simulate the nature of minibus taxi service, I used a novel network structure that represents both travel along road segments and transfers between routes in a single graph.

In building this model, I made the following assumptions:

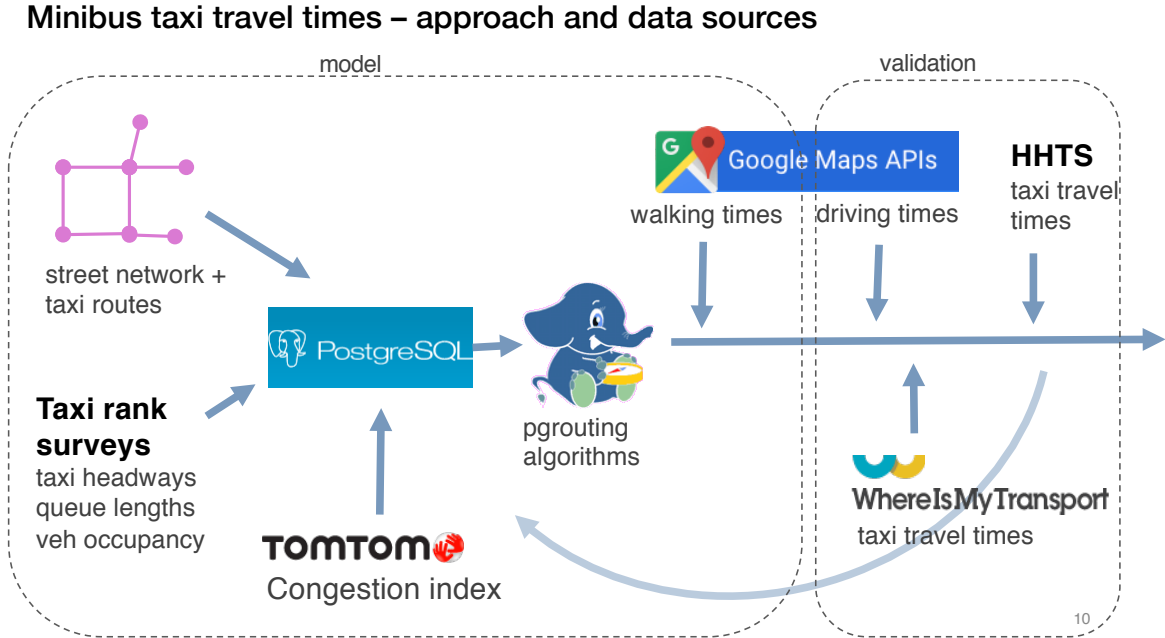
- Taxis operate along defined routes and do not deviate from those routes. This is fairly close to how the taxis in Cape Town operate, although in reality taxis do occasionally deviate from routes, although more often in the off-peak than during peak hours.
- Passengers use the route(s) with the shortest total travel time.
- Taxis can stop to pick up or drop off passengers at any node along the route, except along highways. This is fairly close to how they actually operate.
- Passengers choose points at which to board and alight from taxis by trading off distance from their origin or destination to that point and the number of taxi routes available at that point.
- Access time is by walking and is the street network distance from the origin or destination point to the chosen taxi route.
- At taxi ranks (i.e., at terminal points in a route) wait time is a function of the route's headway and the expected queue length.
- Along routes (i.e., not at terminal points), wait time is a function of the route's headway and the expected probability of the next vehicle having a vacant seat.
- Passengers can transfer to another route at any node where the routes intersect, except along highways. This is pretty close to how transfers work in practice. Of course, taxi ranks are more common transfer points.
- Passengers can transfer from one route to another by walking between them.

The model finds the shortest path from one zone to another by minimizing the sum of in-vehicle time, waiting time, and transfer access time. I used the shortest path algorithm provided by pgRouting, an extension to PostgreSQL/PostGIS.

Figure 5.3 shows how the model's various components interrelate. Broadly speaking, the model first estimates taxi travel times for each street segment using an initial set of parameters, then parameters are adjusted by comparing estimates against validation data. In a sensitivity analysis, I reran the model with different parameters representing different cases. The remainder of this section will describe each component in more detail.

Why build this model rather than simply use the travel times from the City's EMME model? The simplest reason is that I did not have access to the EMME model and therefore

Figure 5.3: Modules in the minibus taxi travel time and accessibility model



I could not simulate the travel time effects of removing taxi routes. My model also improves upon the existing official model in a few ways. First, it explicitly allows passengers to board and alight taxis not just at taxi ranks and terminals, but most places along the route, which is a more realistic assumption. It also explicitly accounts for vehicle capacity. Additionally, it uses information about actual levels of taxi supply post-MyCiTi, whereas the City’s EMME model assumed taxi levels would remain the same on routes unaffected by BRT.

**Network topology for the taxi system** Because pgRouting was designed for simple road networks, not transit, using it to calculate travel times for the taxi network required manipulating the network topology. Like most path-finding algorithms, the package’s functions are written for a network graph with set of street segment “links” connecting a set of intersection “nodes.” Each link is assigned a weight that represents the cost of traveling along that link. Because links can only hold one weight for each direction and nodes cannot hold

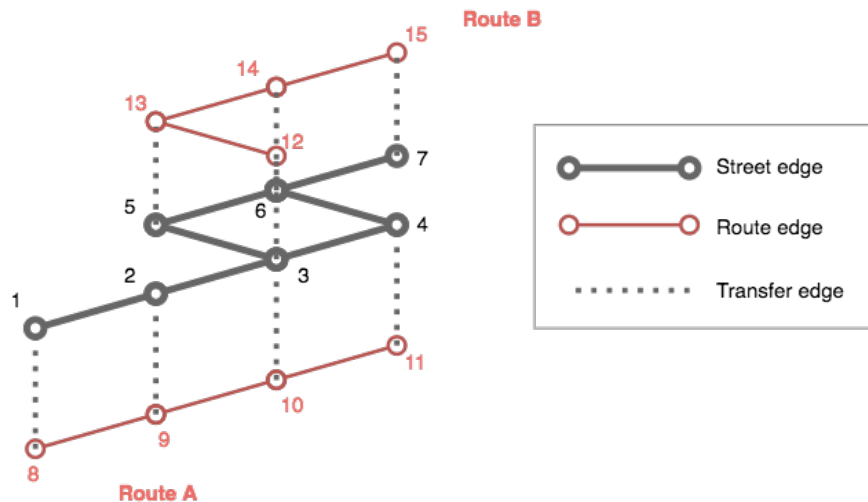
weights at all, a conventional street network graph, on its own, cannot contain information about transit routes or transfers.

In order to represent routes and transfers in the minibus network, I defined three types of links: *street links*, *route links* and *transfer links*. *Street links* simply represent physical street segments. Each *route link* represents a taxi route that operates along a street segment. These links geographically correspond with street segments, and when multiple routes operate along a given street, there will be multiple route links occupying the same geographical space. One can think of route links as virtual street networks overlaying the “real” street network. Each *transfer link* represents a connection from one route to another. Because passengers can transfer from one vehicle to another anywhere along the route, transfer links occur at each node where routes overlap.

The weight of each link represents generalized cost, and can in theory include time, money, disutility, or any other cost defined by the user. In this application, I considered time cost only, thus the weight of each link represents the time required to travel that link. For route links, the time-cost is the time it takes to traverse the street segment, a function of speed and distance. For transfer links, the time-cost is the expected wait time for the route to which one is transferring. Since I assumed people access taxi routes by walking, the time-cost for street links is the time to travel that segment by foot.

The graph is bi-directional, meaning each link can only be traversed in one direction, allowing for different costs assigned to each direction. Bi-directional analysis is appropriate for peak-hour estimation when traffic may slow speeds in one direction. To represent the bi-directional nature, each street segment is represented by two links, one in each direction.

Figure 5.4: Idealized minibus taxi network graph.



A representation of the taxi graph is shown in Figure 5.4. One can think of the thin-lined “route links” as a layer on top of the thick-lined “street links.” The layers are connected by the dotted “transfer links.” Imagine a passenger traveling from node 1 to node 7. They



would begin by waiting for a Route A taxi at node 1. The edge 1-8 represents the waiting time for Route A. They would then take the Route A taxi from node 8 to node 9 and 10, then transfer through node 3 to the Route B taxi. The Route B taxi travels from node 12 to 15, at which point the passenger would arrive at node 7. All links in this diagram are bidirectional.

I began by preparing the taxi network graph in a PostgreSQL database. Details of the network preparation are available in Appendix A. In addition to the taxi network, I also prepared a network representing travel by car that consisted only of street links. This was necessary because, for data availability reasons, I used travel time by car to estimate the congestion delay. Travel times by car do not figure into the final results, except for use in the validation step.

**Estimating taxi in-vehicle travel time** For street links and route links, the time-cost of each link equals the time needed to travel that segment, or distance divided by speed. Distance is defined by the link length, while speed varies according to road type and traffic conditions, and requires estimation. My general approach to estimating speed was as follows. First, I defined the free-flow travel speed for each link based on road type, since different road types are designed for different speeds. Second, I defined a linear parameter, the “congestion delay factor” to represent the reduction in speed due to congestion. I estimated values for this factor by validating travel times calculated for the car network against travel times obtained from Google Maps. I compared my estimated values for congestion delay against those provided by the TomTom Traffic Index.

I assumed the speed accounting for traffic along road segment  $s$  at a given time of day can be expressed as

$$speed_{s,traffic} = \theta * speed_{s,free-flow}; 0 < \theta \leq 1 \quad (5.5)$$

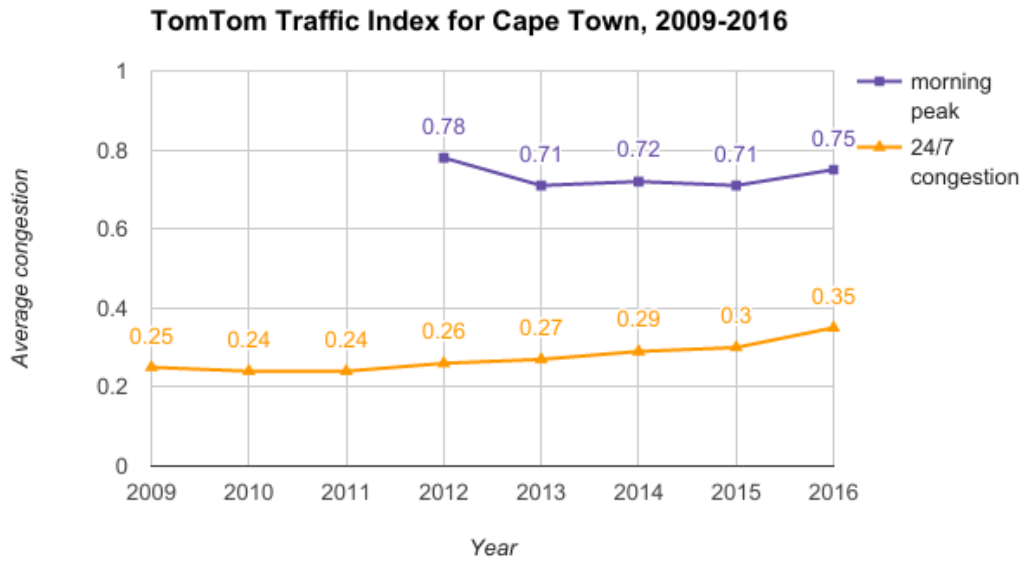
where  $\theta$  is a parameter that I call the congestion delay factor. To estimate the value of  $\theta$ , I used the Google Maps’ traffic model, which relies on historical traffic data to estimate typical travel times at a given time and place. With estimated driving times from my car network model compared with the Google Maps driving time data for validation, I found values of  $\theta$  that minimized the root mean squared error (RMSE) while also keeping the mean error near zero. Details of the travel speed estimation are provided in Appendix A. The estimated values are shown in Table 5.1, of which the best (the baseline) results in an RMSE of 6.55 and a mean error of -0.60. To account for uncertainty in congestion levels and consequently travel speeds, I also ran calculations using values 10% higher and 10% lower than the baseline.

Since I only had current Google Maps traffic data, I had to use a different source of data for congestion levels in 2011. The best available data with which to compare congestion levels in Cape Town in 2011 versus 2015 is the TomTom Traffic Index. This index is a metric that TomTom has computed for cities worldwide since 2009 using GPS vehicle data from customers of its navigation service (Cohn 2014). The traffic index is the “percentage

Table 5.1: Estimated values for the congestion delay factor

Model version	Congestion category				
	1 (light or no traffic)	2	3	4	5 (heavy traffic)
Baseline (best estimate)	0.8	0.6	0.4	0.35	0.3
Low estimate	0.72	0.54	0.36	0.315	0.27
High estimate	0.88	0.66	0.44	0.385	0.33

Figure 5.5: Congestion index for Cape Town 2009-2016



*Morning peak index not available before 2012. Source: TomTom Traffic Index*

of extra travel time experienced by drivers in that city, 24/7 for the given calendar period, when compared to the free flow travel times” (Cohn 2014, p. 4). The index is weighted by the number of vehicle observations on each road segment. According to TomTom, the overall average level of congestion in Cape Town has increased from 25% in 2009 to 35% in 2016, with a large jump between 2015 and 2016 (Figure 5.5). However, the congestion level during the morning peak has remained relatively steady at over 70% since 2012 (morning peak data before 2012 are not available). Since my model focuses on the morning peak, it is fair to assume the congestion levels, and hence  $\theta$  values, have not changed over the study period.

The right-hand columns in Table 5.2 show the Traffic Index converted into the delay factor  $\theta$ . As one can see, the average citywide delay parameter during the morning peak is around 0.56 to 0.59, not too different in magnitude from the values I calculated.

Table 5.2: Congestion index for Cape Town and translated to the congestion delay factor

Year	TomTom Traffic Index		Congestion delay factor, $\theta$	
	Morning peak	All-day	Morning peak	All-day
2009		0.25		0.80
2010		0.24		0.81
2011		0.24		0.81
2012	0.78	0.26	0.56	0.79
2013	0.71	0.27	0.58	0.79
2014	0.72	0.29	0.58	0.78
2015	0.71	0.3	0.58	0.77
2016	0.75	0.35	0.57	0.74

The TomTom data are only available citywide; from these data it’s not possible to isolate congestion changes in the MyCiTi corridor. To check if MyCiTi may have lessened congestion on roads in that corridor, I compared 2016 driving times by car obtained from Google Maps with the City of Cape Town’s estimated driving times by car for 2010. Even though these datasets come from different sources, there is no reason to suspect systematic bias in favor of a certain part of the city. I randomly sampled driving times between zones within the MyCiTi trunk corridor and compared them with driving times between a “control” set of zones sampled from outside the corridor. If MyCiTi did help to reduce congestion, as was intended, we would expect either a greater reduction in travel time in the MyCiTi corridor compared with the control sample, or a smaller increase in travel time compared with the control sample. In fact, I found the opposite: travel times actually increased more in the corridor than outside. (See the appendix for details on these numbers.) This does not prove MyCiTi had no impact on congestion, because I did not consider a proper counterfactual—e.g., population may also have grown much more in the MyCiTi corridor. Nevertheless, it does provide evidence that using a single congestion index for the city is appropriate.

The TomTom index has some other limitations. Although GPS data has been shown to be accurate as a measure of travel speed and congestion level, it’s possible the TomTom data in the Cape Town case are not consistently representative of the entire city. Specifically, since the index is weighted by the number of vehicle observations on each road segment, if the TomTom GPS user rate is systemically greater in some years or in some parts of the city, congestion in those years or areas might be overestimated. The observed increase in congestion index might be due not to actual increased congestion, but greater GPS penetration in congested parts of the city.

Having estimated the travel speeds, I calculated an in-vehicle travel time for each route link in the network according to the equation:

$$t_{s,p,in-veh} = \frac{dist_s}{\theta * speed_{s,p,free-flow}} \quad (5.6)$$

where  $t_{s,p,in-veh}$  is the in-vehicle travel time for road segment  $s$  in time period  $p$ . In the taxi

network, the in-vehicle time applies to route links only.

Another limitation is that this approach assumed, on a given road segment, minibus taxis and cars have the same travel speed. Since minibus taxis likely travel more slowly than cars due to making frequent stops, it is likely that my model slightly underestimates in-vehicle travel times. (Although wary taxi passengers would say drivers often speed up between stops to make up for lost time!)

**Estimating taxi wait times** Passengers can board a vehicle either at a taxi rank, where the wait time is a function of the headway and queue length, or along the route, where wait time is a function of headway and seat availability. Taxi nodes in the network model are therefore labeled as either a taxi rank or not, with a different wait time function applying to each.

I assumed vehicle capacity is 15 passengers, the standard minibus taxi size in Cape Town. According to the taxi rank survey data, only about 5% of vehicles have more or fewer than 15 seats. Drivers overload vehicles very infrequently—only 1.5% of vehicles recorded in the rank taxi surveys were over capacity—so the number of seats accurately represents vehicle capacity.

**Queue length and wait time** Consider the case of boarding at one of the 309 taxi ranks in the network. At a rank, passengers might have to wait in line, wait as the vehicle fills, or wait for a vehicle to arrive. In the morning peak commute, demand exceeds vehicle supply on most routes, so the wait time is most likely to be spent waiting in line or waiting for the vehicle to arrive, and is thus a function of queue length and headway. Let us assume vehicles arrive at the taxi rank at a constant rate, determined by the headway  $h$ , and passengers arrive randomly. Then a given passenger has a uniform chance of arriving at any time in the interval between vehicles and, if there is no queue, the expected wait time is simply  $\frac{h}{2}$ . If there is a queue of, say 20 people, and the vehicle capacity is 15, the passenger will have to wait for the next vehicle: the expected wait time is now  $\frac{h}{2} + h$ . If the number of people in exceeds the capacity of two vehicles, we must add an additional headway to the wait time, giving  $\frac{h}{2} + 2h$ .

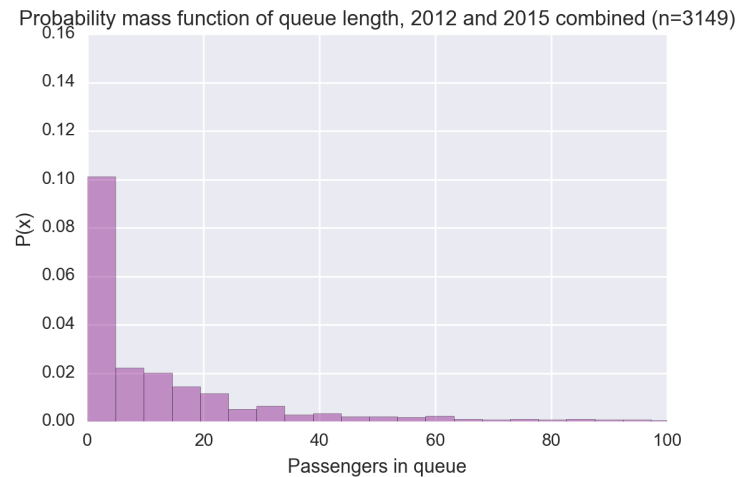
Formally, we can write the wait time as a function of the queue length  $q$  at the time the passenger arrives. Then the expected wait time at a rank is given by:

$$t_{wait,rank}^{\hat{}} = \frac{1}{2}h + h \sum_{n=1}^{\infty} nP(nc \leq q \leq (n+1)c) \quad (5.7)$$

where  $t_{wait,at-rank}^{\hat{}}$  is the expected wait time for the rank,  $c$  is the vehicle capacity, and  $n$  is an integer representing the number of vehicles that must arrive before the passenger can board. The probability given by  $P(nc \leq q \leq (n+1)c)$  is the area under the probability mass function (pmf) of  $q$  between  $nc$  and  $(n+1)c$ .

I obtained the queue length distribution from the city’s taxi rank surveys, which provides queue lengths for a sample of ranks at given periods in the years 2012 and 2015. (The queue length data were not available for 2012.)

Figure 5.6: Probability distribution for queue length, 2012 and 2015 combined, AM peak only



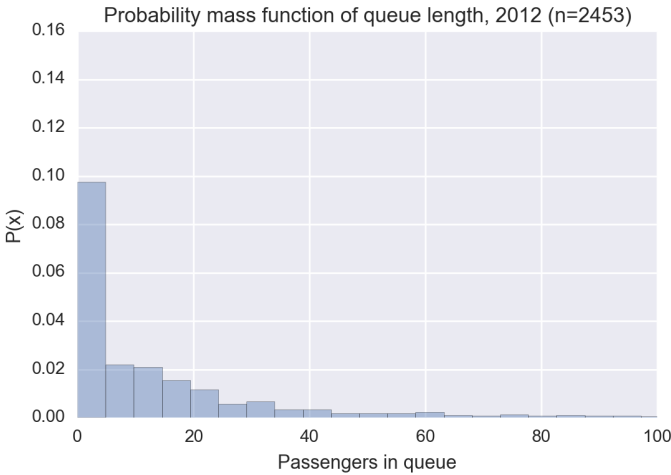
*Source: City of Cape Town taxi rank surveys*

The overall probability distribution for queue length, filtered for morning peak, is shown in Figure 5.6. The figures suggest that in 2015, ranks were slightly less likely to have a queue, compared to 2012. This shift is consistent with the hypothesis that taxi ridership fell from 2012 to 2015 due to passengers shifting to MyCiTi or private car, while the supply of taxi vehicle did not change—if this is the case, then we’d expect lines to be shorter. However, because rank survey sampling differed in the two years, it’s not possible to conclude that queues actually did become shorter. Further, for queue lengths of greater than zero, the distribution between 2012 and 2015 is not that different.

Using Eq. 5.7 with the queue length probability distribution, the average expected wait time in 2012 and 2015 combined at taxi ranks is  $0.93h$ . In other words, a passenger arriving at a taxi rank in the morning peak should expect to wait almost a full headway to board a taxi. If we just use the 2012, data, the value is  $0.94h$ , while with 2015 data it is  $0.88h$ . In the base model, I use separate values for 2011 (actually using 2012 data) and 2015. In the sensitivity analysis, I used the value for both years combined.

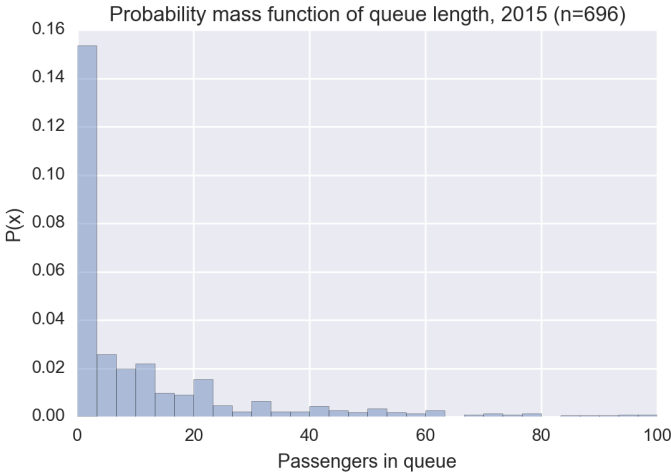
Using a single queue length probability distribution for all routes likely overestimates travel times for low-demand routes because high-demand routes tend to have both longer queues and low headways; the line is long but it moves fast. Low-demand routes are likely to have little or no queues. Using an “average” probability distribution would assign longer queue lengths to low-demand routes, thus overestimating travel time. Unfortunately, the

Figure 5.7: Probability distribution for queue length in 2012



Source: City of Cape Town taxi rank surveys

Figure 5.8: Probability distribution for queue length in 2015



Source: City of Cape Town taxi rank surveys

surveys report data by rank, not by route, and so it's not possible to estimate queue lengths for each route separately. The queue length does vary somewhat by rank, and although I could have assigned different queue lengths to different ranks, it would not be meaningful because I could not assign them to the correct route.

**Seat availability and wait time** When boarding a taxi along the route, passengers have to wait for a vehicle to arrive, and then can only board if a seat is available. Assuming passengers arrive randomly and vehicles arrive at a constant rate, the expected wait time is  $\frac{h}{2}$ , if a seat is available. If no seats are available, the passenger must wait for the next vehicles and wait time is  $\frac{h}{2} + h$ .

In theory, one could be so unlucky that all vehicles passing are full. In reality, there is some limit to the time a passenger would wait, so we can write the equation as:

$$t_{wait,route}^{\hat{}} = \frac{1}{2}h + h \sum_{n=1}^{n_{max}} n(P(seats = 0))^n \quad (5.8)$$

where  $n_{max}$  is the maximum acceptable number of vehicles that pass. In these calculations, I assumed  $n_{max}=5$ . (The probability of having to wait for more than 5 vehicles to pass is very low.)

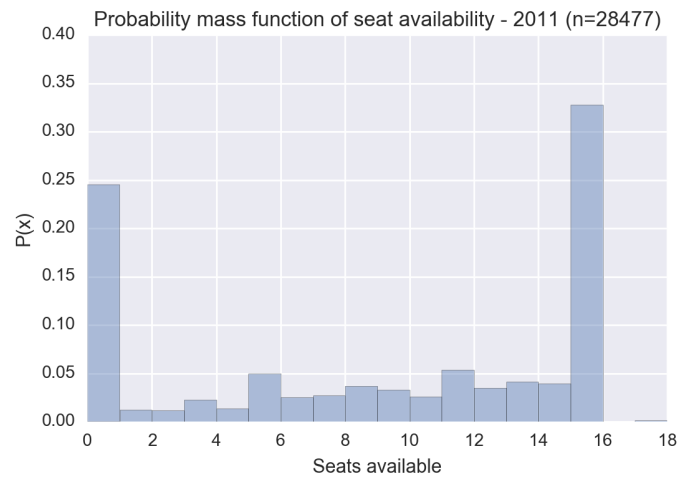
I calculated the probability of seat availability from the city's taxi rank surveys, which recorded the number of passengers in each vehicle upon arrival at the taxi rank, and assumed the distribution of vehicle occupancy upon arrival at taxi ranks is the same as the distribution along the route. This is a reasonable approximation because sometimes drivers leave a rank before a taxi is full, as they expect to pick up passengers en route, and it's common for some passengers to alight before the terminal stop.

The probability distribution of the number of seats available is shown in Figure 5.9. The data reveal a slight shift in seat availability between 2011 and 2015, as  $P(seats = 0)$  citywide declined from 0.25 in 2011 to 0.14 in 2015. Might this apparent shift be due to different samples, rather than to actual changes in vehicle occupancy levels? Restricting the sample to only the central Cape Town taxi rank,  $P(seats = 0)$  showed the same trend, decreasing from 0.28 in 2011 to 0.12 in 2015. The apparent trend of increasing seat availability makes sense if we hypothesize the number of taxi passengers between 2011 and 2015 fell, as more switched to MyCiTi or driving, while the supply of taxi vehicles did not change. However, not all ranks experienced the same trend, and since the sampling times and locations in each year were not identical, we cannot conclude the seat availability levels actually decreased. To deal with this uncertainty, in the sensitivity analysis I consider both possibilities.

Using the values for  $P(seats = 0)$  in Eq. 5.8, we find that the expected wait time on a route for both years combined is  $0.79h$ , with a value of  $0.69h$  in 2015 and  $0.82h$  in 2011. In other words, we expect passenger hoping to board a taxi along a route with a headway of 10 minutes to wait for an average of 6.9 to 8.2 minutes.

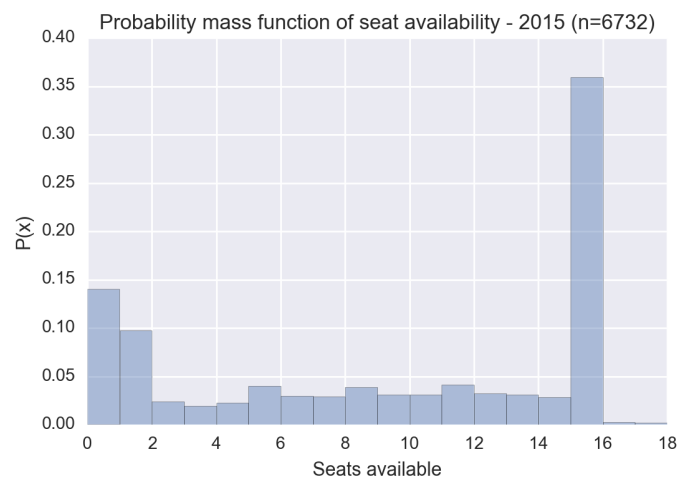
As with the queue lengths, I used a single probability distribution for seat availability in each year. As we can see in Figure 5.11, seat availability does in reality vary somewhat by

Figure 5.9: Seat availability probability distribution for all ranks, 2011, AM peak only



Ranks with fewer than 20 observations omitted. Source: City of Cape Town taxi rank surveys

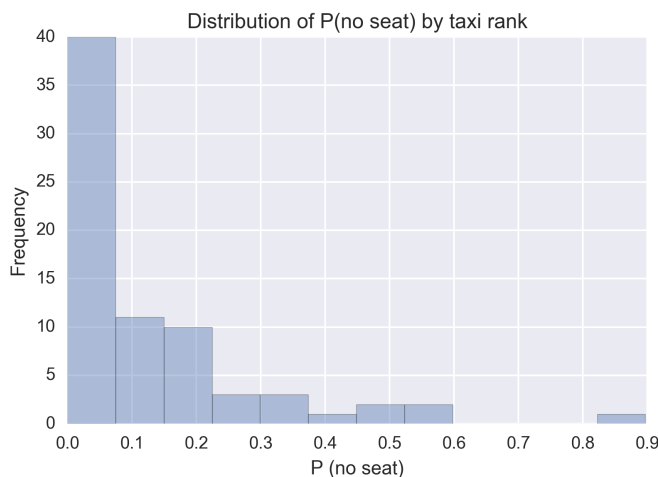
Figure 5.10: Seat availability probability distribution for all ranks, 2015, AM peak only



Ranks with fewer than 20 observations omitted. Source: City of Cape Town taxi rank surveys



Figure 5.11: Distribution of the probability that no seats are available, by taxi rank, 2011 and 2015 combined



Ranks with fewer than 20 observations omitted. Source: City of Cape Town taxi rank surveys

taxi rank; at most taxi ranks, the likelihood of arriving vehicles being full is low, but there are a few exceptions where vehicles often arrive full. However, we are more interested in the seat availability along the route rather than at the rank, and unfortunately we have insufficient information to assign a probability to each route individually. Although the rank surveys do record an origin and destination for each vehicle along with the vehicle occupancy, the data only represent a small fraction of routes. Nor does there appear to be any clear spatial pattern to seat availability. Therefore the best guess is the average probability of there being a seat available, acknowledging that this assumption ignores some of the variability in vehicle occupancy.

**Taxi headways** Route headways come from two sources of information: the taxi routes shapefile from the city’s EMME/2 model and the vehicle counts provided by the city’s taxi rank surveys. The EMME/2 file provides a headway for each route in 2010. The original source of these data is unclear—they may be derived from taxi rank surveys and local knowledge—so I compared the headways I calculated from raw taxi rank survey data. The rank surveys include a record for each vehicle that arrives at or departs a taxi rank within the observation period, along with that vehicle origin or destination. Assuming a route is defined by the origin/destination pair, I calculated the frequency by route as the number of vehicles per hour. The headway,  $h$  is then simply  $1/frequency$ .

As shown in Table 5.3, the headways calculated from the rank survey data are on average lower than those in the EMME/2 data, likely because the rank surveys were more likely to select highly-used routes. When the headways are compared by route, the EMME/2 and

Table 5.3: Summary statistics of minibus taxi headways (in mins) in the AM peak, all routes

	Rank surveys		EMME2
	2011	2015	2010
n obs	244	102	1419
mean	13.2	8.2	23.5
std dev	13.3	8.1	19.7
min	0.6	0.9	1.0
25% quartile	4.4	3.2	9.0
Median	9.2	6.3	15.0
75% quartile	15.0	10.0	36.0
max	60.0	60.0	60.0

*Source: City of Cape Town taxi rank surveys*

rank survey headways are closer in magnitude, although there still are some discrepancies, which I resolved by more closely inspecting the data. More details on this methodology are in Appendix A. The model also reflects potential changes in taxi headways from 2011 to 2015, by using taxi rank data from each year. I found change in headways on some routes, and these changes are reflected in the model. In other words, in the model some routes have a different headway in 2015 than in 2010.

**Estimating access time** Passengers in the model access taxi routes by walking. I calculated walk times at the origin and destination ends of the journey using travel times from Google Maps. Each origin and destination point is the centroid of their respective TAZ; hence the access time is the walking time between the centroid point and the taxi node. To choose the taxi node, I assumed passengers consider both the distance to the node and the number of routes served by that node. For details on this calculation, see section 8.7 in Appendix A. Walk times are calculated via Google Maps with the TAZ centroid as one end and the taxi node as the other. To my knowledge, Google Maps is the most complete source for walk times in Cape Town. I also considered using Open StreetMap, which in some cities has been found to more complete and up-to-date for pedestrian networks. However, I found in Cape Town that Google Maps had more complete representation of streets in informal settlement areas than did Open StreetMap.

Walk times when transferring between taxi routes are already included in the taxi network model, where they are represented as street links. I assumed walk speed is 3mi/hr (4.8km/hr).

**Taxi travel time validation** Having estimated taxi travel times using the model, I needed to evaluate the quality of the results. For validation, I used two separate data sources: the

2013 Cape Town HHTS and the WhereIsMyTransport API. Both are imperfect sources for validation, but taken together they provide an approximate gage of model quality.

The Cape Town Household Travel Survey (CT HHTS) was conducted by the city in 2013 for transportation planning purposes and included a face-to-face household survey with  $N=22,332$  (approximately 2% of total households). The household survey collected information on individual-level and household-level work or school travel behavior, as well as socio-demographic characteristics. Data are available at the travel analysis zone (TAZ) level. Zones are sufficiently small to enable spatial analysis; the 1,787 TAZs have an average area of 2.19 sq. km. and on average approximately 1,700 households, with an average of 34 (2%) households sampled in each TAZ.

I pre-processed the CT HHTS data so that it represented average total travel time for morning commute trips made by taxi or a combination of walking and taxi. I first filtered only for trips made by taxi, with no modes other than walking, and for trips that began during the morning peak period. I grouped travel times by origin and destination TAZ, producing average travel times by TAZ pair, for a sample of 2,816 TAZ pairs.

Since travel times are self-reported, their accuracy is somewhat questionable. Further, many respondents rounded to the nearest 15 minutes. This imprecision is not detrimental, however, because the accessibility score responds not to small differences in travel time, but only to whether a value is above or below the  $t_{max}$  cutoff. To address the imprecision in the HHTS data, I grouped both the validation and estimated values into bins with midpoints of 30, 45, and 60. Then, for each TAZ pair, I defined a variable equal to ‘True’ if both the validation and estimated value are in the same bin, and ‘False’ otherwise. Therefore the evaluation metric, which I call the ‘bin accuracy,’ is the percentage of observations correctly matched.

A more serious problem is that the data represent only trips actually taken, which introduces a selection bias within each zone that tends to underestimate travel time. To be concrete, imagine a zone in which all the taxi stops are located on one edge of the zone—a fairly typical situation. The taxi network model assumes passengers originate from the zone centroid and walk to the ‘best’ taxi stop, which happens to be on the zone’s edge. Especially if the zone is large, this might be a long walk, say 25 minutes. In reality, many people would consider a 25-minute walk too long, and either would not make that trip or would use a different travel mode. The HHTS is therefore likely to select for those travelers in the zone who live sufficiently near the taxi stop to such that a taxi trip is desirable, leaving out those who live further away. If a ‘reasonable’ walking time is 10 minutes, then we have a 15-minute difference between the model-estimated time and the survey-validated time. If the bias occurs on the destination end as well, we have a total error of 30 minutes. Since the HHTS does not specify the location of the trip origin and destination within the zone, unfortunately it was not possible to directly estimate the magnitude of the bias.

The South African company WhereIsMyTransport (WIMT) collected data in 2016 on Cape Town’s minibus taxi routes by manually traveling all of the city’s routes at various times of day. These data were used to create a model that is accessible through a public API, which returns estimated journey time by taxi, given a pair of coordinates. WhereIsMyTransport

(WIMT) is likely more accurate than the HHTS because travel time data were collected directly rather than through self-reporting. It is also not subject to the selection bias that affects the HHTS data.

One downside of WIMT is the travel time model available through the API is a ‘black box’—the user must trust the results are accurate. Furthermore, this model cannot be used to estimate all taxi travel times for the current analysis because it does not represent pre-MyCiTi taxi travel; however, it is useful for validation. Another limitation of WIMT is that the model only allows transfers between routes at taxi ranks, whereas in reality, and in my model, passengers can typically transfer between routes at any point. Therefore, it can provide validation only for journeys that do not involve transfers. To prepare the validation dataset, I manually selected a sample of TAZ pairs that, based on taxi route available, I knew would be direct routes. Because manual selection of TAZ pairs was necessary, I could use only a limited sample, 44 TAZ pairs.

The model performs relatively poorly in terms of the errors statistics (Table 5.4). When validated against HHTS data, the model for 2011 has a bin accuracy of 33%, and an RMSE of 34.7. On average, the model appears to overestimate travel times, with mean error of 11.3 minutes. The model does not perform much better when compared with WIMT data. However, in this case, the model substantially underestimates travel times: the mean error is -22.6 minutes.

Table 5.4: Summary of validation error statistics for taxi travel times (base model)

	HHTS data		WIMT data	
	2011	2015	2011	2015
n obs	1,854	1,854	44	44
mean error (mins)	11.3	9.9	-22.6	-23.9
RMSE	34.7	34.1	33.3	33.6
bin accuracy	33%	34%	25%	25%

When compared with HHTS data, the model appears to overestimate travel times, while compared against the WIMT data, the estimated travel times are too low. Which is correct? Most likely, neither the HHTS or WIMT is a very reliable source of validation data. In particular, the potential selection bias in the HHTS data produces poor validation metrics. To investigate this hypothesis, I plotted the validation error for each trip against the trip’s total walk time. The plot suggests errors do increase with walk times over 40 minutes, although when walk time is less than 40 minutes there does not appear to be a relationship. A spatial analysis of residuals revealed that trips beginning or ending in further-out zones had larger errors than in closer-in zones. Therefore, it does appear selection bias in the HHTS data is a problem. The source of error in the WIMT validation is harder to diagnose, since the main problem here is lack of transparency in how the data were collected and how travel times were modeled. Based on my personal experience with taxis in Cape Town, the WIMT seem quite high.

**Sensitivity analysis** In order to understand how changes in the input values would affect results, I performed a sensitivity analysis in which I varied values for the congestion delay factor and headways. I also varied the values for the headway multipliers that are a function of queue length and seat availability. Details of the sensitivity analysis are in Appendix A.

To account for the uncertainty in the headway values, I compared the lowest headway values in the three sets (the EMME/2 data, the 2011 rank surveys, and the 2015 rank surveys) with the highest values. I also consider the case in which headways remained constant from 2011 to 2015. Results suggested that although changes in these values affected the magnitude of accessibility scores, they generally did not change the relative accessibility between population groups, except for some land uses at the 45-minutes threshold. In both the at-rank and on-route cases, differences in the seat availability and queue length assumptions did not dramatically change wait times, especially when headways were low. For example, given a headway of 10 minutes, typical for many routes especially in the morning peak period, moving from an average value to year-specific values at most results in a difference in wait time of 1 minute. Even with a headway of 60 minutes, the change in expected wait time varies by about 6 minutes. The model is thus relatively insensitive to assumptions about queue length and seat availability.

In terms of seat availability, the base case uses two different values for 2011 and 2015. The alternative case assumes the probability of there being no seat available ( $P(\text{seats} = 0)$ ) is constant in both years, and is equal to the 2011 and 2015 combined value of 0.22.

The model results, in terms of accessibility scores, were more sensitive to changes in the congestion factor than to changes in headways or seat availability. For this reason, I spent more time calibrating the congestion factor, and less time on the headway values.

For the final calculations, in order to account for uncertainty in model parameters, I calculated accessibility scores using input values both 10% higher and 10% lower than the baseline, as shown in Table 5.5. The accessibility results are thus presented as a range of values. I also considered the possibility taxi headways, queue lengths, and seat availability did not actually change from 2011 to 2015, and instead the appearance of change is fully explained by differing rank survey sampling in the two periods. This possibility is represented by the ‘constant’ case.

### **MyCiTi travel time estimation**

To get travel times for MyCiTi for each pair of TAZs, I used the Google Maps API, which provides routing and travel time information based on transit schedules provided by the City’s transport authority. I made requests using a departure time of 7:45AM on a Tuesday, the same as when requesting data for the taxi travel time validation. Input coordinates were the coordinates of each TAZ centroid. I only included the 307 TAZs whose centroid was within 1 km of a MyCiTi stop. Zones outside the MyCiTi area were assigned accessibility scores of zero. The travel time results include transfer times between MyCiTi routes, for example, between trunk and feeder routes.

Table 5.5: Parameter values used in different model scenarios for sensitivity analysis

Model case	Congestion delay factor (by segment class)					Headway	Seat availability	Queue length
	Heavy		None					
Baseline (best estimate)	0.3	0.35	0.4	0.6	0.8	Use rank survey + EMME2 values	vary from 2011 to 2015 (0.82 to 0.69)	vary from 2011 to 2015 (0.944 to 0.877)
Low estimate	0.27	0.315	0.36	0.54	0.72	baseline * 1.1	same as baseline	same as baseline
High estimate	0.33	0.385	0.44	0.66	0.88	baseline * 0.9	same as baseline	same as baseline
Constant across years	0.3	0.35	0.4	0.6	0.8	Baseline, but use same values for 2011 and 2011	use same value in both years (0.79)	use same value in both years (0.929)

Access time was calculated as the walking time from the TAZ centroid to the nearest MyCiTi stop (and the reverse for destinations). The Google model automatically accounts for access time and any transfer time. However, the Google model assumes the passenger times his or her departure precisely so as to minimize wait time. A more realistic assumption is that passengers partially time their departures to fit transit schedules. For example, a passenger taking a bus that comes reliably every twenty minutes might try to arrive at the stop five minutes before scheduled departure, while for high-frequency routes he or she might not time their departure at all. Thus passengers do not arrive randomly, but such that the average wait time is less than half the headway. Given that morning peak headways for MyCiTi are nearly all less than or equal to 15 minutes, an expected wait time of 5 minutes is a reasonable assumption; I added 5 minutes to each transit time.

During the morning peak, long queues can form at some MyCiTi stations, particularly those on the trunk route, such that passengers might have to wait for more than one vehicle to pass. Based on my experience, passengers at the busiest stations (Wood and Table View) might have to wait for a second bus, and at most a third. Given that peak-hour headways on this route are 3 minutes, a likely wait time is less than 6 minutes, and a maximum wait time is 9 minutes. Therefore an expected wait time of 5 minutes is still reasonable.

### Estimated travel times summary

A summary of model-estimated travel times for minibus taxi and MyCiTi is shown in Table 5.6. Travel times are presented only for TAZ pairs served by that mode, more than 2.6 million zone pairs for minibus taxi, and 86,470 for MyCiTi.

The MyCiTi travel time values are on average smaller than those for taxi because the MyCiTi network serves a more limited area, and therefore fewer long trips. The 2015 taxi

travel times are slightly shorter on average than those in 2011. This is likely because, even though the removal of some taxi routes in 2015 would have increased average taxi travel times, the reductions in wait time resulting from shorter headways, shorter queues, and higher seat availability more than compensated for the removal of routes, at least when considering citywide averages. When we look specifically at the Phase 1 service area, taxi travel times will have likely increased from 2011 to 2015—we will explore this further in the analysis of accessibility scores.

Table 5.6: Summary statistics for travel times (mins) estimated for minibus taxi and MyCiTi

	Minibus taxi*		MyCiTi
	2011	2015	2015
count	2,636,028	2,636,028	86,470
mean	103.2	101.7	57.09
std	48.8	48.3	30.1
min	1.3	1.3	6.0
25% quartile	70.7	69.6	33.0
50%	95.4	94.3	57.0
75% quartile	126.3	124.6	78.0
max	610.6	608.9	165.0

\*For minibus taxis, values shown are for the baseline case.

## Calculating the accessibility score

With the total travel times for each mode estimated, I calculated accessibility scores according to Eq. 5.3. For minibus taxi, I calculated scores for the two time periods, 2011 and 2015, while MyCiTi only existed in 2015. I used three different values for the maximum travel time,  $t_{max}$ : 30, 45, and 60 minutes. In fact, Cape Town commutes very often exceed 60 minutes, but arguably such long commutes are undesirable and would not be considered a reasonable definition of “accessibility.”

### Combined MyCiTi and minibus taxi accessibility

Those living in areas with access to both minibus taxis and MyCiTi could use either mode in 2015, thus a combined accessibility score for both modes is meaningful. To calculate this score, I used the total travel time estimated in the MyCiTi and minibus taxi models, and for each pair of TAZs I found the minimum travel time, considering both modes. I then used the matrix of minimum travel times in Eq. 5.3. This is equivalent to saying that a passenger can access activities in another zone if the travel time by MyCiTi OR minibus taxi is less than  $t_{max}$ .

### Assessing distribution of accessibility

**Income and race** After computing accessibility, I overlaid the accessibility scores for each mode in each time period with census data on income and race. The census provides the number of persons of each race and the number of households by income in each census unit, or SAL. The SAL units are typically smaller than TAZs, the zones for which I calculated accessibility scores. To merge data for the two geographies, I used an area-weighted proportion as follows. First, I intersected TAZ and SAL geometries, with the population in each intersected area equal to:

$$pop_{intersection} = pop_{SAL} * \frac{Area_{intersection}}{Area_{SAL}}. \quad (5.9)$$

I then combined the intersected areas into TAZ units such that the population of each TAZ is equal to:

$$pop_{TAZ} = \sum_J pop_{intersection} \quad (5.10)$$

where  $J$  is the set of intersected areas in the TAZ. I was then left with the estimated number of persons and households, by race and income respectively, in each TAZ. I also grouped household income into categories defined by Stats SA: low (0-R19,600), middle (R19,601-R307,600), and high (over R307,600). Census data are from 2011 and I assumed the distribution of population did not change between then and 2015. I then calculated the mean and median accessibility score for each population group.

I also calculated accessibility scores for residents in the MyCiTi area, defined as within 1km of a MyCiTi stop, compared to those outside. As with the census data, I used an area-weighted proportion to estimate the number of households and persons within the MyCiTi area. The MyCiTi area is divided into Phase 1 trunk, Phase 1 feeder, and N2 Express service areas.

## 5.3 Findings

### Coverage of MyCiTi and taxi networks

In terms of network coverage, the ubiquity of taxi coverage is clear. In 2011, 98% of Cape Town's population had access to a taxi, defined as living in a zone with its centroid within 1km of a taxi route. (This doesn't mean exactly 98% of the population lived within 1km of a taxi route, since in larger zones with taxi service some residents may still be further than 1km from a route. Instead it's a rough estimate.) After removal of taxi routes to make way for MyCiTi, roughly 73,000 residents lost access to taxis, bringing the population served to 96% (see Table 5.7). The number of residents who experienced reduced taxi access is larger, closer to 381,000, because many in the Phase 1 area still had access to taxi routes that ran to destinations outside the MyCiTi area; only routes within the Phase 1 area were removed.



In comparison, as of 2015 MyCiTi served 16% of Cape Town’s population (about 599,000 residents). The addition of MyCiTi, even with the removal of taxis, brought the population served by MyCiTi or taxi up slightly, to 98.9%.

Table 5.7: MyCiTi and taxi network coverage in 2015 by income and by race

	Households by income level				Percent of households (column pcts)			
	Households (1000s)				All			
	Low	Mid	High	households	Low	Mid	High	households
Cape Town	185	591	145	1,068	100.0%	100.0%	100.0%	100.0%
Access to MyCiTi	28	103	31	187	14.9%	17.5%	21.4%	17.5%
Phase 1	14	70	30	130	7.7%	11.9%	20.7%	12.2%
Phase 1 trunk	9	35	13	65	4.7%	5.9%	8.7%	6.1%
Phase 1 feeder	9	56	27	103	4.9%	9.5%	18.5%	9.6%
N2 Express	13	33	0.9	57	7.2%	5.6%	0.6%	5.3%
Access to taxi, 2015	182	565	126	1,015	98.2%	95.6%	87.0%	95.0%
Access to MyCiTi or taxi	183	580	138	1,047	99.1%	98.2%	95.1%	98.0%

	Population by race				Percent of population (column pcts)			
	Population (1000s)				All			
	Black	Coloured	White	all races	Black	Coloured	White	all races
Cape Town	1,445	1,585	586	3,740	100.0%	100.0%	100.0%	100.0%
Access to MyCiTi	237	217	123	599	16.4%	13.7%	20.9%	16.0%
Phase 1	114	125	122	381	7.9%	7.9%	20.9%	10.2%
Phase 1 trunk	68	50	59	187	4.7%	3.2%	10.0%	5.0%
Phase 1 feeder	72	113	104	305	5.0%	7.1%	17.7%	8.1%
N2 Express	123	92	0.3	218	8.5%	5.8%	0.0%	5.8%
Access to taxi, 2015	1,410	1,555	510	3,593	97.6%	98.1%	87.1%	96.1%
Access to MyCiTi or taxi	1,429	1,563	555	3,669	98.9%	98.6%	94.7%	98.1%

Calculations are for the number of households or residents living in zones with a centroid within 1km of a MyCiTi stop or taxi route. Totals may not add up to 100% because ‘other’ and nonresponses are excluded.

Table 5.7 also shows the proportion of households by income, and population by race, with access to the MyCiTi and taxi networks. MyCiTi Phase 1 disproportionately served middle- and high-income households: 20.7% of high-income and 11.9% of middle-income households had access to Phase 1, compared to only 7.7% of low-income households. In terms of race, Phase 1 served whites disproportionately, as 20.9% of the white population had access to Phase 1, compared to only 7.9% of blacks and 7.9% of coloured residents.

However, the N2 Express narrowed the gap in MyCiTi access, serving 7.2% of low-income households and 5.6% of middle-income households, but only 0.6% of high-income. Similarly, the N2 Express provided access to 8.5% of Cape Town’s black population and 5.8% of its coloured population, but less than 0.1% of whites.

The taxi network in 2015 still served the vast majority of residents, but proportionately more low-income households and black and coloured residents. Of low-income households,

98% had access to a taxi, while only 87% of high-income households did. The taxi network served 98% of the black population, 98% of the coloured population, and 87% of the white population. The lower access for high-income households and white residents is due to the fact that these households are more likely to live in low-density areas without taxi route or in the MyCiTi phase 1 area where taxis were removed.

## Accessibility scores

Maps showing the spatial distribution of accessibility by retail can be found in Figure 5.12 and plots summarizing the accessibility scores by mode and category are in Figures 5.14 and 5.15. The full set of figures are in Appendix A. Many of the findings are intuitive. As expected, accessibility by each mode corresponds with the spatial coverage of the network, with greater accessibility in zones nearer the city center. Figure 5.12 shows accessibility scores to retail space within 45 minutes for taxi in 2011, taxi in 2015, and MyCiTi in 2015. The pattern for taxi is as expected, considering the location of retail space (see Figure 5.1)—accessibility scores are highest in the areas closest to the city center, and extending along the arterials to the east and northeast. Scores in the center of the map are somewhat heterogeneous, reflecting variations in proximity to taxi ranks and route as well as service frequencies. For taxi, changes between 2011 and 2015 are slight—as expected, for zones along the middle part of MyCiTi Phase 1 corridor accessibility dropped, although the effect is not extensive because scores along most of the corridor were already low in 2011.

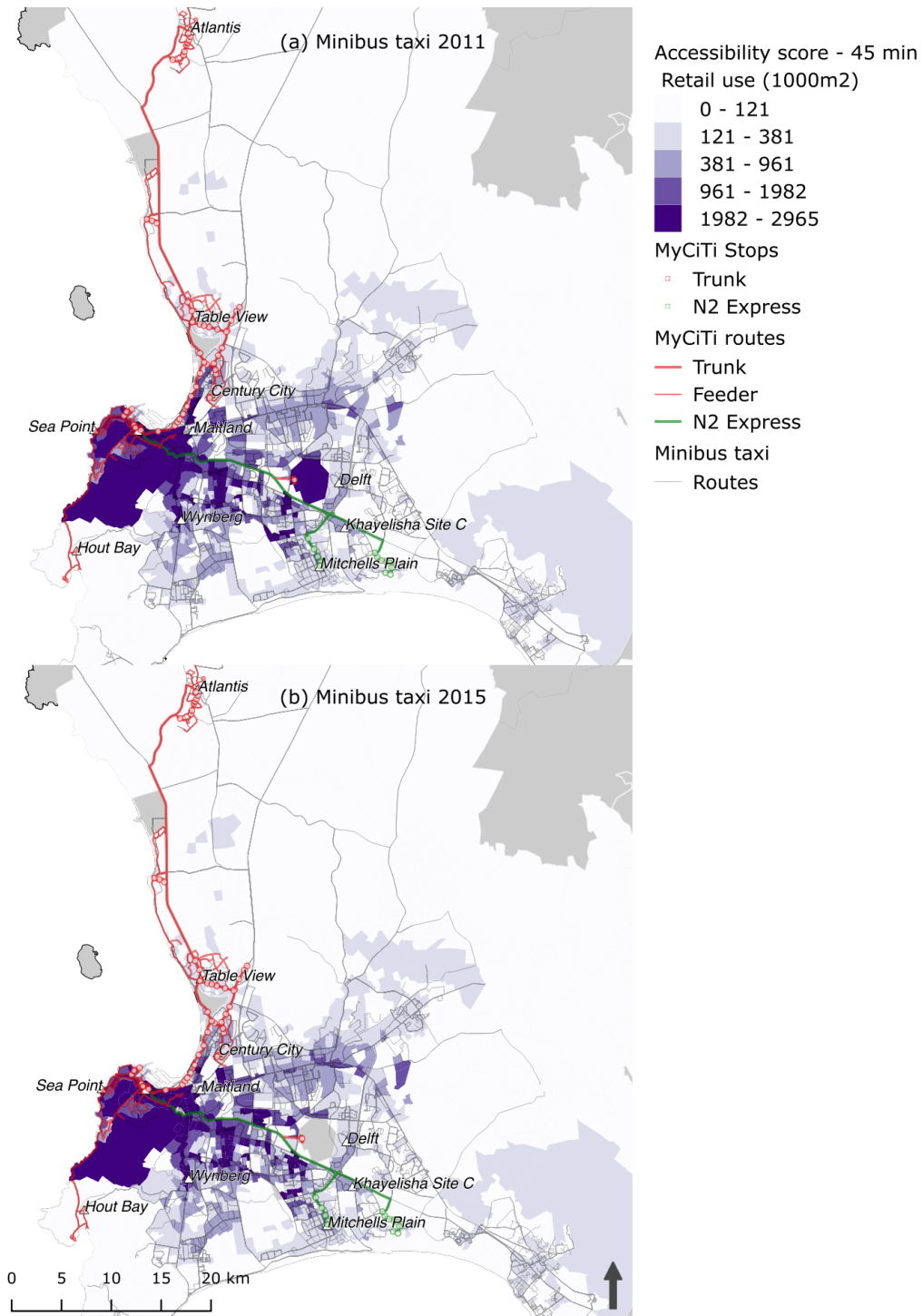
The highest accessibility scores for MyCiTi can be found, unsurprisingly, along the part of the Phase 1 corridor closest to the city center. Notably, the Table View area, which had relatively poor accessibility by taxi in 2011 and 2015, is much better served by MyCiTi. Similarly, the Khayelitsha and Mitchell’s Plain area served by the N2 Express have higher accessibility with MyCiTi than with taxi. Importantly, the map of accessibility by both modes combined covers a larger area than either mode alone, indicating the MyCiTi and taxi networks are not redundant.

Not surprisingly, at the far end of the Phase 1 corridor, the Atlantis neighborhood has low accessibility scores in all categories; travel times from Atlantis to almost all activity centers are more than one hour by public transport. Figure 5.13 shows accessibility scores for retail at 60 minutes, zoomed in on Atlantis and rescaled to more easily visualize lower accessibility scores. Here, we can see that MyCiTi does provide greater accessibility to retail for zones in Atlantis compared to taxi in 2011, although it appears taxi provided better accessibility for the less populated zones around it.

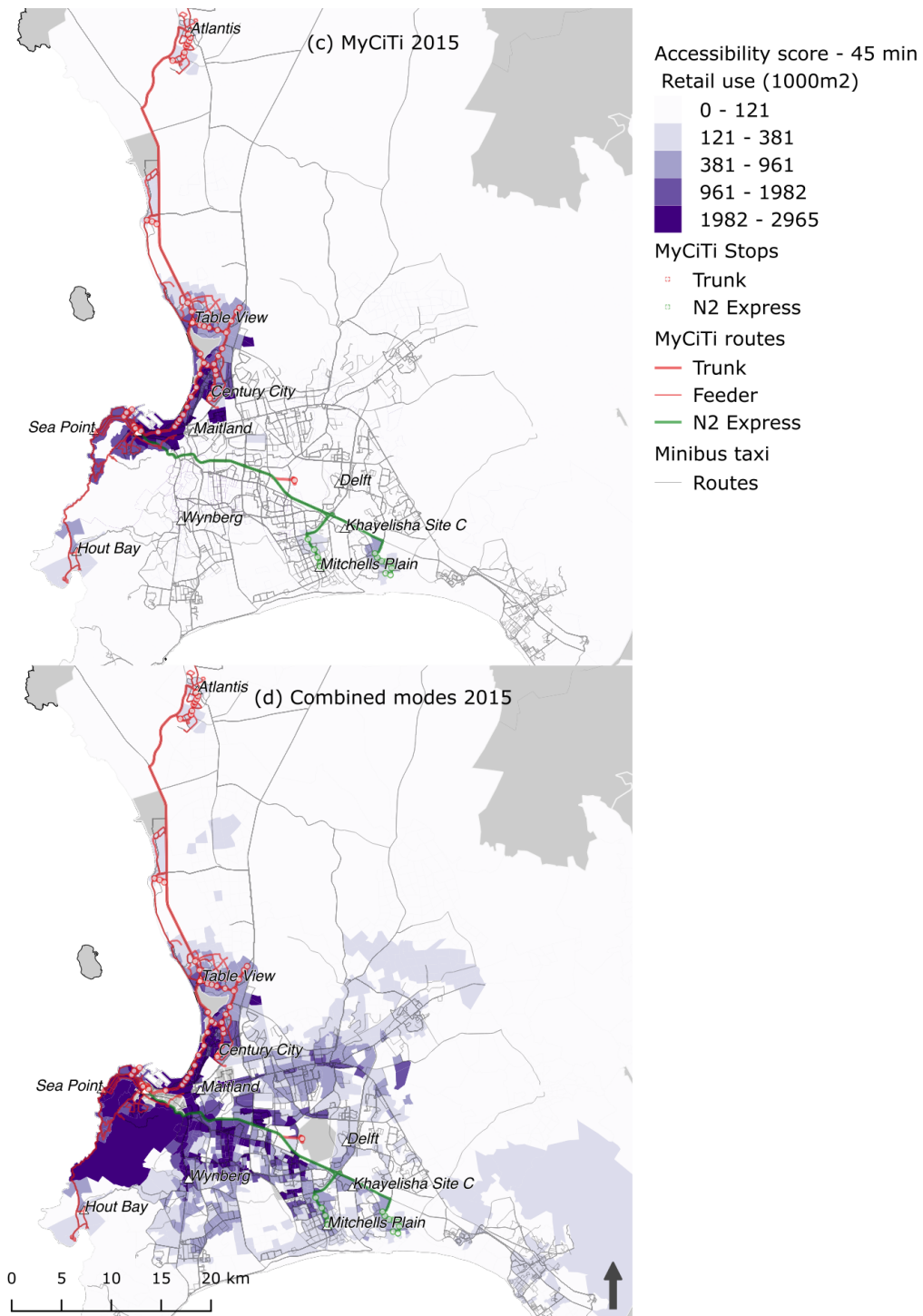
## Changes in taxi accessibility

On average, when comparing taxi in 2011 to combined modes in 2015, citywide accessibility scores increased over the study period. Figure 5.14 shows average citywide accessibility scores by mode when using the baseline values for wait times. (On this plot and all plots in this chapter, the error bars represent the range of values from the low estimate to high

Figure 5.12: Accessibility scores to retail within 45 mins by minibus taxi in (a) 2011 and (b) 2015

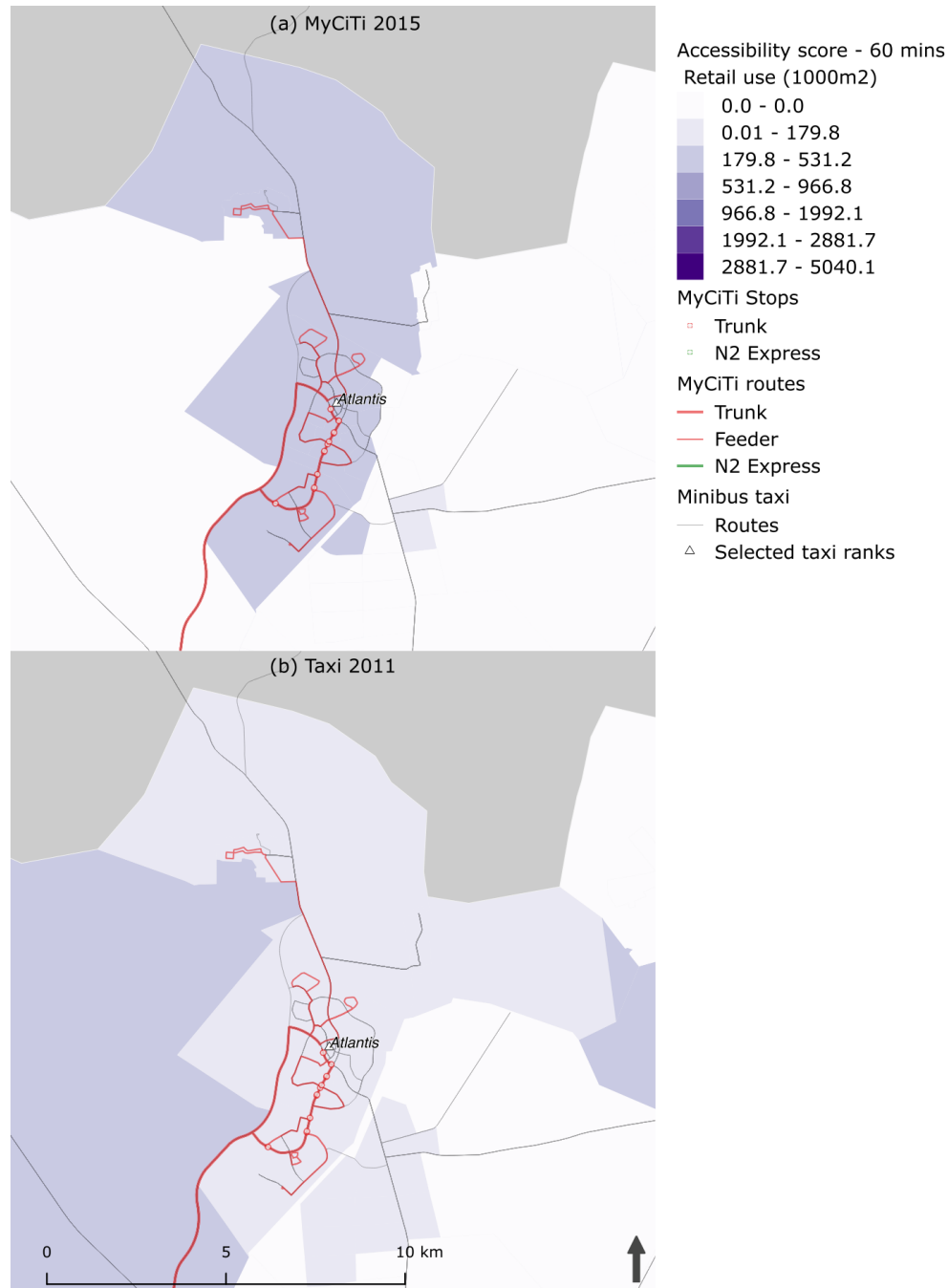


*Baseline values for taxi wait times*



*Baseline values for taxi wait times*

Figure 5.13: Detail of accessibility scores to retail uses within 60 mins by (a) MyCiTi and (b) minibus taxi in 2011



*Baseline values for taxi wait times*

estimate, as defined in Table 5.5.) Figure 5.14 suggests accessibility by taxi overall increased slightly from 2011 to 2015. The increase is due to apparent lower wait times, which, averaged over the entire city, more than compensated for the removal of some taxi routes.

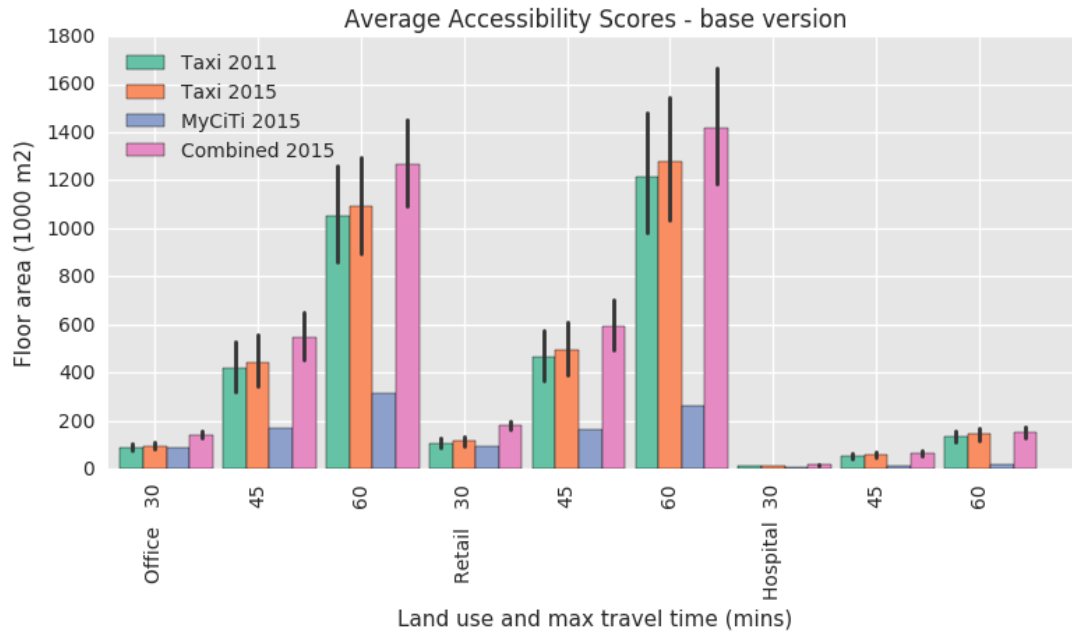
I expected to find large changes in the MyCiTi Phase 1 area where taxi routes were removed. The model has several points of uncertainty, but in this case we can be very confident Phase 1 area taxi service was reduced—even if some taxis on the affected routes continued to operate illegally (for example, on the Sea Point route), interviews and personal experience confirms it is today much more difficult to travel the Cape Town-Table View corridor by taxi than it was in 2011. It’s therefore somewhat surprising that the change in accessibility by taxi between 2011 and 2015 is quite small, even in the Phase 1 area. As shown in Table 5.8, when we assume there was no change in taxi wait times among the routes that remained, taxi accessibility in the Phase 1 trunk area decreased from 1 to 12%. If we allow for changes in taxi headways and wait times, it appears shorter wait times largely compensated for the removal of taxi routes; accessibility by taxi in the Phase 1 trunk area declined at most by 3%.

Table 5.8: Percent change in accessibility by taxi from 2011 to 2015, for MyCiTi Phase 1 trunk area only

Land use	Minutes	Pct change accessibility	
		Baseline	Constant
Retail	30	1.10%	-1.17%
	45	0.57%	-6.49%
	60	-3.41%	-12.50%
Office	30	-0.03%	-0.16%
	45	-1.64%	-3.84%
	60	-2.67%	-7.81%
Hospital	30	13.12%	-0.03%
	45	-3.16%	-1.15%
	60	0.79%	-4.62%

Thus, if we assume the wait times changed during this time period as reflected in the raw data, then it appears accessibility by taxi actually improved citywide. If we assume wait times remained constant, then accessibility by taxi appears to have worsened. Both results are plausible. Outside the Phase 1 area, taxi service might have improved if vehicles displaced by MyCiTi ended up serving routes elsewhere in the city. But it’s also possible those vehicles were scrapped or otherwise prevented from operating, while at the same time taxi supply on non-affected routes declined due to factors such as increasing costs, increasing congestion, or reduced demand.

Figure 5.14: Citywide accessibility scores by mode



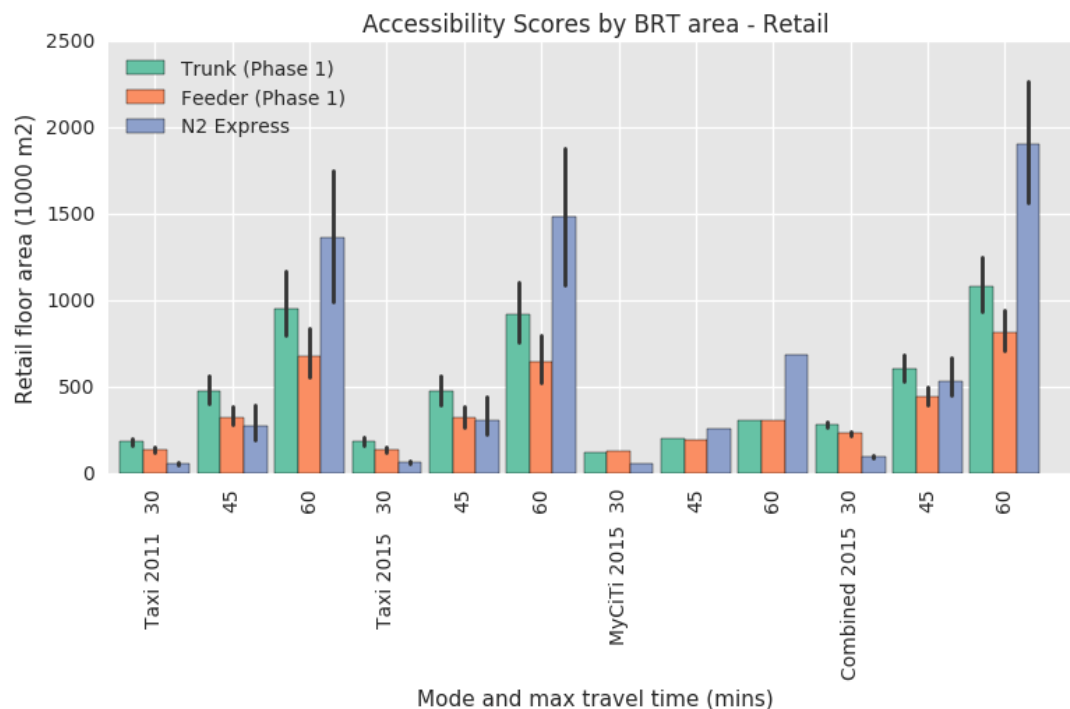
Assuming baseline values for taxi wait times

### Accessibility changes for taxi vs. MyCiTi

Overall, minibus taxi provides greater accessibility than does MyCiTi, which is expected given the taxi network's greater spatial coverage. The two modes have similar accessibility scores when max travel time is 30 minutes, but allowing 45 or 60 minutes taxis can reach a wider range of destinations than can MyCiTi. When we restrict our analysis only to the MyCiTi Phase 1 area (both the trunk and feeder areas), it appears MyCiTi provides better accessibility, at the 30-min and 45-min level, compared to taxi in 2011. In this area, taxi accessibility decreased or remained flat in 2015 due to the removal of many routes. Hence, under the model assumptions, MyCiTi actually provides greater accessibility to these land uses, for those willing and able to travel up to 45 minutes.

I expected to find the MyCiTi trunk service to provide greater accessibility than the feeder service. Yet, surprisingly, zones in the feeder area displayed accessibility scores very close to those in the trunk area, and in some cases higher. This result is likely due to the fact that much of the feeder network lies in the city center and Sea Point area, which contain concentrated commercial activities, and in number these zones outweigh those in the outlying feeder network. In contrast, more zones classified as trunk service lie along the Cape Town-to-Atlantis corridor, where there is much less commercial development. (A more useful comparison of trunk and feeder service accessibility would be to compare zones only

Figure 5.15: Accessibility scores by BRT area - Retail space



along this northern corridor.)

### Change in combined taxi and MyCiTi accessibility

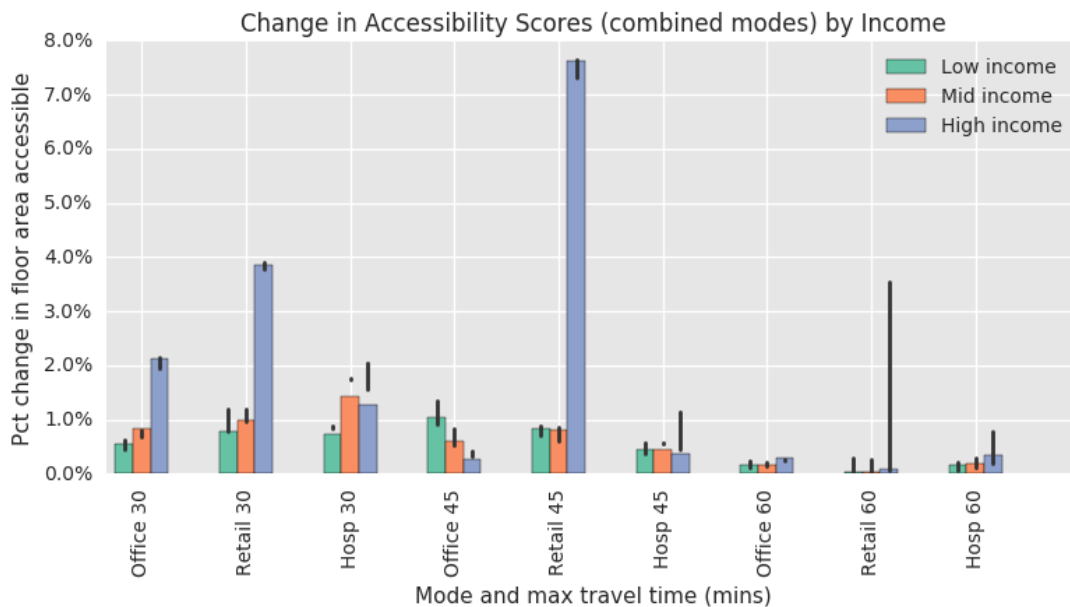
I measured change in accessibility over the study period as the difference between accessibility by taxi in 2011 and by taxi and MyCiTi combined in 2015. As we can see in Figures 5.16-5.18, the average change in almost all cases is positive, although the magnitude is relatively small, on the order of less than 10%. For office use within 45 minutes, for example, 1187 of 1784 zones (67%) had increased accessibility. These zones contain about 85% of the city's population.

The results suggest taxi and MyCiTi combined in 2015 fairly consistently improved accessibility scores over those by taxi alone in 2011. Change in accessibility from 2011 taxi to 2015 combined was positive for almost all groups, land uses, and travel times. As shown in Figure 5.15, the positive change holds not just in the N2 Express area, where the addition of MyCiTi on top of taxi service would be expected to be an unmitigated improvement, but also in the Phase 1 area, where MyCiTi replaced many taxi routes. The model suggests, on average, in the Phase 1 area the shift to MyCiTi allowed residents to access between 50,000 and 100,000 extra square meters of retail and office space, and a few thousand extra square meters of hospital use.



Changes were not evenly distributed. In percentage terms, high-income and white households experienced the greatest increases in accessibility, for the retail and 45-minute category, followed by the retail 30-minute category. This appears to be due to the increases in accessibility to retail provided by MyCiTi, especially in the Phase 1 Trunk corridor (Figure 5.18). The maps in Figures 5.19 and 5.20 suggest the greatest increases were in Phase 1 corridor, and in zones where higher income, white populations were more concentrated.

Figure 5.16: Change between 2011 taxi accessibility and 2015 combined modes accessibility, by income.



In the N2 Express service area, the results are straightforward: the addition of MyCiTi improved combined accessibility, especially for the 45- and 60-minute thresholds. This finding is no surprise, since there is no reason to expect the N2 Express would have reduced accessibility—it introduced an additional option without removing any options.

Figure 5.20 shows change in office accessibility within 45 minutes, using (a) baseline values for wait time and (b) time-constant values for wait time. Relatively few zones (44 out of 1784, or about 2.5%) had declines in accessibility (shown in orange), and those that did were mainly outside the MyCiTi area. These zones represent only about 1% of the city’s population. The zones north of the city center but not in close proximity to MyCiTi stops had the most consistent declines; in these areas taxi routes were removed from these zones without corresponding introduction of BRT service. These zones are sparsely populated, and the number of residents who gained accessibility outweigh the relatively few residents in these “losing” zones.

Some zones in other areas experienced modest decreases in accessibility, due to changes in taxi service frequencies that may or may not be related to the MyCiTi introduction. For

Figure 5.17: Change between 2011 taxi accessibility and 2015 combined modes accessibility, by race



Figure 5.18: Change between 2011 taxi accessibility and 2015 combined modes accessibility, by BRT area

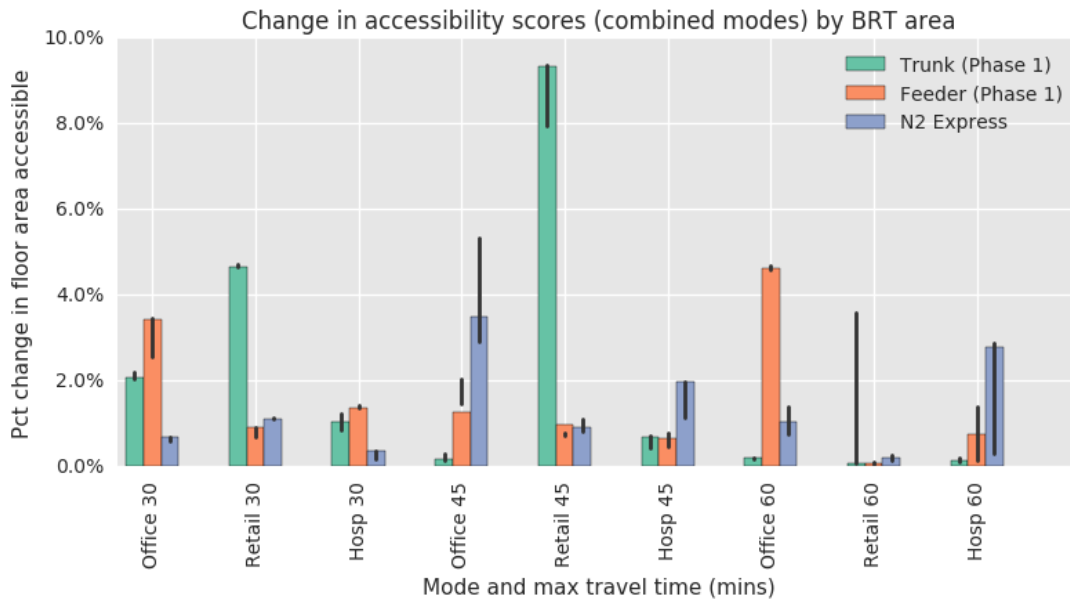
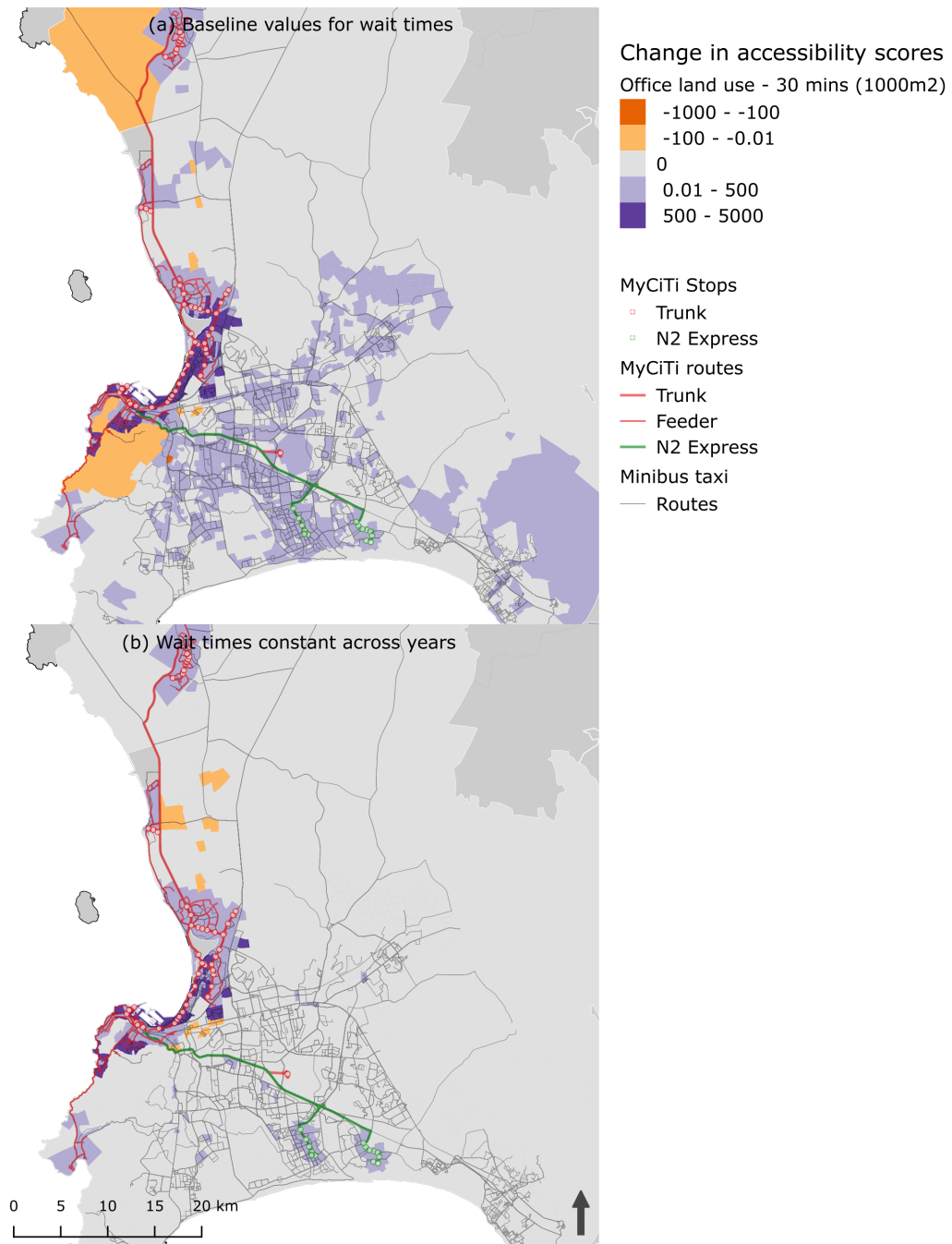


Figure 5.19: Change between 2011 taxi accessibility and 2015 combined modes accessibility, for office 30



example, accessibility dropped in the Maitland area in some categories: retail 45, retail 60, office 60, office 45. In other categories—office 60, retail 60—the Wynberg area grew more inaccessible by taxi (Figure 5.21).

Changes in accessibility are in some cases sensitive to assumptions about taxi service frequencies and wait times, however. When we assume taxi wait times remained constant, it appears accessibility declines in more zones. Figure 5.22 shows detail of change in office accessibility in the Phase 1 area using (a) baseline wait time values and (b) constant wait time values for 2011 and 2015. In the constant case at the 45-minute threshold, accessibility drops not just in the Maitland area, but also in the zones just north of that, which are technically within the MyCiTi Trunk corridor, but whose centroid is a long walk from MyCiTi stop.

### Accessibility by population group

When we consider accessibility scores by income and racial group, some interesting patterns emerge. For accessibility by taxi in both 2011 and 2015, high-income households enjoy greater accessibility compared to lower income groups when travel time is capped at 30 minutes, for office and retail uses. However, for longer travel times, the pattern reverses, and at the 60-minute threshold taxi provides greater accessibility to low-income households than higher-income ones. This result appears to be a consequence of an unusual pattern of land use in Cape Town, where low-income households are concentrated in the southeastern townships (see Chapter 3) and office and retail uses form a partial ring around them (see Figure 5.1). The distance between the two is such that reaching the office/retail ring from the townships typically requires at least a 45-minute journey, but once the 45-minute threshold is crossed, many destinations are accessible. In contrast, high-income households are more likely to live within 30 minutes of local office and retail centers, but city's geography tends to cut them off from more distant centers. High-income households are also more likely to live within a 30-minute journey of the city center, which holds the greater concentration of opportunities, while low-income households are much more likely to live more than 45 minutes from the city center.

Taxi accessibility to hospitals exhibits a slightly different pattern; low-income households have better accessibility by taxi to hospitals at all travel time thresholds, likely because of one or two large hospitals located in the Metro Southeast. Lower-income groups' higher hospital accessibility scores may not actually indicate superior access to health care, since in this case greater floor area does not necessarily equate to better quality. As discussed in section 5.2, the cumulative opportunities approach considers only the floor area of land use activities, not their quality or their availability after accounting for demand. It would not be surprising if the hospitals located in the lower-income areas have lower quality service when compared with those in high-income areas and, even if they are larger, they must also serve a larger population. We would expect hospital uses are more subject to these limitations than office and retail uses are. Still, in terms of location and floor area alone, taxis appear to provide lower-income households with greater accessibility to hospitals compare to high-

Figure 5.20: Change between 2011 taxi and 2015 combined modes accessibility for retail 45, using (a) baseline values for wait time and (b) constant wait time values

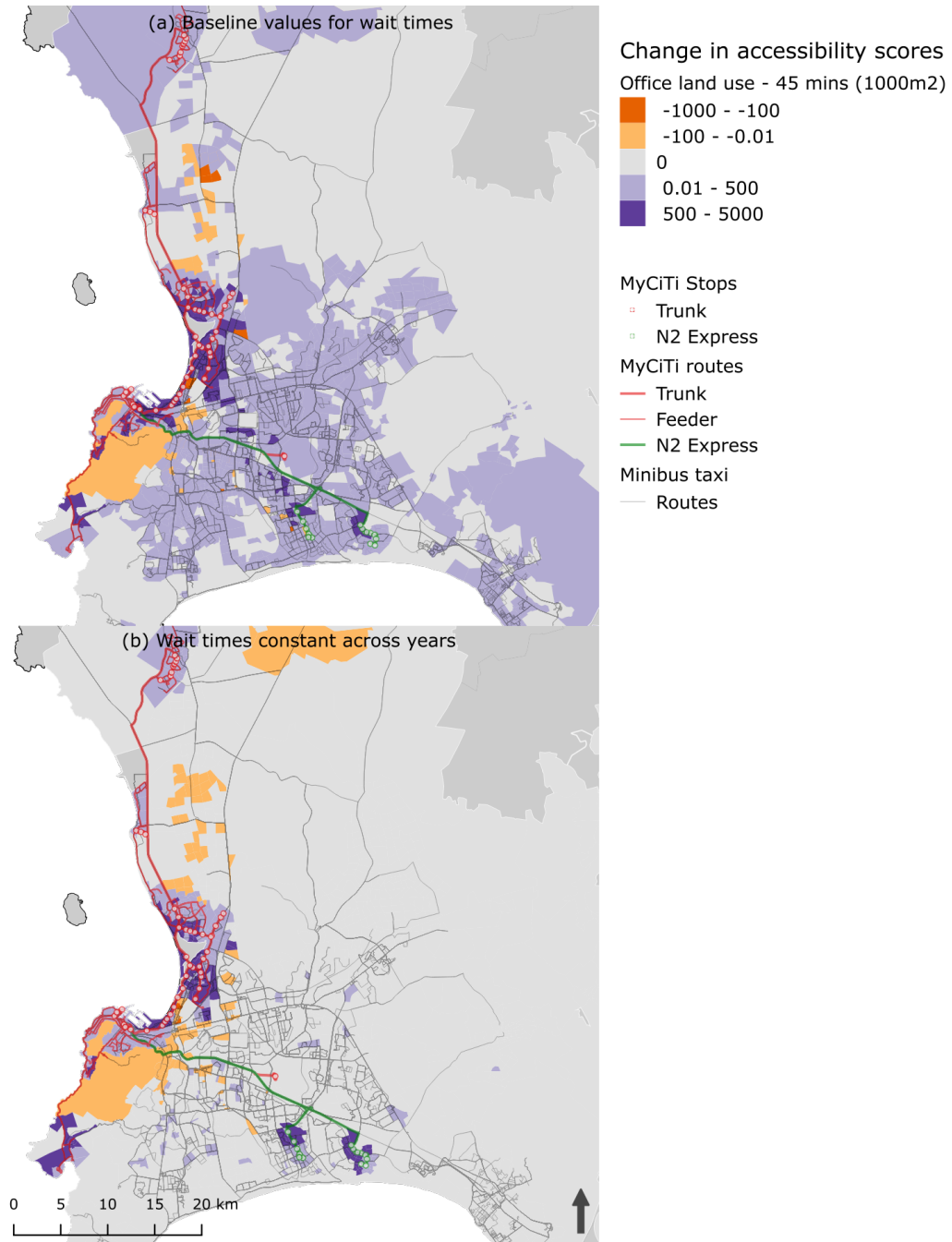
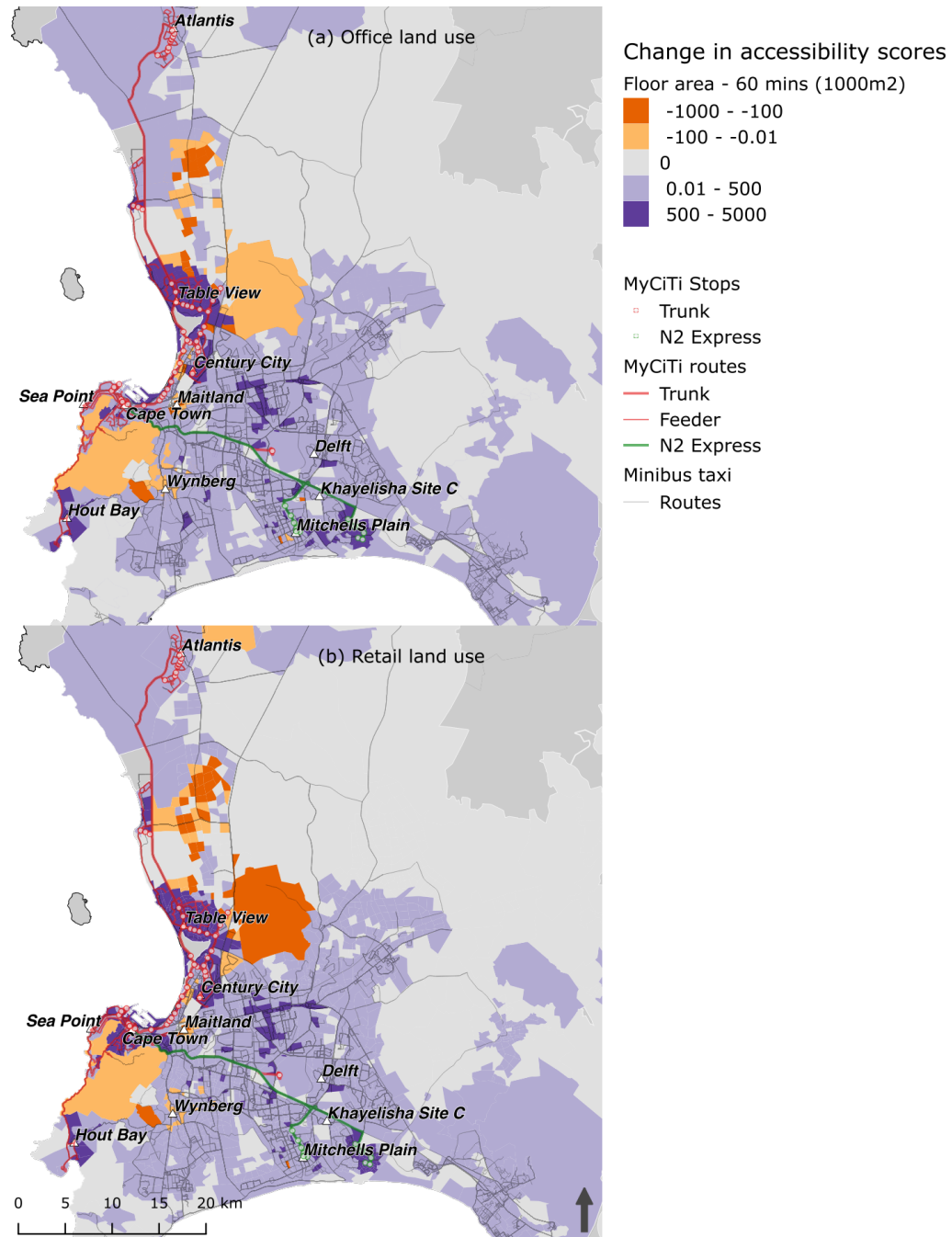


Figure 5.21: Change between 2011 taxi and 2015 combined modes accessibility, 60 minutes, for (a) office and (b) retail uses



*Baseline values for taxi wait times*

Figure 5.22: Change between 2011 taxi and 2015 combined modes accessibility, for retail 45, using (a) baseline values for wait time and (b) constant wait time values

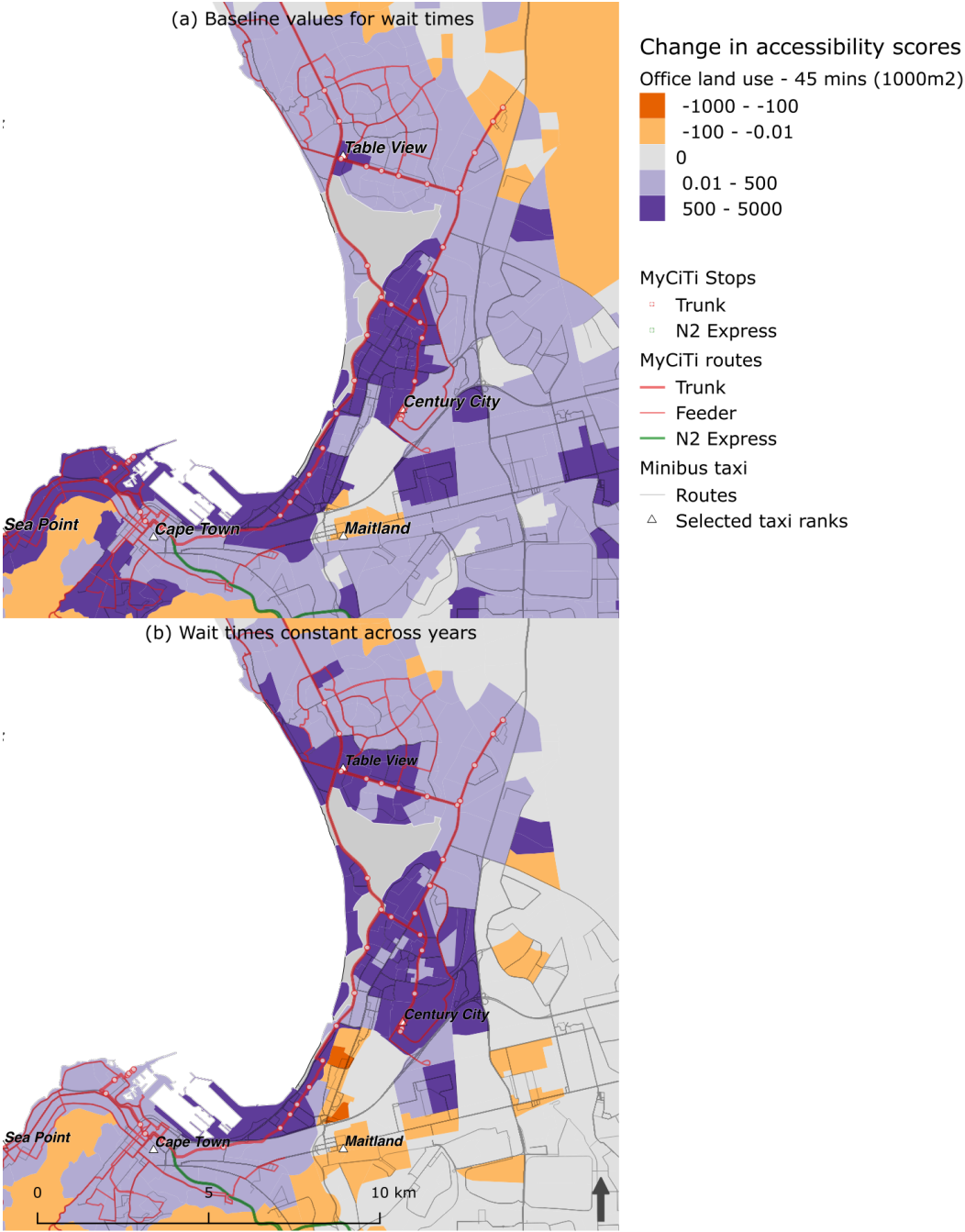
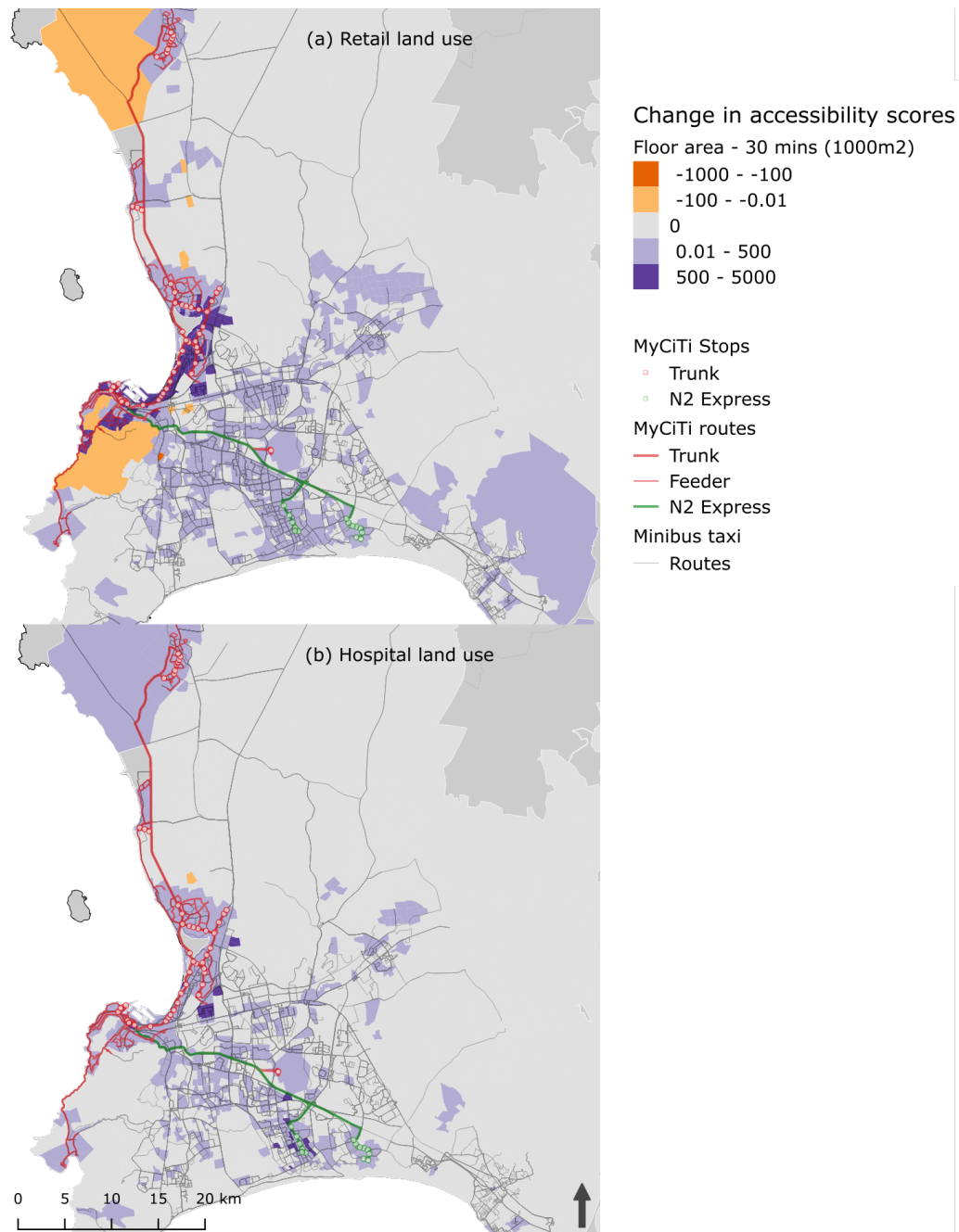


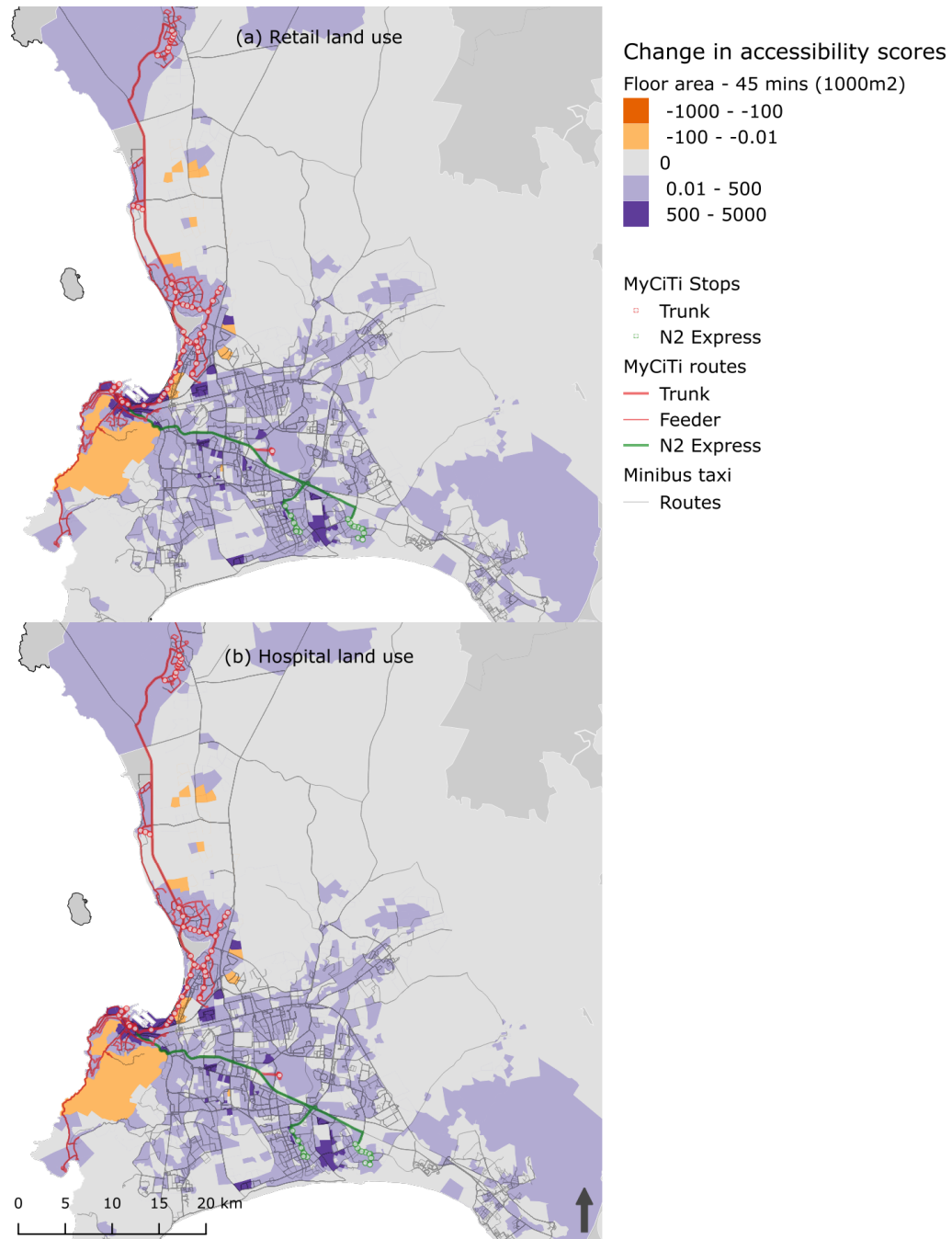
Figure 5.23: Change between 2011 taxi and 2015 combined modes accessibility, 30 minutes, for (a) retail and (b) hospital uses



*Baseline values for taxi wait times*

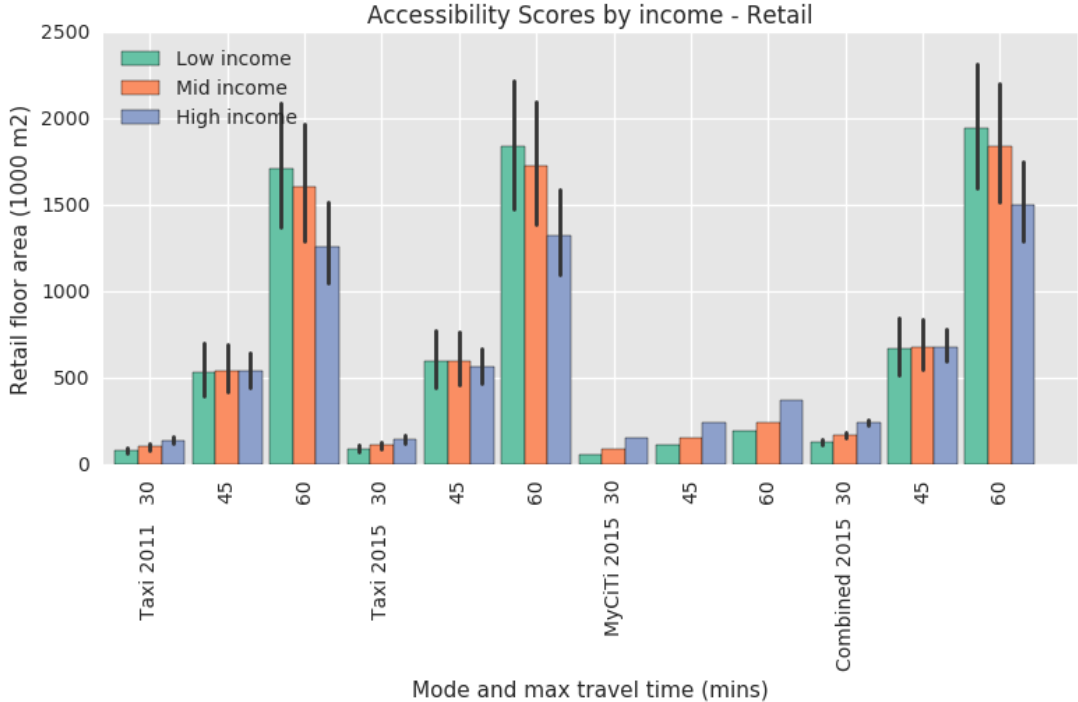


Figure 5.24: Change between 2011 taxi and 2015 combined modes accessibility, 45 minutes, for (a) retail and (b) hospital uses



*Baseline values for taxi wait times*

Figure 5.25: Accessibility scores by income - Retail space



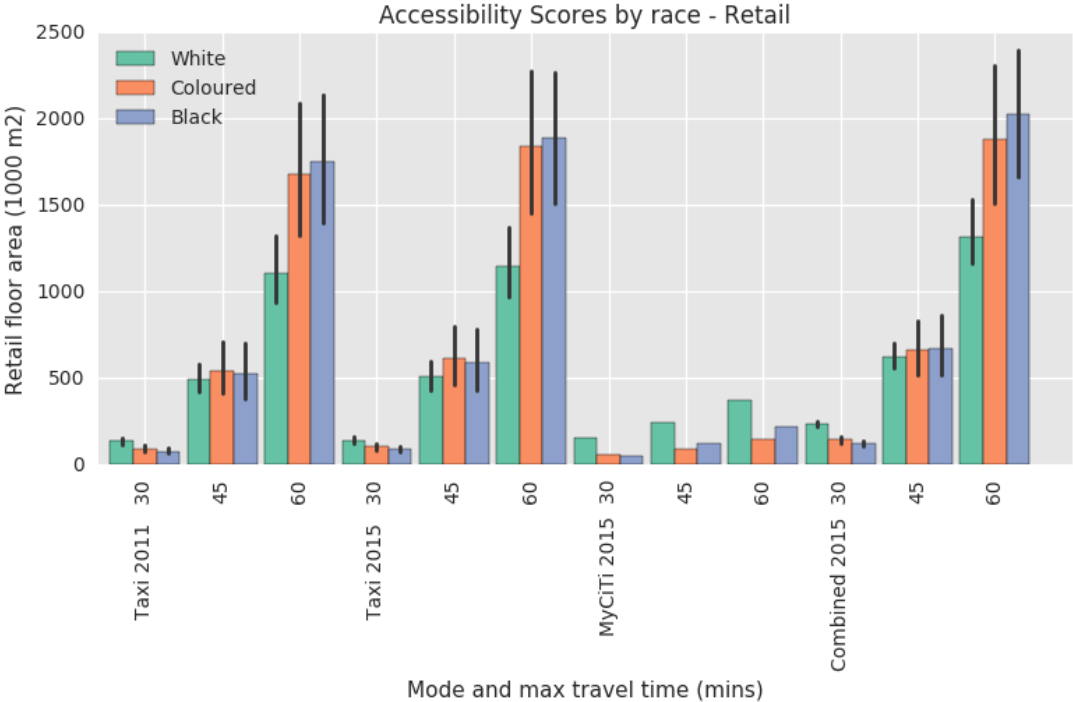
income households. In addition, hospital uses are important not just for health care services, but also for a large number of jobs.

Whereas taxi provides low-income households with greater accessibility at higher travel time thresholds, accessibility by MyCiTi favors high-income households at every travel time level. This pattern, which holds across all land use types, can be explained by geography, since the MyCiTi service area has a higher-than-average concentration of high-income households. The N2 Express area, which serves mainly middle- and low-income households, is an exception. We can see from Figure 5.15 that residents in the N2 Express area traveling by MyCiTi can access very few retail activities within 30 minutes, but can reach many within 60 minutes. The same pattern holds for office use. This result reflects the N2 Express’ design as a long-haul commuter service between the two largest southeastern townships and the city center.

That accessibility scores correlate with income so consistently across modes and land use types is itself notable. Whether the relationship between accessibility and income is positive or negative, in almost every case, the middle-income group on average has an accessibility score that falls in between the two extreme groups. In the few cases where this is not true, accessibility scores are more or less flat across income groups. The consistency of this relationship attests to Cape Town’s high degree of spatial segregation by income.

Turning to accessibility scores by race, the model results follow a pattern similar to

Figure 5.26: Accessibility scores by race - Retail space



income, as evident in Figure 5.26. For retail uses, white residents have higher accessibility by taxi at 30 minutes, but black and coloured residents have higher accessibility at longer travel times. However, compared to blacks, coloured residents tend to have high accessibility scores by taxi, whereas blacks have higher scores by MyCiTi. This pattern is likely explained by the fact that in the MyCiTi Phase 1 area, a large coloured population lives in the Atlantis area, located at the very far end of the MyCiTi trunk line and more than 60 minutes from the city center, while a large black population lives somewhat closer to the city center in Dunoon. From the distant Atlantis area, very few activities are accessible even within a 60-minute travel time. Accessibility scores for office use follow the same pattern.

In most cases, though, on average coloured residents have better accessibility by taxi compared to blacks, likely because the part of the city with the highest concentration of coloured residents, Mitchell’s Plain, is located closer to the city center and other destinations than is the area with the highest concentration of black residents, Khayelitsha. Differences in taxi accessibility scores between blacks and coloureds are relatively small, however, and at the 45-minute and 60-minute thresholds are much higher than scores for whites. As with income, this pattern likely reflects Cape Town’s geography and also, potentially, the relatively high density and frequency of taxi service in the southeastern parts of the city.

## 5.4 Discussion

How does accessibility by the 2015 system, consisting of reduced taxi routes combined with the new MyCiTi network, compare with that of the 2011 taxi-only system? In the MyCiTi service area, accessibility scores for 2015 combined taxi and MyCiTi increased in every category over the scores for the 2011 taxi-only network and the number of residents who gained accessibility far exceeds the number who lost. It's not surprising the new MyCiTi service more than made up for the removal of some taxis. With the introduction of MyCiTi, residents in the Phase 1 area were able to access on average 1% to 9% more retail and office activities compared to 2011, even though many taxi routes were removed. Let's consider how accessibility would be affected if all taxi service was removed from the Phase 1 area. Comparing only 2011 taxi to 2015 MyCiTi, we can see that in the trunk and feeder areas, MyCiTi has higher accessibility scores for 30-minute and 45-minute thresholds, while taxi in 2011 has higher scores for the 60-minute threshold. This suggests MyCiTi did, on average, improve the ability of residents within 1km of stops to reach activities within 30 or 45 minutes. Likely because of its greater coverage, taxi service in 2011 offered greater access for those willing to travel 60 minutes.

As discussed in Chapter 4, the MyCiTi introduction did not actually remove all taxi routes even in the Phase 1 area because some taxis continued operating illegally. In 2015 one could still often take a taxi from the MyCiTi service area to destinations outside it, and sometimes even within the service area. Therefore the combined taxi plus MyCiTi accessibility scores for those in the MyCiTi area exceeded the 2011 taxi scores. One could take advantage of MyCiTi's improved accessibility for shorter trips, and simultaneously take advantage of taxis' service coverage for longer trips. In this case of partial formalization, it appears the actual effect was generally increased accessibility. Even assuming no change in taxi service other than the removal of routes, as represented by the "constant" values case, accessibility overall increased.

In fact, the reforms may have improved accessibility even more than expected, if the introduction of MyCiTi "pushed" taxi supply from the affected area into other parts of the city. The data on taxi supply, which show overall slightly lower headways, shorter queue lengths, and greater seat availability in 2015 compared to 2011, suggest this effect as a possibility, represented in the model's "baseline" values case. If we believe the data, we can think of the "baseline" case a representation of how formalization actually affected accessibility, whereas the "constant" case represents the what was intended. As discussed earlier though, these observed changes in taxi may simply reflect a different sampling method in 2015. Therefore, it may be that formalization had the unintended effect of increasing taxi accessibility outside the MyCiTi area, but we will have to leave this as a hypothesis requiring further investigation.

In the long run, the new bus service might negatively affect accessibility by undermining the viability of the taxi industry and forcing taxis to reduce service, but in the short run there was no evidence MyCiTi adversely impacted taxi service levels in the N2 area.

Considering citywide effects, all racial and economic population groups apparently ben-

efited from increased accessibility, although not equally so. MyCiTi Phase 1 disproportionately served upper-income households and white residents, and although the N2 Express narrowed the racial and income gaps in access to MyCiTi, whites and high-income groups still disproportionately benefited. These groups had the largest increases in accessibility in percentage terms. On the whole, coloured residents appear to have had the smallest gains in accessibility 2011 to 2015. For retail and office use, MyCiTi provides the greatest accessibility to white and high-income residents, followed by blacks; taxis provide greatest accessibility to blacks (at longer travel times). Coloured residents apparently have better accessibility to hospitals, probably due to the location of a large hospital near the majority-Coloured Mitchell's Plain neighborhood.

Although it appears MyCiTi provided the largest accessibility increases to white and high-income residents, at least at the 30- and 45-minute thresholds, the addition of the N2 Express greatly increased accessibility for the limited number of residents near those stops, who are predominantly lower-income and non-white.

### **Accessibility and generalized cost**

In this analysis, I measured accessibility in terms of activities reachable within an absolute travel time. While this focus was necessary in order to make the analysis tractable, it simplifies the concept of accessibility. A more complete analysis of accessibility considers the activities reachable given a generalized cost that takes into account not just absolute time cost of travel, but also the monetary cost of travel, the value of time, and even the perceived time cost. While directly incorporating generalized cost calculations in the accessibility model is beyond the scope of this dissertation, it's worthwhile to consider how these factors would play into accessibility in the Cape Town case.

### **Value of travel time**

A substantial literature suggests that how people value time spent traveling varies according to many factors, including trip purpose, travel mode, income, and components of the trip (Shires and de Jong 2009; Abrantes and Wardman 2011; Small 2012). For the Cape Town case, there is no compelling reason to believe the introduction of MyCiTi substantially changed trip purpose of income levels. The relevant factor is the trip component—walk time vs. wait time vs. in-vehicle time—since MyCiTi reforms did change the relative contribution of each.

In the most recent available meta-analysis of the literature, which focused mainly on studies conducted in Europe but also included some from other countries, Wardman et al. (2012) estimated how the value of travel time varies with several factors. Their findings, which largely corroborated those from earlier meta-analyses, suggested that across Europe, people behave as though time spent walking and time spent waiting are 1.9 times more costly than time spent in-vehicle. (In the UK these ratios were lower: 1.68 and 1.62, respectively.) Although the ratios vary with context, studies in China, India and Latin America have

consistently found people value wait and walk time more highly than in-vehicle time (Liu 2007; Shires and de Jong 2009). Compared to minibus taxis, MyCiTi generally increased access time and wait time in relation to in-vehicle time. Taken together, these facts suggest MyCiTi replaced a less onerous type of travel time (in-vehicle) with more onerous ones (wait and walk), and the model may have overestimated accessibility benefits.

However, the valuing of time is more complex than that. Wardman et al. (2012) showed people value in-vehicle time spent in congestion at 1.5 to 1.58 times that of free-flow in-vehicle time. In the Phase 1 area, an exclusive bus lane allowed MyCiTi vehicles to bypass congestion that affected minibus taxis. Thus in this area MyCiTi traded more onerous in-vehicle travel for relatively less onerous in-vehicle travel, and if in-vehicle time is sufficiently greater than access and wait time, the effect might compensate for the negative impact on accessibility.

Furthermore, as I will discuss in Chapter 7, public transport users in Cape Town are very concerned about safety and security, and their willingness to walk to, or wait at, a transit stop depends greatly on perceived risk of crime. The literature suggests an environment perceived as insecure increases the disutility of walk time, by a multiple as large as 2.6 (Börjesson 2012). My user interviews suggested travelers generally view MyCiTi stations and vehicles as more secure than minibus taxi stops or vehicles, although walking to a MyCiTi stop was perceived as just as unsafe as walking to any other mode (see Chapter 7). In other words, I would expect travelers in Cape Town to value wait time for minibus taxis as more onerous than wait time for MyCiTi, suggesting the model may not actually overestimate accessibility benefits of MyCiTi.

Another factor is crowding and comfort. Studies have consistently shown in-vehicle crowding increases disutility of travel time, compared to average in-vehicle value of time, by a multiple of up to 2.3 for standing in very crowded conditions (Wardman and Whelan 2011; Tirachini et al. 2016). It's unclear whether taxi or MyCiTi has the advantage in terms of crowding and comfort though. Even during the peak period minibus taxi passengers will get a seat, even if it's small and uncomfortable. MyCiTi seats are comfortable, but during the peak buses are crowded and some passengers have to stand.

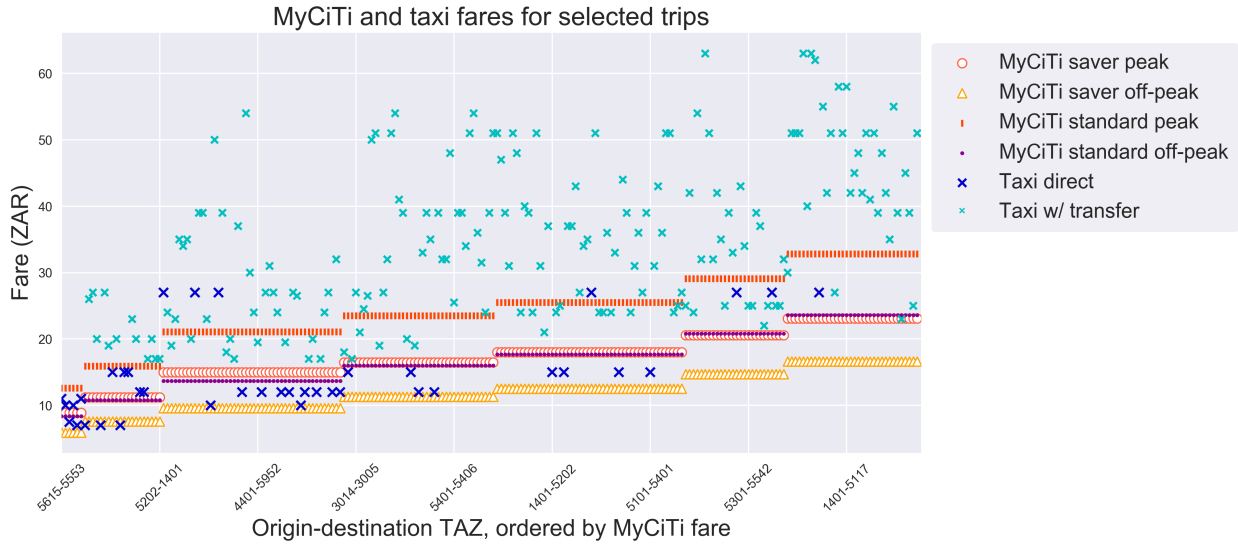
In future research it would be interesting to explicitly consider the value of different kinds of travel time in accessibility impacts attributable to BRT. In contexts like Cape Town, incorporating the appropriate multipliers to account for insecurity in wait and walk times would be especially important.

### **Monetary cost of travel**

My interviews with public transport users confirmed affordability figures heavily into travel decisions, especially for those with lower incomes. MyCiTi's fares, which are publicly subsidized, were designed to be comparable to those of the conventional bus service Golden Arrow, which are also subsidized. MyCiTi fares depend on whether or not the passenger travels in the peak period, and whether or not the passenger buys a standard ticket or a 'saver' package, with peak-period and standard ticket fares being higher. Fares also vary

by distance, with the per-kilometer rate decreasing with longer trips. Transfers within the MyCiTi system are free. Minibus taxi fares, in contrast, are not subsidized. Fares are fixed per route, and vary by distance. Transferring between routes requires paying an additional fare. Prices are sometime negotiable, but in general passengers pay a fixed rate.

Figure 5.27: A comparison of MyCiTi and taxi fares for 219 origin-destination pairs



The x-axis is categorical and represents the OD-pair, ordered by increasing MyCiTi fare

Because taxi fares are unsubsidized and no discounts are available for transfers, they are generally higher than MyCiTi fares for the same trip. To compare fares between modes, I selected several origin-destination pairs within the MyCiTi service area representing a variety of commute patterns, and obtained MyCiTi and taxi fares for each trip. For MyCiTi fares, I used the system’s fare table from 2016. For taxi, I used the WIMT API to obtain the fare for each trip. Figure 5.27 displays the results for the TAZ 219 pairs. The x-axis represents OD-pair, ordered by increasing MyCiTi fare. The lines of orange markers represent MyCiTi fares at different levels: peak and off-peak, saver and standard. The saver peak fare, in dark orange, is what most peak-period commuters would pay. One can see that MyCiTi fares are generally lower than taxi fares, represented by the scattered blue markers. However, for direct taxi trips, shown in dark blue, the fare is often but not always a bit lower than the saver peak-period MyCiTi fare. For most trips, total taxi fares are higher because they require transfers (light blue markers). The taxi fares for transfer trips might be overestimated because WIMT may not account for partial fares when a passenger only travels part of the route, but even if taxi fares are overestimated, it is still clear they would be higher than MyCiTi if a transfer is involved. Table 5.9 shows a comparison of fares for selected common commute trips. In all cases, taxi fares exceed MyCiTi saver fares, although MyCiTi is sometimes more expensive with a standard ticket.

Table 5.9: Comparison of taxi and MyCiTi fares for selected trips

Origin	Destination	Fare (ZAR)				
		Taxi	MyCiTi fare Saver, peak	Saver, off-peak	Standard, peak	Standard, off-peak
Mitchell's Plain	Kloof Street	27	16.5	11.3	23.5	16
Greenpoint	Hout Bay	33	16.5	11.3	23.5	16
Atlantis	Cape Town center	39	23.1	16.6	32.8	23.6
Khayelitsha (Govan Mbeki Rd)	Cape Town center	24	18	12.5	25.5	17.7
Century City	Wood Drive	17	15	9.6	21.1	13.7

## 5.5 Limitations

As with any simulation model, this analysis depends on the model assumptions and the quality of the data available. Throughout this chapter I have discussed how assumptions and potential errors in the data affect the model results. A further limitation of this analysis is that it does not account for reliability. The MyCiTi travel times returned by Google Maps are based on published schedules and assume on-time service, so do not reflect potential service delays. Similarly, the taxi travel times assume a constant service frequency for each route, rather than using a probabilistic approach that accounts for variability in vehicle arrival times. I chose to use a deterministic model rather than a probabilistic one due to data availability—I would be able to estimate the variance in taxi headways from the taxi rank survey data, but I have no equivalent source for MyCiTi headways. Since accounting for taxi variance would increase the expected wait times for all taxi routes, without a similar adjustment in MyCiTi times, my analysis would underestimate MyCiTi travel times relative to taxi travel times. Since I'm most interested in the relative accessibility scores between modes and time periods, rather than absolute scores, it is better to assume both have equal reliability.

Another important limitation is the accessibility model does not consider multimodal use. The 'combined' accessibility score represents the ability to travel by either MyCiTi or minibus taxi, but not both in one trip. My interviews suggested many travelers actually do avoid combining minibus taxi with MyCiTi, since that would require paying two fares. However, some do use both—according to HHTS, roughly 3% of all commuters used more than one public transport mode in their trip, and less than 1% combined private car and public transport. Among respondents to my survey of travelers, 16.7% said they used both MyCiTi and taxi for their commute, a finding I will discuss in greater detail in Chapter 6. For the current model-based analysis, the exclusion of multimodal travel results in underestimating



accessibility by MyCiTi and taxi combined, suggesting the introduction of MyCiTi may be slightly more beneficial than estimated here. A useful extension of this research would be to adapt the travel time model to allow multimodal trips.

The model does not represent endogeneity in taxi demand as supply characteristics change. In the MyCiTi area, taxi usage likely decreases as some passengers switch to MyCiTi. With fewer passengers using MyCiTi, travel speeds would increase due to lighter traffic and less frequent stops. At the same time, fewer passengers would mean longer wait times at taxi ranks. On balance, though, taxi travel times would likely decrease slightly, making taxi relatively faster than MyCiTi and attracting more passengers. Increased usage of MyCiTi would also affect its travel speeds by potentially increasing dwell time at the stations, although because stops are fixed rather than on-demand the effect would be relatively smaller than with taxis. Modeling these dynamics is outside the scope of this dissertation, but might be interesting for future work.

In the next chapter, I will account for some of these limitations – the effects of multimodal trips, reliability, affordability, and other intangible factors – by analyzing actual travel choices of survey respondents.

## Chapter 6

# Analysis of survey data

BRT reforms can potentially improve accessibility by reducing travel times, although whether it actually does in practice depends on many factors. If introduction of the BRT lessens congestion, all road users benefit from reduced travel times. When it adds transit with a dedicated right-of-way, it can increase travel speed, saving users of that mode travel time. A new configuration of routes might benefit some users while inconveniencing others. Transfers are a key factor—mass transit like BRT often uses a trunk-and-feeder network in which more users must change vehicles, which could add significant time to a trip. But additional transfers could be balanced by higher frequencies and higher travel speeds. Seemingly smaller decisions like station placement and access design affect travel times for users. To access BRT stations, passengers might have to cross a pedestrian bridge, rather than catch a minibus at the roadside, or they might have to wait at a payment kiosk, rather than pay cash on board. In the MyCiTi case, for example, malfunctioning platform doors were a persistent problem, often delaying vehicles several minutes along each route.

A principal goal of MyCiTi was to reduce travel times. Cape Town's Integrated Development Plan of 2006/07 set ambitious targets for reducing average peak period commute time for public transport users. The plan expected to reduce the average commute to from 45 minutes in 2007 to 35 minutes in 2012 (City of Cape Town 2007).

Chapter 5 used a model-based accessibility score approach to address the question of how the MyCiTi reforms influenced accessibility. Besides the limitations thoroughly discussed in that chapter, a model can only tell us how reform affected travel times for available options, not real travel times for options people actually chose. Actual (revealed) choices incorporate the range of factors people use in making a decision, from reliability and comfort to safety and cost, including idiosyncratic factors like time required to cross a busy street or delays due to vehicle breakdowns.

In this chapter, I analyze travel time changes using empirical survey data on actual travel choices before and after the introduction of MyCiTi. Unlike the accessibility model in Chapter 5, this analysis accounts for shifts from modes other than taxis and changes in origin and destination location and changes in routes. Using a difference-in-difference approach, I assessed the degree to which changes in travel time can be attributed to MyCiTi reforms.

## 6.1 Research questions

This chapter addresses the following questions: *Question 1. How have travel times changed with the introduction of MyCiTi and the reform of taxis? Question 2. How have MyCiTi reforms affected travel times for different population groups differently?*

I expect to find that:

- Average accessibility, as measured by travel time, has increased, because for the majority of people affected by the reform, MyCiTi has introduced an additional option. (i.e., they still have a choice of MyCiTi or taxi).
- But for the population in the Blaauwberg corridor, where the Phase 1 trunk corridor runs and where taxis have been mostly removed, accessibility has become more unequal.

## 6.2 Methodology

The analysis in this chapter uses data collected by an intercept survey that I designed and conducted in Cape Town in 2015. The survey targeted Cape Town residents both inside and outside the MyCiTi service area who traveled, and asked them about their travel behavior in 2015 (after the MyCiTi ‘treatment’) and in 2010 (before MyCiTi opened). The objective was to collect data on how residents’ travel behavior had changed since the roll-out of MyCiTi, and data on personal factors that might predict mode choice. The survey methodology follows a design and protocol approved by UC Berkeley’s Committee for Protection of Human Subjects.

### Intercept survey

Recruitment relied on intercepting travelers at public transport interchanges and other highly trafficked areas in Cape Town. After considering alternative methods, I decided that the practical advantages of an intercept survey outweighed the disadvantages, the most critical of which is non-representativeness. Since I was only interested in the behavior of those who travel, and especially those who travel by public transportation, an intercept survey would allow me to specifically target that population. An intercept survey also had the advantage of precedents—I could learn from other researchers who had used the method to survey travelers in Cape Town and had obtained large sample sizes at reasonable cost. The downside was that I would only be able to sample from those who traveled through intercept points at particular times, and the sample would be biased toward people who have longer wait times and those who do not have pressing needs, since they’d be more likely to have time to complete a survey. It would be particularly difficult to survey people who previously used public transport and now drive.

In light of these disadvantages, I considered household-based and employer-based surveys as alternative options. Both presented serious logistical problems. A household survey

is typically considered the method most likely to produce a sample representative of the population living in an area (Dillman, Smyth, and Christian 2014). Unfortunately, I did not have a reliable way of reaching residents in the areas of interest. Unsurprisingly in a place where many people rely on mobile phones, there was no list of telephone numbers. I could use mail, as physical street addresses are available in many parts of the city, but this would leave out informal settlements that did not have street addresses, and would probably also leave out many township residences that had addresses but not reliable mail delivery. For informal settlements and townships, I considered door-to-door recruiting, but this had many potential problems: the population I most wanted to reach, travelers, would be the least likely to be home; in many neighborhoods I would not be able to guarantee fieldworkers' safety, especially neighborhoods controlled by gangs; and it would be prohibitively time-consuming and expensive. Household surveys, whether telephone, mail, or in person typically have lower response rates than intercept surveys and therefore would be more expensive. These challenges made a household-based survey impractical given my budget and timeline.

I also considered an employer-based survey, in which I would persuade employers at a sample of workplaces to allow me to survey their employees. This could potentially yield a large sample at relatively low cost, since I would have access to many potential respondents in one place. Potential respondents would all be people who travel and, provided I chose the employers carefully, it could have a fairly representative sample of public transportation users across class, age, race, and gender groups. The main barrier was that I was unsure I'd be able to convince enough employers to participate within the timeframe available. Based on information from another researcher who had attempted this method, most employers were resistant to participating. For the method to be practical, I'd have to enlist relatively large employers with a wide range of workers (for example, a hospital), and gaining permission would require going through many bureaucratic steps and, even if they eventually agreed, it might take too long. I deemed the employer-based survey option to be too risky and settled on the intercept method.

## **Target population and sampling strategy**

The target population was all residents of Cape Town who travel within selected MyCiTi service areas. Those areas are the Cape Town city center, the MyCiTi T1 trunk service area (Blaauwberg Corridor), and the N2 Express corridor (Mitchell's Plain and Khayelitsha). To ensure respondents could compare their current travel to their travel in 2010, I excluded anyone under the age of 20 or who had lived in Cape Town less than five years. The target population included MyCiTi and minibus-taxi users, but also those who travel by train, car, and non-motorized transport. I aimed to capture people who travel for work, education, and other purposes. In order to obtain sufficient data to address the research questions, I oversampled MyCiTi and minibus-taxi users. The target sample size was 1,000 respondents.

## Questionnaire design

The principal challenge in the survey design was balancing the need to collect sufficient information with the need to keep the questionnaire a manageable length. When intercepting travelers, one has a very limited time to ask questions. Based on pretests, I determined that the ideal survey would take five minutes to complete, with a maximum of ten minutes. A longer survey would be more likely to produce biased results, since only people with extra time would complete it.

I was interested in how MyCiTi has affected travel for both work or school and travel for other purposes. However, I concluded that asking about both work and non-work travel would make the questionnaire too long. Therefore, I used two questionnaires: one for work travel and one for non-work. Except for questions about trip purpose and destination, the two questionnaires had nearly identical questions. The work travel questionnaire would be administered only to people who traveled for work or school, while all eligible travelers could respond to the non-work questionnaire, whether or not they were employed. The two surveys were administered to two different groups of respondents.

The survey asked respondents to answer questions about the trip they normally make to reach their place of work or study. For non-work travel, respondents were asked questions about the trip they normally make to go shopping for food. If the respondent never shopped for food, they would be asked about their travel to visit friends or family. Copies of the work and non-work questionnaires are provided in Appendix B.

Respondents were asked about their current typical travel and how they typically traveled in 2010. For each typical trip, they were asked about mode choice, number of days per week traveled, total travel time, origin and destination location. They were also asked to compare their current trip with the 2010 trip in terms of affordability, reliability, comfort, safety, and security. Finally, they were asked about household demographic questions. I conducted a one-day pretest prior to the actual survey in order to test response rates, the clarity of survey questions, and practicality of the survey protocol. I revised the survey questions, locations and times, and protocol based on pretest feedback. For instance, the pretest suggested a question about transport cost was too complicated because respondents found it difficult to consider daily vs. weekly vs. monthly fares, especially for five years ago. Rather than risk inaccuracies, I decided to omit the question.

## Limitations of retrospective surveys

The survey uses retrospective questioning, where respondents are asked to provide information about their travel behavior five years ago. As a way of collecting data on multiple points in time, retrospective surveys are widely perceived as less accurate and less reliable compared to panel studies, in which individuals are tracked and questioned over time (Moss and Goldstein 1979); however, some in the transportation field have argued the retrospective method is suitably reliable in certain circumstances (Hollingworth and Miller 1996; Behrens and Mistro 2010). The main disadvantage of retrospective surveys is that respondents may

not accurately recall information, as individuals' recall ability declines over time (Moss and Goldstein 1979). Memory may also be distorted by individuals' tendency to rationalize past behavior in order to make sense of past events (Hollingworth and Miller 1996). However, panel studies have problems as well. High attrition rates can introduce bias since dropouts are usually not random. Panel studies are also expensive and time-consuming, and are usually not possible within the normal timeframe for dissertation research.

Survey experiments in the transportation field suggest that retrospective surveys can be fairly reliable when asking respondents about travel behavior or residential location choices, provided the elapsed time is not too long. Hollingworth and Miller (1996) found that respondents had difficulty recalling their employment location history over a period of ten years, but when the timeframe was reduced to five years, almost all respondents were able to answer the questions. The same authors found that all respondents could remember the year they moved homes. Based on findings from a small-sample test survey of commuters in Cape Town, Behrens and Del Mistro (2010) suggested respondents had little trouble recalling travel behavior from as long as 30 years ago, because changes in travel behavior were so often associated with major life events (such as moving or graduating school) or trauma (such as having a car accident or getting mugged on the train). These authors argued that although memory accuracy declines with time, it also depends on the type of event and even mundane information like commuting routes is easier to remember when associated with important life events.

My survey used a slightly different approach than the questioning used by Hollingworth and Miller (1996) and Behrens and Del Mistro (2010); whereas they asked respondents to recall the last time (or last several times) they moved or changed travel behavior, my survey asked respondents where they lived and how they traveled five years ago, in 2010. I tried to aid respondents memory by reminding them that was the year of the World Cup, a major event for many Capetonians. People seemed to respond well to that prompt. I also tried to minimize error by asking about changes over only a five-year period. Based on survey fieldworkers' reports, most respondents did not seem to have trouble recalling the information asked of them.

## **Survey procedure**

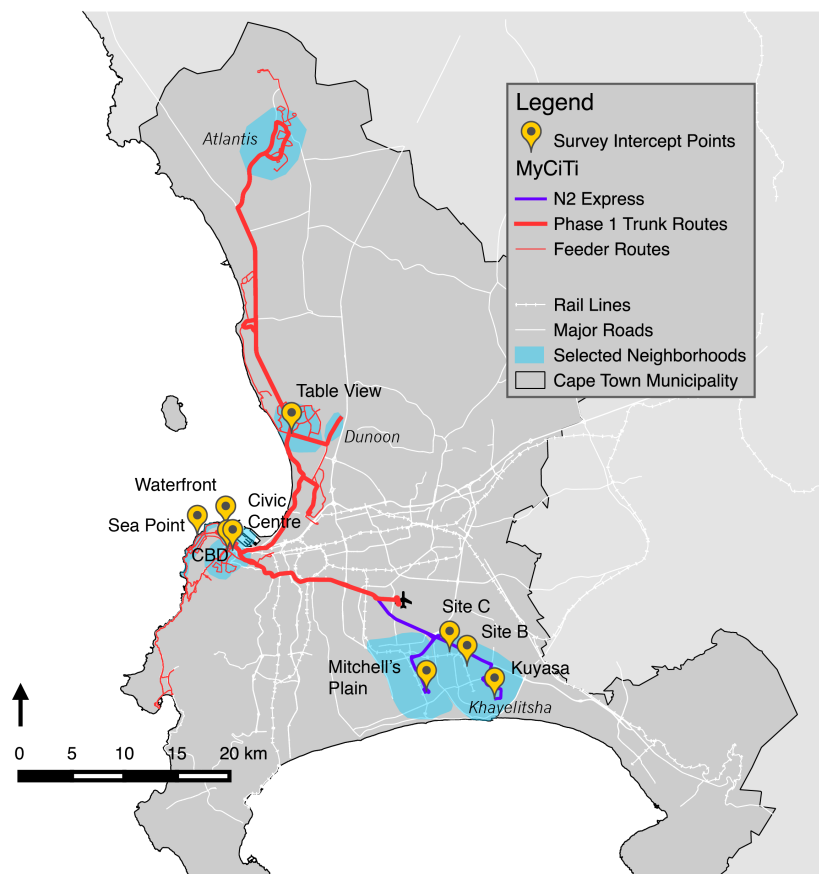
The survey was conducted between October 27th and November 19th, 2015. I chose this time of year because it is free of major holidays that would disrupt normal travel patterns and the weather is generally mild with little rain.

## **Survey locations and times**

I selected survey locations and times that have a high volume of travelers, especially MyCiTi and minibus taxi users. I included shopping centers and markets in order to capture non-public transport users.

Survey times were Monday through Friday during the morning peak (5:00AM– 9:00AM) and afternoon peak (3:00PM–7:00PM), and Saturday midday (10:00AM–4:00PM). The times varied slightly by location. For example, in outlying areas like Khayelitsha, the morning peak begins much earlier, at 5AM, than it does in close-in areas, where it does not become busy until 6AM. I modified the survey times and locations slightly as the survey proceeded as I learned which times and places produced the highest response rates.

Figure 6.1: Locations of survey intercept points



Initially I planned to survey at the Dunoon taxi rank, near where one of the MyCiTi trunk routes ends, and where taxis are continuing to operate. However this was not possible as conflicts between the taxi association and the City raised security concerns. Thus surveying was concentrated at the city center, Mitchell's Plain and Khayelitsha taxi ranks.

It proved much more difficult than expected to obtain responses from private car users. In Cape Town, there are few times when private car users are in public spaces, as most offices and shopping areas are directly connected to car parks under heavy security. I initially planned to capture car users in the parking areas of shopping centers and markets. However, shopping areas tend to have heavy security surveillance even in the parking areas, and

Table 6.1: Survey intercept locations

Area	MyCiTi stations/stops	Taxi ranks/stops	Train stations	Shopping centers/public spaces
City Center	Civic Centre, Waterfront	Civic Centre (Top Deck), Somerset Hospital	Cape Town station	Golden Acre, Civic Centre plaza, St. Georges Mall, Sea Point Promenade
Table View	Table View	Century City		Century City, Bay View
Mitchell's Plain	Mitchell's Plain	Town Centre	Town Centre	Town Centre shopping center, Liberty Promenade
Khayelitsha	Kuyasa	Site C, Site B	Kuyasa	Site C shopping center/market, Site B shopping center, Khayelitsha Day Hospital

security officers did not permit the fieldworkers to work there. At the Century City shopping center and Bayside Mall security officers turned away the survey team. Management did not respond to my multiple requests for permission. When surveyors could work in parking areas, few people were willing to stop and answer the questionnaire.

After these setbacks in targeting private car users, I decided to survey in the following public spaces:

- St. George's Mall. This is a pedestrian street in the city center where I targeted office workers during their lunch breaks and shoppers on the street.
- Civic Centre plaza. This is the indoor plaza within the municipal Civic Centre complex. It is a public space where residents come to conduct business with the city, such as renewing drivers' licenses or applying for business permits. I obtained permission from the City to survey here during midday, when many office workers in the complex were taking lunch breaks in the food courts and when traffic from regular citizens was high.
- Sea Point promenade. This is a public walking path along the coast popular among white Capetonians (as well as other races). I targeted people here on Saturdays, especially in parking lots.

For each day, each survey team was instructed to use either the work or non-work travel questionnaire. Thus each survey worker would collect only work questionnaires for the day, or only non-work questionnaires. The only exception to this rule was in the case of targeting surveying to capture car users. Since it was so difficult to find people who drove, we determined it was important for them to answer the survey whether or not they traveled to work. At the St. George's Mall and Civic Centre locations, if the respondent indicated they did not work or go to school, they were asked to respond to the non-work travel questionnaire



instead. As a result the non-work travel survey responses from car drivers may be slightly biased toward non-workers.

## Languages

In Cape Town the three official languages are English, Xhosa, and Afrikaans. Almost all Capetonians speak at least some English even if it is not their first language. However, many people, especially older and Xhosa-speaking residents, are more comfortable in their first language. I had heard from colleagues in Cape Town that many Xhosa speakers felt frustrated by having to usually communicate with the city and city services in English. (For example, the city's website is in English only.) I felt I would receive more numerous and less biased responses from Xhosa speakers if the survey were administered in Xhosa, so I hired four fieldworkers who were native Xhosa speakers. The survey questionnaire was in English, and respondents could choose to speak in either English or Xhosa. Surveyors were instructed to approach potential respondents in either language, according to their best judgment. Initially I planned to also make the survey available in Xhosa, and the pretest used a Xhosa translation of the questionnaire. However, in the pretest fieldworkers found it more natural to use an English questionnaire but to speak in Xhosa when appropriate. This is not surprising given that Xhosa is primarily a speaking language, and in conversation most Xhosa speakers use a mixture of both English and Xhosa.

I also considered using an Afrikaans translation as well. However, I did not have the resources to hire an additional Afrikaans-speaking team or find appropriate translators. Moreover, compared with Xhosa speakers, Afrikaans speakers are generally more educated and more likely to also be comfortable with English. The survey teams reported they did not run into problems with potential respondents being unable to participate due to language barriers, although it is possible Afrikaans speakers would have felt more comfortable and been more open if the questionnaire were administered in their first language.

## Survey team

I hired nine fieldworkers, including one supervisor. I decided to form two teams, each to work in a different area of the city. Four students from the University of Cape Town (UCT), chosen for their interest in the subject and their experience in doing survey work, formed the first team. This team conducted surveys in English only and focused on the locations in Cape Town, the Blaauwberg Corridor, and Mitchell's Plain.

The other team consisted of four Khayelitsha residents chosen for experience in community work and fluency in both English and Xhosa, and one supervisor who directly managed the team. This team focused on surveys in Khayelitsha, Cape Town and the Blaauwberg Corridor. It was necessary to use fieldworkers from the community because Khayelitsha, as well as other black townships, is often perceived as dangerous for other races and for foreigners. (Three of the four university students were foreign citizens.) As local residents, the Khayelitsha fieldworkers were more familiar with the community, felt safer there, and

were better able to interact with Xhosa speakers. Using local residents was also logistically practical, as the long distance between Khayelitsha and central Cape Town makes it difficult for non-local residents to reach for a 5AM work shift, and it could be unsafe to travel back in the dark after an evening shift.

All fieldworkers completed a training session in which they learned about the project background, received instruction in the survey protocol, and practiced administering the questionnaire. The pretest also served as practice for the fieldworkers.

## Survey Protocol

The fieldwork teams conducted the survey according to a predetermined protocol. Pairs of surveyors were assigned to a specific location and time. For identification purposes they wore a UCT ID card and carried a canvas bag with the UCT logo.

Each surveyor was instructed to approach passengers waiting in queues or walking past. To ensure randomness, surveyors were to approach every fifth person encountered, unless there were few people around, in which case they were to approach every person.

The surveyor was instructed to introduce himself or herself and the research. For example, “My name is [name] and I’m conducting a survey on behalf of the University of Cape Town and the University of California, Berkeley. We’re trying to understand how public transportation is working for Cape Town.”

Then he/she was to then ask the following screening questions:

- Are you a resident of Cape Town?
- Were you a resident of Cape Town 5 years ago?
- Are you over the age of 19?
- Do you travel for work or study? [this question is omitted for the non-work travel questionnaire]

If the answer to all of these questions was “yes,” the surveyor was to continue: “Ok, I will ask you questions about how you typically travel. All questions are voluntary and anonymous, and you can stop at any time. Do you agree to participate?”

If the potential respondent agreed, the surveyor continued on to the questionnaire.

If at any time the potential respondent said no or declined to participate, the surveyor said “thank you” and move on to the next potential respondent. A separate handout with information about the research project (i.e., purpose, research questions, funding) was available for those who requested it.

Surveyors administered the questionnaire verbally and recorded answers using pen and paper. The questionnaire was one page front and back and took between five and ten minutes to complete. All questions were voluntary and the respondent was allowed to skip questions or stop at any time. Sometimes respondents who were waiting for a bus or taxi had to

leave in the middle of the survey; in this case, surveyors were instructed to be considerate of respondents' schedules and not pressure them if they were in a hurry. At the completion of a questionnaire, the surveyor offered the respondent a small thank-you token (a pen with the UCT logo or a chocolate).

### **Monitoring and quality control**

The fieldwork supervisor and I periodically observed surveyors' work and addressed any problems as they arise. We reviewed questionnaires visually for completeness and legibility soon after they were completed and any problems with data quality or response rates were addressed with individual surveyors as soon as possible. Each survey questionnaire was printed with a unique code to enable tracking and quality control. Student workers entered the survey responses into a database on an on-going basis and a second data enterer double-checked a random sample of entries.

### **Response rates**

On average, survey workers collected 3.8 surveys per hour. Peak times and busy transit hubs yielded the most responses. Response rates ranged from about 20% at shopping centers and public spaces to about 50% at bus and taxi queues. I determined it was too burdensome to ask survey workers to record each time they approached a potential respondent so I do not have exact data on response rates. Instead, fieldworkers were asked to report the number of people they approached on a few random days.

The survey team collected a total of 1239 questionnaires for the work travel survey and 670 questionnaires for the non-work travel survey. Responses were considered "complete" if the respondent made it to the final section of the questionnaire, the demographic section, even if they skipped some questions. (That is, they were coded "complete" if any questions in the final section were answered.) By that measure, 75 work surveys and 52 non-work surveys were marked incomplete. Another 48 work and 39 non-work responses had to be excluded because one fieldworker was suspected of fabricating data.

The key variable needed in the following analysis are travel time and origin/destination locations. Of the 1115 (work) and 590 (non-work) complete responses, I omitted rows missing travel time or origin or destination locations, leaving  $N=1020$  work travel responses and  $N=558$  non-work travel responses (Table 6.2). As expected, fewer respondents answered questions about their travel in 2010, probably either because they could not remember or because that section was later in the questionnaire. Inspection of the data did not reveal any other systematic patterns in missingness.

### **The challenge of surveying white and high-income residents**

A critical limitation in this survey is the underrepresentation of white respondents and respondents who use cars. This is a general problem with surveys in South Africa. It's

Table 6.2: Missing data in complete survey responses

	Work travel	Pct	Non-work travel	Pct
Complete responses	1,115	100.0%	590	100.0%
Travel time missing	7	0.63%	5	0.85%
Travel time 2010 missing	57	5.11%	20	3.39%
Home location missing	3	0.27%	3	0.51%
Destination location missing	13	1.17%	5	0.85%
Home location 2010 missing	49	4.39%	31	5.25%
Destination location 2010 missing	58	5.20%	4	0.68%
Final observations (N)	1,020	91.48%	558	94.58%

well documented that high crime rates and a climate of distrust can make South Africa a challenging environment for survey data collection. As Seekings and Natrass (2005, p. 302) put it, “achieving a representative sample is extraordinarily difficult in South Africa, primarily because of uneven response rates among different classes (with the rich, including most white people, being difficult to interview).”

The 2013 Cape Town Household Travel Survey (CT HHTS) is an example. In that case, surveyors were unable to collect responses from 115 of 726 zones, resulting in a lower than expected sample size. The survey report listed various reasons for the reduced sample, including: violence in survey areas, labor disputes including bus strikes, respondent refusals due to “people pretending to be surveyors and then robbing households,” Councillors refusing to allow surveying in certain Khayelitsha wards, and non-response from residents in high-security gated communities. Surveyors could not work in areas where their safety might be at risk, and in some areas residents viewed the surveyors themselves as a threat. In some instances, “respondents refused to give out information regarding their household and travel patterns as they believed that the surveys were conducted due to political reasons and not for transport planning purposes” (Royal HaskoningDHV Team and City of Cape Town 2014, p. 11). These problems highlight the importance of gaining trust from the communities to be surveyed.

The experience of the CT HHTS illustrates how, while surveying is difficult in both high- and low-income communities, obtaining adequate sample sizes from high-income residents is even more difficult. Entire wards in Khayelitsha could not be surveyed at all, but could be compensated for by high response rates in other nearby wards. In contrast, the lowest response rates were in wealthier Southern Suburbs where high-security residential complexes are more common. In the CT HHTS, it’s unclear how much the response rates were correlated with income because nearly half of respondents refused to specify their income. Among those that did, the low-middle income group (making (R3,201 – R25,600 monthly) was overrepresented with compared with census data, while those making more or less were underrepresented.

### Challenges of collecting income data

The difficulty of collecting income data is also well-documented, not just in South Africa but in many places. In my survey, 42% of respondents to the work survey and 49% of respondents to the non-work survey declined to answer the household income question. This refusal rate is comparable that of the CT HHTS, where 44% of respondents refused to specify income. In the HHTS, analysts constructed estimates of household income based on observable variables like dwelling type, number of workers, and education level, assuming the distribution of income among the non-respondents matched the distribution among those who responded – an assumption unlikely to reflect reality. I chose not to impute income using such a method because I lacked sufficiently detailed data and because it would require similarly dubious assumptions.

I had expected high refusal rates on the income question and I had hoped education level, which has higher response rates, to provide a socio-economic status indicator. However, I found the responses to the education question were not very reliable. The problem was the question wording. Respondents were asked to report the highest level of education they had completed, and could choose among “Primary,” “Secondary (grade 10/12),” “Tertiary” and “Other.” I chose these categories in response to feedback from local partners. “Tertiary” was intended to refer to a bachelor’s or graduate degree, but in fact many respondents interpreted “tertiary” as anything beyond secondary, including vocational training or certificate programs. Forty-two percent (41% in the non-work survey) of respondents said they had completed tertiary education, when according to Stats SA only 3.7% of the population in Western Cape had completed a Bachelor’s degree in 2011.

### Trip purpose

The sample size for my work travel survey was larger than that for the non-work travel survey. MyCiTi is in fact used by more people for commuting than for other purposes, according to the City’s market research surveys conducted by the research firm yellowwood. The firm surveyed 525 MyCiTi users between November 2013 and May 2014, intercepted at various points within the MyCiTi service area. The results showed 85% of respondents used MyCiTi for commuting to work, while 38% used it for shopping, 33% for “trips and outings on the weekends”, 7% for special events such as concerts/sporting events, and 8% for other purposes. (Respondents could cite more than one purpose.) Reported purpose varied by location. For those intercepted in Dunoon (n=50), 100% used MyCiTi for work, 36% for outings, 52% for shopping. In Atlantis (n=50), 74% used it for work, 60% for outings, 86% for shopping. In all areas, work commuting was the most reported purpose. Unfortunately, the data are not reported in a way to break out what percentage of MyCiTi trips were for which purpose.

## Statistical tests

To test for statistical significance in travel time before and after BRT implementation (that is, from 2010 to 2015), I used t-tests paired by individual respondent, while I used unpaired t-tests to compare between groups and to understand the distribution of impacts. The main variable analyzed was travel time, for either work or non-work trips. Importantly, I accounted for whether or not survey respondents changed home and destination location since 2010. I assumed benefits from BRT can only be attributed to survey respondents who between 2010 and 2015 did not change home or destination location (hereafter referred to as “non-movers”).

Changes in travel time might result from changes in a number of trip attributes: travelers might move and change origin and destination, they might switch modes, they might use a different route, or they might have changes in speed (in-vehicle and access time). Throughout most of the analysis, I was interested in mode switches, and so I controlled for origin/destination changes by focusing only on non-movers. I also used a regression model to isolate the influence of mode choice and other factors on changes in travel time. The last part of the analysis focuses on movers to see whether changes in accessibility may have motivated travelers to move to a different location or change their destinations.

## 6.3 Findings

### Descriptive Statistics

Tables 6.3 through 6.6 show socio-demographic statistics for survey respondents compared with the general Cape Town population. Certain populations are overrepresented in the survey sample: women, blacks, and those under the age of 35. In part, this reflects the fact that the survey oversampled public transport users, who in Cape Town are more likely to be younger and female, as well as travelers in majority-black neighborhoods.

Table 6.3: Respondent gender for work and non-work travel surveys, compared to 2011 Census and 2013 HHTS

	Work travel	Pct	Non-work travel	Pct	All Cape Town (2011 Census) Pct	Work/edu travelers (2013 HHTS) Pct
Female	601	58.9%	299	53.6%	51.1%	47.6%
Male	405	39.7%	248	44.4%	48.9%	51.6%
No response	14	1.4%	11	2.0%	0.0%	0.8%
Total	1020	100.0%	558	100.0%	100.0%	100.0%

*Source: Stats SA, City of Cape Town*

Table 6.4: Respondent race for work and non-work travel surveys, compared to 2011 Census

Race	Work travel, 2015	Pct	Non-work travel,2015	Pct	All Cape Town (2011 Census) Pct
Black African	604	59.2%	363	65.1%	38.6%
Coloured	293	28.7%	125	22.4%	42.4%
White	67	6.6%	45	8.1%	15.7%
Indian/Asian	12	1.2%	8	1.4%	1.4%
Other	0	0.0%	0	0.0%	1.9%
No response	36	3.5%	15	2.7%	0.0%
Prefer not to answer	8	0.8%	2	0.4%	0.0%
Total	1020	100.0%	558	100.0%	100.0%

*Source: Stats SA*

Table 6.5: Respondent age for work and non-work travel surveys, compared to 2011 Census and 2013 HHTS

Age	Work travel	Pct	Non-work travel	Pct	All Cape Town (Census) Pct	Work/edu travelers (HHTS) Pct
20-34	516	50.6%	279	50.0%	44.3%	39.9%
35-59	478	46.9%	261	46.8%	43.1%	52.9%
60+	11	1.1%	14	2.5%	12.6%	3.6%
No response	12	1.2%	4	0.7%	0.0%	3.6%
Prefer not to answer	3	0.3%	0	0.0%	0.0%	0.0%
Total	1020	100.0%	558	100.0%	100.0%	100.0%

*Census and HHTS percentages are for population age 20 years or more only. Source: Stats SA, City of Cape Town*

The choice to intercept survey respondents at multiple locations in Khayelitsha likely further accounts for the oversample of blacks. Although I do not have secondary data with which to compare gender, anecdotally women are more likely to use MyCiTi because many perceive it as safer than the train or taxis. It's also possible that in poorer communities like Khayelitsha, women are more likely to have regular employment that would require them to travel at typical peak times, whereas men might be more likely to be unemployed or work more irregular hours.

Although in general response rates were quite high, nearly 35% of respondents in the work survey and 42% in the non-work survey declined to give their household income (Table 6.6). Among those who did respond, the middle to high income ranges (R3200+) were

overrepresented, compared to the general population. Low income households (<R3200) were underrepresented, likely due to respondents with lower incomes being more reluctant to share that information, as well as low-income residents being less likely to travel. The response rate for the work survey was higher; those who work probably earn more and might be more willing to report income to a stranger. It's likely a substantial portion of the 35%-42% who did not respond fall in the lower middle-income range, which would make them able to afford to travel, but hesitant to talk about income. Because of the low response rate, I chose not to use household income information in the statistical analysis, and instead used race – which had a response rate of 96 to 97% – as an indicator of socioeconomic status. As discussed in Chapter 3, race is strongly correlated with income.

Table 6.6: Respondent monthly household income for work and non-work travel surveys, compared to 2011 Census and 2013 HHTS

Income (ZAR)	Work travel	Pct	Non-work travel	Pct	All Cape Town (Census) Pct	Work/edu travelers (HHTS) Pct
No income	16	1.6%	28	5.0%	13.7%	2.6%
1 - 400	1	0.1%	1	0.2%	2.7%	0.5%
401 - 800	5	0.5%	0	0.0%	4.0%	1.1%
801 - 1600	9	0.9%	11	2.0%	10.6%	3.2%
1601 - 3200	42	4.1%	24	4.3%	16.0%	7.0%
3201 - 6400	179	17.5%	82	14.7%	14.5%	13.4%
6401 - 12 800	115	11.3%	46	8.2%	13.0%	14.1%
12 801 - 25 600	103	10.1%	48	8.6%	11.9%	10.9%
25 601 - 51 200	67	6.6%	29	5.2%	8.7%	5.5%
51 201 - 102 400	28	2.7%	10	1.8%	3.6%	1.8%
102 401 - 204 800	15	1.5%	1	0.2%	0.9%	0.3%
204 801 or more	11	1.1%	3	0.5%	0.5%	0.4%
Don't know	52	5.1%	24	4.3%	0.0%	3.4%
Prefer not to answer	356	34.9%	232	41.6%	0.0%	29.2%
No response	21	2.1%	19	3.4%	0.0%	6.7%
Total	1020	100.0%	558	100.0%	100.0%	100.0%

*Source: Stats SA, City of Cape Town*

Table 6.7 shows survey respondents' main travel mode in 2015, compared with work/school travel mode in the 2013 HHTS. Note the 2013 HHTS mode share is in terms of the number of trips, not respondents. The 2013 HHTS captured only a small sample of MyCiTi users. It also did not report mode share for non-work travel. As planned, the survey sample includes a large number of MyCiTi and minibus taxi users. Even accounting for the deliberate oversampling of public transport users, the number of responses from car drivers was smaller than intended. The small sample sizes of whites and car users is a weakness of the intercept



Table 6.7: Respondent main travel mode in 2015 for work and non-work travel surveys, compared with main travel mode to work/school in 2013 Cape Town HHTS

Main mode, 2015	Work travel	Pct	Non-work travel	Pct	Work/edu travelers (2013 HHTS)	Pct
Bicycle	4	0.4%	2	0.4%	75	0.4%
Car as driver	86	8.4%	93	16.7%	4,711	25.2%
Car as passenger	14	1.4%	14	2.5%	2,187	11.7%
Golden Arrow	30	2.9%	10	1.8%	1,477	7.9%
Minibus taxi	342	33.5%	270	48.4%	2,860	15.3%
MyCiTi	455	44.6%	107	19.2%	56	0.3%
No response	7	0.7%	2	0.4%	n/a	n/a
Other*	6	0.6%	2	0.4%	1,477	7.9%
Train	66	6.5%	20	3.6%	2,038	10.9%
Walk	10	1.0%	38	6.8%	3,851	20.6%
Total	1,020	100.0%	558	100.0%	18,694	100.0%

\* “Other” includes metered taxi, company car, motorcycle, Sibanye bus

*Source: City of Cape Town*

methodology. Reaching whites and car users was a problem throughout the survey exercise, despite efforts to specifically target those groups. Those who primarily walk are also under-represented, especially for the work travel survey. The following analysis will keep in mind the survey responses are not representative of the general population of travelers in Cape Town.

In the non-work travel survey, 67% of respondents reported on travel for shopping purposes, while 27% said they did not shop, but visited friends or family. Seven percent did not specify the trip purpose. When analyzing non-work travel we must consider that respondents traveled for different purposes. Some may have combined these purposes with work commutes as well; for example, shopping on the way home from work.

### Changes in travel time in MyCiTi users vs. non-MyCiTi users

Overall, survey respondents reported significant reductions in travel time to work or school, from an average of 47 minutes in 2010 to 45.5 minutes in 2015; the average decrease was 1.5 minutes (Table 6.8). The reduction is somewhat surprising, since we might expect population and employment increases over the time period to create longer and more congested journeys. However, as discussed in Chapter 5, the overall traffic congestion levels during the morning peak period remained fairly flat from 2012 to 2015. Regardless of possible changes in congestion, the work travel time reduction among respondents is probably due to the oversampling for MyCiTi and minibus taxi users, who, as it will be shown later, reduced their travel times. Respondents’ average commute time of 45.5 minutes in 2015 is close in

Table 6.8: Mean commute time (mins) by 2015 main mode, compared with HHTS

Main mode, 2015	2010 freq	2010 travel time	2015 freq	2015 travel time	HHTS Freq	HHTS travel time
Minibus taxi	352	38.6	342	39.3	4466	51
MyCiTi	4	52.5	455	52.3	95	54.1
Golden Arrow	250	66.6	30	54.7	2289	70.6
Train	157	63.3	66	50.5	3139	72.5
Car as driver	133	34.1	86	36.2	7308	46.3
Car as passenger	35	29.7	14	30.4	3471	34.8
Walk	56	14.0	10	15.4	6065	22.8
Bicycle	4	11.2	4	11.2	103	40
Other	22	36.6	6	27.5	0	na
No response	7	42.9	7	44.3	0	na
All	1020	47.0	1020	45.5	31247	46.1

Table 6.9: Mean shopping/personal visit travel time (mins) by 2015 main mode

Main mode, 2015	2010 freq	2010 travel time	2015 freq	2015 travel time
Minibus taxi	2	15.0	270	29.1
MyCiTi	2	35.0	107	32.0
Golden Arrow	306	29.5	10	51.0
Train	40	15.9	20	44.8
Car as driver	87	20.3	93	15.5
Car as passenger	25	21.0	14	19.4
Walk	1	7.0	38	12.8
Bicycle	35	59.6	2	14.0
Other	60	52.7	2	5.0
No response	2	15.0	2	15.0
All	560	31.0	558	26.8

Table 6.10: Commute time (mins) for movers vs. nonmovers

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value*
Non-movers	607	52.6	46.5	-6.16	-11.7%	0.00000
Movers	413	38.6	44.1	5.47	14.2%	0.00029
Home loc changed	194	38.2	42.7	4.53	11.9%	0.04366
Dest loc changed	337	37.3	44.7	7.44	19.9%	0.00001
All	1020	47.0	45.5	-1.45	-3.1%	0.09687

\*p-value is for paired t-test between 2010 and 2015 travel time.

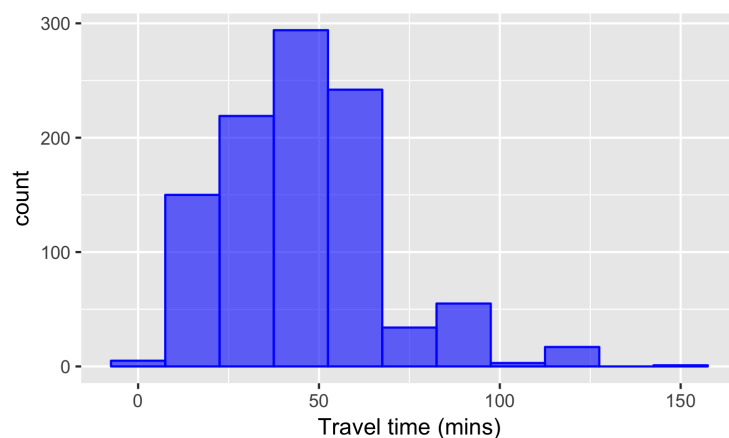
Table 6.11: Shopping/personal visit travel time (mins) for movers vs. nonmovers

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Non-movers	249	33.2	27.7	-5.54	-16.7%	0.00000
Movers	309	29.2	26.1	-3.07	-10.5%	0.02375
Home loc changed	117	28.7	26.7	-1.95	-6.8%	0.33004
Dest loc changed	269	29.6	26.4	-3.20	-10.8%	0.03141
All	558	31.0	26.8	-4.18	-13.5%	0.00001

magnitude to the average commute time found in the 2013 HHTS (Table 6.8), although averages by mode differ between my survey and the HHTS, making it evident the two surveys sampled different populations.

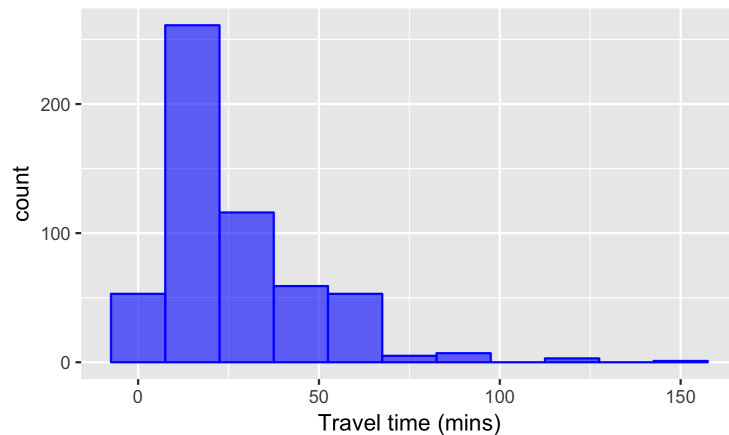
Of the total work travel survey sample, 40.5% relocated their home or work between 2010 and 2015 ('movers', hereafter), while 59.5% changed neither home nor work ('non-movers'). As shown in Table 6.10, the observed drop in travel time occurred mainly among non-movers, who began with longer commutes than did movers. Non-movers significantly reduced their commutes by 6.1 minutes on average (p-value=0.0000). Movers started with shorter commutes, but they increased, by on average 5.5 minutes (p-value=0.0003). This result is not consistent with what we'd expect if respondents moved in order to take advantage of more accessible locations, and suggests those who moved did so either because they were attracted by something other than travel time savings, or because they had little choice. Non-movers must have reduced their commutes by some means other than a change in origin or destination. Travel times for non-work purposes also decreased significantly, and the decrease was larger for 69.5% of respondents who did not move than for those who moved (Table 6.11).

Figure 6.2: Distribution of commute times in 2015 for survey respondents



Along with these patterns in average values, travel times vary widely within respondent groups. Travel time values have a standard deviation of roughly 20-30 minutes (Table 6.12),

Figure 6.3: Distribution of shopping/personal visit travel times in 2015 for survey respondents



and Figures 6.2 and 6.3 show distributions with a large range. The t-tests used throughout this chapter account for variance in seeking to detect significant differences between group averages.

Table 6.12: Summary statistics for travel time (mins), work and non-work travel surveys

	Work 2010	Work 2015	Work mean change	Non-work 2010	Non-work 2015	Non- work mean change
Min.	0.0	4.0	-95.0	2.0	2.0	-130.0
1st Qu.	25.0	30.0	-15.0	15.0	15.0	-10.0
Median	45.0	45.0	0.0	25.0	20.0	0.0
Mean	47.0	45.5	-1.5	31.0	26.8	-4.2
3rd Qu.	60.0	60.0	15.0	40.0	35.0	3.0
Max.	180.0	150.0	105.0	150.0	150.0	105.0
Std. dev.	28.7	22.1	27.9	23.8	19.9	21.4

### Is there evidence the observed changes in travel time are due to MyCiTi?

As shown in Table 6.13, non-movers who used MyCiTi significantly reduced their commute times, by 5.5 minutes on average, which might suggest MyCiTi helped reduce travel time. However, non-movers who used other modes reduced commute times even more, 6.8 minutes

Table 6.13: Commute times (mins) for MyCiTi users vs. non-users

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Non-movers						
Did not use MyCiTi	310	46.4	39.6	-6.81	-14.7%	0.00000
Used MyCiTi	293	59.1	53.6	-5.46	-9.2%	0.00136
All	607	52.6	46.5	-6.16	-11.7%	0.00000
Movers						
Did not use MyCiTi	219	38.2	39.2	0.91	2.4%	0.62788
Used MyCiTi	192	39.0	49.9	10.91	28.0%	0.00001
All movers	413	38.6	44.1	5.47	14.2%	0.00029

Table 6.14: Shopping/personal visit travel times (mins) for MyCiTi users vs. non-users

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Non-movers						
Did not use MyCiTi	163	28.6	24.8	-3.83	-13.4%	0.00003
Used MyCiTi	85	42.2	33.3	-8.88	-21.0%	0.00244
All	249	33.2	27.7	-5.54	-16.7%	0.00000
Movers						
Did not use MyCiTi	269	29.2	25.4	-3.79	-13.0%	0.00669
Used MyCiTi	39	26.9	31.4	4.49	16.7%	0.25864
All	309	29.2	26.1	-3.07	-10.5%	0.02375

on average. Table 6.14 shows that for non-work travel, non-movers who used MyCiTi had larger reductions than those who used other modes, and the difference between the two is slightly significant (p-value=0.0932). Still, on average all non-movers in both surveys experienced significant time savings, regardless of whether or not they used MyCiTi. This suggests that even if the introduction of MyCiTi led to travel time savings, other factors are also at play in reducing travel times. It may be that MyCiTi played a role in reducing congestion; however, evidence presented in Chapter 5 suggests congestion was not significantly reduced.

Tables 6.15 and 6.16 show travel time changes by 2015 main mode for non-movers in the work and non-work travel surveys respectively. For work travel, both minibus taxi users and MyCiTi users significantly reduced travel time, by 19% and 9% respectively. For non-work travel, significant reductions are evident among minibus taxi (9%), MyCiTi (25%), and car (23%) users. These are large reductions, especially considering they are not due to changes in trip origin or destination but to other reasons, such as mode switching or changes in speed.

To investigate whether or not mode switching seems to have affected travel time, we can examine travel time changes for only those who switched to MyCiTi or taxi, breaking out by the main mode of the same trip in 2010. For work travel, (Tables 6.17 and 6.18) the MyCiTi users with significant reductions in travel time were those who switched from Golden Arrow (25% reduction, p-value of 0.0000), and from train (15% reduction, p-value of 0.01). Those

who used minibus taxi in 2015 also had significant reductions if they switched from Golden Arrow (33% reduction, p-value 0.000) or train (48% reduction, p-value 0.000). Interestingly, those who used minibus taxi in both 2010 and 2015 significantly increased their travel time by 1 minute on average, suggesting the observed reduction in travel time is not, in general, due to increased speed or better service among taxis. The 66 respondents who used car in both periods also had a slight and insignificant increase in travel time, from 31.7 minutes in 2010 to 33.2 minutes in 2015 (p-value 0.4964), providing more evidence that observed travel time savings come from mode switching and not from increased in-vehicle travel speed.

Thus, it appears non-mover survey respondents reduced their travel times by switching from slower public transport modes—Golden Arrow and train—to comparatively fast public transport modes – minibus taxi and MyCiTi. Some respondents also reduced travel time for non-work travel by switching from public transport to car. So far, the evidence suggests MyCiTi helped save time for travelers previously stuck using slow public transit modes, but it also appears minibus taxis did so as well. For shopping and social visits, both MyCiTi and minibus taxi users reduced their travel times, by 10 mins and 3 mins respectively, but MyCiTi users had greater savings, a difference that is significant at the 95% level (p-value=0.0302 ). The evidence suggests that for non-work travel MyCiTi was more effective at reducing travel time, while for work travel minibus taxi and MyCiTi appear associated with more or less the same magnitude of savings, at least on average. Whether switching to taxi or MyCiTi offers a greater time savings probably depends on the trip origin and destination, which I will explore shortly.

Table 6.15: Change in commute time (mins) by 2015 mode for non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Minibus taxi	228	48.6	39.3	-9.35	-19.2%	0.00000
MyCiTi	276	59.6	54.0	-5.56	-9.3%	0.00186
Golden Arrow	11	50.5	42.3	-8.18	-16.2%	0.13989
Train	30	55.8	54.5	-1.30	-2.3%	0.31735
Car	51	35.4	37.2	1.76	5.0%	0.56064
Walk/Bike	6	17.5	16.7	-0.83	-4.8%	0.36322
Other	1	45.0	45.0	0.00	0.0%	
No response	4	56.2	48.8	-7.50	-13.3%	0.64702
All	607	52.6	46.5	-6.16	-11.7%	0.00000

## How do travel time savings differ by race?

The initially large racial gap in travel times lessened slightly in these data. Echoing findings from the NHTS, commute times varied widely by race, with an average commute for black respondents of 50 minutes in 2010, 44.7 minutes for coloured, and 33.6 minutes for whites. The gap among respondents narrowed in 2015: blacks as a group saved 4.8 mins on average,

Table 6.16: Change in shopping/personal visit travel time (mins) by 2015 mode for non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Minibus taxi	96	32.3	29.3	-3.02	-9.4%	0.01315
MyCiTi	72	41.8	31.5	-10.35	-24.7%	0.00137
Golden Arrow	6	43.3	55.0	11.67	26.9%	0.18541
Train	10	60.0	48.0	-12.00	-20.0%	0.15948
Car	51	21.4	16.5	-4.92	-23.0%	0.00044
Walk/Bike	13	14.5	11.2	-3.38	-23.3%	0.30212
No response	1	15.0	15.0	0.00	0.0%	
All	249	33.2	27.7	-5.54	-16.7%	0.00000

Table 6.17: Change in commute time (mins) by 2010 mode for those who used MyCiTi in 2015, non-movers only

Mode in 2010	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Minibus taxi	91	46.0	49.5	3.46	7.5%	0.21265
MyCiTi	1	30.0	30.0	0.00	0.0%	
Golden Arrow	109	74.1	55.7	-18.39	-24.8%	0.00000
Train	31	74.4	63.5	-10.81	-14.5%	0.09959
Car	35	40.0	48.1	8.14	20.4%	0.13301
Other	8	48.8	74.4	25.62	52.6%	0.04276
No response	1	60.0	60.0	0.00	0.0%	
All	276	59.6	54.0	-5.56	-9.3%	0.00186

Table 6.18: Change in commute travel time (mins) by 2010 mode for those who used Minibus taxi in 2015, non-movers only

Mode in 2010	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Minibus taxi	126	35.7	36.8	1.14	3.2%	0.06357
Golden Arrow	56	64.5	43.5	-20.98	-32.5%	0.00000
Train	34	74.3	38.8	-35.44	-47.7%	0.00000
Car	8	38.1	48.8	10.62	27.9%	0.23086
Walk/Bike	1	10.0	15.0	5.00	50.0%	
No response	3	45.0	50.0	5.00	11.1%	0.47777
All	228	48.6	39.3	-9.35	-19.2%	0.00000

a significant change, while coloured and white respondents significantly increased their travel times (Table 6.21). The difference in travel time change between whites and non-whites was significant at the 99% level (p-value=0.0046).

Among non-movers, white MyCiTi users increased travel time, largely because white

Table 6.19: Change in shopping/personal visit travel time (mins) by 2010 mode for those who used MyCiTi in 2015, non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
MyCiTi	1	25.0	50.0	25.00	100.0%	
Golden Arrow	49	37.1	32.5	-4.59	-12.4%	0.14362
Train	2	25.0	12.5	-12.50	-50.0%	0.34404
Car	3	20.0	31.7	11.67	58.3%	0.36883
Other	4	78.8	27.5	-51.25	-65.1%	0.14845
No response	13	57.3	30.4	-26.92	-47.0%	0.00006
All	72	41.8	31.5	-10.35	-24.7%	0.00137

Table 6.20: Change in shopping/personal visit travel time (mins) by 2010 mode for those who used Minibus taxi in 2015, non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Golden Arrow	68	27.4	26.3	-1.06	-3.9%	0.30737
Car	8	27.2	33.8	6.50	23.9%	0.20571
Other	8	40.6	29.4	-11.25	-27.7%	0.06184
No response	12	57.9	42.9	-15.00	-25.9%	0.00422
All	96	32.3	29.3	-3.02	-9.4%	0.01315

users were more likely to switch from car. Non-white MyCiTi users had savings, and the difference in change in travel time between nonwhite and white MyCiTi users was statistically significant at the 10% level (p-value=0.0927). For non-work travel, black respondents had the largest travel time savings, on average 5.5 mins, a statistically significant change (Table 6.22). Changes among other racial groups were on average smaller and not statistically significant due to smaller sample sizes. Blacks who used BRT for non-work travel decreased travel time significantly, by almost 10 minutes on average, while white BRT users increased travel time – although the sample size was too small for the change to be significant (Table 6.24). This offers some evidence that BRT has not exacerbated travel time inequality among races and if anything has helped improve it. However, black and coloured residents still have longer travel times compared to whites. Furthermore, we do not have sufficient data from white travelers, particularly car users, to conclude that their travel times increased among the general population, so we can't say that travel times became more equitable overall.

### How does the need to transfer affect changes in travel time?

As expected, MyCiTi users whose trips involved a transfer had smaller time savings compared to both MyCiTi users without transfers and non-MyCiTi users (Table 6.25). The differences between the two groups are not significant (p-values = 0.7092 and 0.6200 respectively). Thus BRT appears to offer commute time savings even when a transfer is required, which makes



Table 6.21: Change in commute time (mins) by race (all respondents)

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Black African	604	50.0	45.3	-4.69	-9.4%	0.00004
Coloured	293	44.7	48.4	3.70	8.3%	0.02277
Indian/Asian	12	37.5	39.6	2.08	5.6%	0.82021
No response	36	46.0	38.8	-7.22	-15.7%	0.16839
Prefer not to answer	8	31.9	30.6	-1.25	-3.9%	0.78952
White	67	33.6	41.3	7.63	22.7%	0.01743
All	1020	47.0	45.5	-1.45	-3.1%	0.09687

Table 6.22: Change in shopping/personal visit travel time (mins) by race (all respondents)

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Black African	363	33.4	27.9	-5.53	-16.6%	0.00000
Coloured	125	28.2	25.3	-2.90	-10.3%	0.14522
Indian/Asian	8	27.5	31.2	3.75	13.6%	0.61150
No response	15	20.2	34.3	14.13	70.0%	0.12285
Prefer not to answer	2	40.0	30.0	-10.00	-25.0%	0.29517
White	45	23.0	19.0	-4.02	-17.5%	0.19056
All	558	31.0	26.8	-4.18	-13.5%	0.00001

Table 6.23: Change in commute time (mins) by race, MyCiTi users only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Black African	258	55.1	52.8	-2.32	-4.2%	0.23779
Coloured	172	49.1	53.8	4.71	9.6%	0.04685
Indian/Asian	5	26.0	44.0	18.00	69.2%	0.31977
No response	17	53.5	47.1	-6.47	-12.1%	0.49577
Prefer not to answer	2	45.0	55.0	10.00	22.2%	0.29517
White	31	32.4	41.5	9.10	28.1%	0.05866
All	491				NA%	0.47449

Table 6.24: Change in shopping/personal visit travel time (mins) by race, MyCiTi users only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Black African	66	43.4	33.6	-9.80	-22.6%	0.00674
Coloured	30	35.3	31.3	-4.00	-11.3%	0.26598
Indian/Asian	3	25.0	43.3	18.33	73.3%	0.38022
No response	5	20.6	41.0	20.40	99.0%	0.39004
Prefer not to answer	1	20.0	15.0	-5.00	-25.0%	
White	19	27.1	28.9	1.84	6.8%	0.58783
All	126				NA%	0.04996

sense since users would have been less likely to choose MyCiTi if it increased their travel time, as long as they had another option.

For shopping/personal visit travel, similar to work travel, MyCiTi users who did not move significantly reduced their travel time, regardless of whether they had to transfer (Table 6.26). Both MyCiTi users who transferred and those who did not transfer had similar changes in travel time, 10.1 mins and 11.4 mins, respectively (p-value=0.8317). Interestingly, non-movers who used MyCiTi with a transfer saved on average about 6 minutes more than non-movers who did not use MyCiTi at all, a significant difference (p-value = 0.0775). This suggests MyCiTi improved travel times for non-work travel even when users had to transfer.

Table 6.25: Change in commute time (mins) by transfer, non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
BRT user, no transfer	158	57.2	50.4	-6.71	-11.7%	0.00576
BRT user, with transfer	116	63.4	58.0	-5.39	-8.5%	0.04067
All BRT users	297	59.1	53.6	-5.46	-9.2%	0.00136
All modes, no transfer	407	49.6	43.3	-6.38	-12.8%	0.00000
All modes, transfer	164	61.3	54.8	-6.43	-10.5%	0.00168
All	607	52.6	46.5	-6.16	-11.7%	0.00000

Table 6.26: Change in shopping/personal visit travel time (mins) by transfer, non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
BRT user, no transfer	45	38.4	28.3	-10.13	-26.4%	0.01772
BRT user, with transfer	33	50.6	39.2	-11.36	-22.5%	0.00837
All BRT users	86	42.2	33.3	-8.88	-21.0%	0.00244
All modes, no transfer	188	30.2	24.9	-5.34	-17.7%	0.00002
All modes, transfer	46	48.2	39.4	-8.74	-18.1%	0.00747
All	249	33.2	27.7	-5.54	-16.7%	0.00000

## How do travel time changes in the Phase 1 area compare with Phase 2?

I expected that in the MyCiTi Phase 1 area, where MyCiTi mostly replaced taxis, MyCiTi would have travel time savings for some residents—particularly those who live and work near the trunk route, while worsening travel times for others. In contrast, I expected travel times to generally improve in the (Phase 2) N2 Express area, where MyCiTi was simply an additional service, and taxi service was not reduced. Tables 6.27 through 6.30 compare travel time changes for non-movers in different parts of the city, where the service area is defined as a 1-km buffer around the respective type of stop. As expected, those in the N2

Express area had large and significant reductions in commute time, 8 minutes on average. But those who lived outside the MyCiTi area also had significant reductions in commute time of a similar magnitude. Non-movers in the Phase 1 area (including the T1 trunk and F1 feeder) did not significantly change their commute time, and those in the trunk area (T1) reported increases, which contradicts the hypothesis that trunk-area residents had the greatest time savings. Non-movers who worked or attended school within the Phase 1 area did have significant savings in travel time, but those who worked or studied outside the Phase 1 area had similar reductions. (Only six respondents worked or went to school in the N2 Express area).

It's surprising that residents of the feeder service area reduced commute times while residents of the trunk area had increases, but this is consistent with the finding that transferring on MyCiTi does not seem to significantly affect the magnitude of travel time savings.

For non-work travel, in contrast to commuting, non-movers with a residence or a destination in the Phase 1 trunk area had the greatest reductions in travel time, in percentage terms, and those reductions were significant (Tables 6.28 and 6.30). However, in absolute terms the reductions were larger among non-movers who lived outside the MyCiTi area.

The evidence so far does not suggest that having access to MyCiTi affects travel time change, at least any more than other factors. This finding might be due to the fact that travel time changes were driven just as much by respondents switching from the Golden Arrow and train to taxi as they are by respondents switching from those modes to MyCiTi. If respondents can also save travel time by switching to taxis, access to MyCiTi would not have a unique influence on travel time change.

Table 6.27: Change in commute time (mins) by home location, non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Lived in MyCiTi area	303	52.8	48.5	-4.37	-8.3%	0.00317
Lived in T1 area	83	41.9	43.6	1.75	4.2%	0.50837
Lived in F1 area	65	49.2	45.1	-4.08	-8.3%	0.21988
Lived in N2 area	155	60.2	52.5	-7.77	-12.9%	0.00022
Lived outside of MyCiTi	304	52.4	44.5	-7.95	-15.2%	0.00000
All non-movers	607	52.6	46.5	-6.16	-11.7%	0.00000

Turning our attention to the 459 respondents of the work travel survey who both work and live in the MyCiTi area, the vast majority, 77% use MyCiTi, which makes sense since the survey targeted MyCiTi users. Still, this means at least 23% of travelers who had access to MyCiTi at both ends chose not to use it. Of this population, some (25 respondents) drove, but most (73) used minibus taxis instead. Of the 73 respondents who lived and worked in the MyCiTi area and used minibus taxi, 55% lived in the N2 Express area, while 33 (45%) lived in the Phase 1 area, where taxis were supposedly phased out. This suggests that at least some travelers continued to use taxis even when taxis were supposedly replaced by MyCiTi. Because of selection bias, this survey cannot tell us about the extent of this phenomenon, only that it does exist. Among those that lived in the N2 Express area and worked in the

Table 6.28: Change in shopping/personal visit travel time (mins) by home location, non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Lived in MyCiTi area	126	29.8	25.5	-4.33	-14.5%	0.00506
Lived in T1 area	56	26.2	20.0	-6.16	-23.5%	0.00171
Lived in F1 area	31	29.8	29.1	-0.71	-2.4%	0.85087
Lived in N2 area	39	35.1	30.5	-4.59	-13.1%	0.11414
Lived outside of MyCiTi	123	36.7	29.9	-6.78	-18.5%	0.00011
All non-movers	249	33.2	27.7	-5.54	-16.7%	0.00000

Table 6.29: Change in commute travel time (mins) by destination location, non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Dest in MyCiTi area	485	54.4	48.2	-6.27	-11.5%	0.00000
Dest in T1 area	347	53.1	47.3	-5.73	-10.8%	0.00003
Dest in F1 area	132	58.8	51.1	-7.77	-13.2%	0.00123
Dest in N2 area	6	35.8	31.7	-4.17	-11.6%	0.25863
Dest outside of MyCiTi	122	45.5	39.7	-5.74	-12.6%	0.00661
All non-movers	607	52.6	46.5	-6.16	-11.7%	0.00000

Table 6.30: Change in shopping/personal visit time (mins) by destination location, non-movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Dest in MyCiTi area	172	34.4	28.1	-6.28	-18.3%	0.00002
Dest in T1 area	116	38.5	30.9	-7.61	-19.8%	0.00023
Dest in F1 area	14	32.1	29.6	-2.50	-7.8%	0.58552
Dest in N2 area	42	23.5	19.7	-3.86	-16.4%	0.00934
Dest outside of MyCiTi	77	30.6	26.8	-3.90	-12.7%	0.03246
All non-movers	249	33.2	27.7	-5.54	-16.7%	0.00000

MyCiTi area, both the group that used MyCiTi and the group that used taxi had reductions in travel time, but the change for neither group was significant due to small sample size. Once again, we do not have evidence that MyCiTi on average offered greater travel time reduction than did taxi.

## Regression models

The extent to which MyCiTi was responsible for changes in travel time depends on several interdependent factors: the traveler's home and destination locations, changes in the trip, changes in which modes are available, and the traveler's ability to afford them, and individual preferences. In the preceding descriptive analyses, I've attempted to identify the effect of introducing MyCiTi on travel time by controlling for factors like relocations, race, and mode

choice. Rather than repeatedly slicing the data to control for these variables, however, a regression model can better isolate the effects of mode switching and of access to the MyCiTi system from other factors

In order to better explain the observed changes in travel time among survey respondents, I regressed change in travel time on explanatory variables available in the survey data. I used change in travel time from 2010 to 2015 as the dependent variable and estimated separate models for work and non-work travel.

### Explanatory variables

The relevant explanatory variables are those representing mode choice and mode switching. I included variables for travel mode in 2015, as well as dummy variables representing whether or not the respondent switched from one mode to another. For example, the variable *ga2myciti* indicates if the respondent used Golden Arrow in 2010 and MyCiTi in 2015. Rather than include all possible mode switching combinations, I only included those that were either relevant to the analysis or significant in the model. I also included a dummy variable representing whether or not the respondent used multiple modes for the trip, defined as using any two or more modes, not including walk.

The other variables of interest are dummy variables representing whether or not the origin and destination was within a 1-km radius of a MyCiTi stop, with separate variables for the trunk, feeder, and N2 Express areas. Because I hypothesized that MyCiTi might save time for travelers unless they have to transfer, I also included a dummy variable for transferring in 2010 and 2015. A summary of variables used in the regression and their summary statistics is shown in Tables 6.31 and 6.32.

I controlled for changes in origin and destination by including a variable for change in trip distance, measured as the straight line distance between origin and destination. While network distance might have been more accurate, it would have required making assumptions about route taken, which would have been problematic for trips involving transit and multiple modes. I also included travel time in 2010 as a variable. The non-work travel model includes a variable representing trip purpose (shopping or visiting people) as well.

I wanted to include all sociodemographic variables as controls but, as discussed earlier, more than 40% of respondents refused to disclose their income. I therefore used race as the indicator of socioeconomic status. Other sociodemographic variables are age, gender, and household size. I also include vehicles per person in the household, which may be considered a proxy for household income.

To prepare the data, I first omitted responses where explanatory variables were missing—i.e., where they had values of “No response,” “Prefer not to answer,” and “Don’t know/Don’t remember.” This reduced the number of observations to  $n=758$  for the work survey and  $n=407$  for the non-work survey. I estimated the models using ordinary least squares regression. The dependent variable, change in travel time, is fairly normally distributed, so OLS is appropriate. The plot of residuals against predicted values revealed no heteroschedastic-

ity problems. The Q-Q plot suggests a minor deviation from normality when residuals are highly positive, but the deviation is small.

Table 6.31: Summary of descriptive statistics for continuous and dummy variables, work travel

Statistic	N	Mean	St. Dev.	Min	Max
dist_delta	758	2,286.224	6,890.249	-21,852.300	36,628.270
ttime_2010	758	47.307	29.430	1	180
transfer	758	0.321	0.467	0	1
transfer_2010	758	0.177	0.382	0	1
multMode	758	0.280	0.449	0	1
ga2myciti	758	0.149	0.356	0	1
taxi2myciti	758	0.137	0.344	0	1
train2taxi	758	0.049	0.216	0	1
car2myciti	758	0.062	0.241	0	1
car2taxi	758	0.012	0.108	0	1
train2car	758	0.011	0.102	0	1
walk2myciti	758	0.030	0.172	0	1
home_in_T1	758	0.153	0.360	0	1
home_in_F1	758	0.100	0.301	0	1
home_in_N2	758	0.264	0.441	0	1
dest_in_T1	758	0.621	0.485	0	1
dest_in_F1	758	0.197	0.398	0	1
dest_in_N2	758	0.009	0.096	0	1
OD_in_myciti	758	0.456	0.498	0	1

## Regression results

**Work travel models** Model results are shown in Table 6.33 (work travel) and Table 6.34 (non-work). Model 2 adds location variables indicating whether or not the trip origin and destination were in MyCiTi service areas. For work travel, both models have an  $R^2$  value of 0.61 and an adjusted  $R^2$  of 0.60. Variance inflation factor values for all variables are less than 2.0, indicating collinearity is not a large problem.

Referring to the base model, as expected, an increase in trip distance (*dist\_delta*) is significantly associated with an increase in travel time, such that on average adding one kilometer increased commute time by about one minute—a magnitude of effect that sounds reasonable. Travel time in 2010 is negatively and significantly associated with travel time change, meaning the longer the commute in 2010, the greater the expected travel time savings (or the smaller the expected travel time increase).

Table 6.32: Summary of descriptive statistics for continuous and dummy variables, non-work travel

Statistic	N	Mean	St. Dev.	Min	Max
dist_delta	407	11.732	9,744.261	-75,012.950	45,456.130
ttime_2010	407	31.415	23.841	2	150
transfer	407	0.187	0.390	0	1
transfer_2010	407	0.128	0.334	0	1
multMode	407	0.187	0.390	0	1
ga2taxi	407	0.066	0.249	0	1
taxi2myciti	407	0.103	0.305	0	1
train2taxi	407	0.027	0.162	0	1
walk2walk	407	0.042	0.200	0	1
home_in_T1	407	0.179	0.384	0	1
home_in_F1	407	0.074	0.262	0	1
home_in_N2	407	0.187	0.390	0	1
dest_in_T1	407	0.354	0.479	0	1
dest_in_F1	407	0.049	0.216	0	1
dest_in_N2	407	0.165	0.371	0	1
OD_in_myciti	407	0.302	0.460	0	1

I initially included more sociodemographic variables—household size, gender, age—but none of these were significant. Race is significant at the 0.1 level for whites: being white is associated with a 5.1 minute greater change in commute time compared to blacks.

Not surprisingly, having to transfer in 2015 is significantly associated with greater travel time increase, on average 7.5 minutes, all else equal. The positive association between transferring and travel time is still consistent with earlier findings – having to transfer is associated with increased travel time, but it may still be possible that MyCiTi users save time even when they have to transfer. The coefficient for transferring in 2010 is negative, which is expected, since a commuter who had to transfer before would in 2015 either still have to transfer or would no longer have to transfer. Using multiple modes in 2015 is significantly associated with greater travel time change, adding on average 4.8 minutes to a commute, all else equal.

We are interested in how mode use and mode switching behavior explain the observed changes in travel time. It's important to remember the models do not seek to explain mode choice; rather, mode choice is an independent variable that helps predict the direction and magnitude of travel time change from one period to the next.

Since *mainMode* is a categorical variable, its coefficients must be compared to the reference category, which is MyCiTi. Using minibus taxi in 2015 is associated with larger travel time savings, compared to using MyCiTi. The coefficient of -9.3 is significant at the 0.01

level and indicates that a minibus taxi commuter in 2015 would be expected to have seen a travel time change of 9.3 minutes less than an otherwise equivalent MyCiTi commuter, which translates into either a greater travel time savings, or a smaller travel time increase. Car commuters also had large savings (or smaller increases) compared to MyCiTi users, on average 9.3 minutes. The coefficient for car is significant at the 0.05 level. This suggests minibus taxi users had, all else equal, greater commute time benefits than MyCiTi users.

Golden Arrow and train as main mode in 2015 have coefficients (-1.2 and -2.9, respectively) that are small in magnitude and insignificant, indicating on average commuters using those modes had travel time changes similar to MyCiTi users.

The model indicates fairly large effects associated with switching from Golden Arrow to MyCiTi and from train to minibus taxi. Among the 758 work-travel respondents, 113 shifted from Golden Arrow to MyCiTi, the largest group of mode switchers. This mode shift from Golden Arrow to MyCiTi was significantly associated with a travel time reduction of about 10.2 minutes greater (or a travel time increase 10.2 minutes smaller) compared to those who did not make that switch. Switching from train to minibus taxi had a similar effect: the 37 respondents who used minibus taxi after using train in 2015 could expect a travel time savings of about 11.8 minutes.

Not surprisingly, switching from walking to MyCiTi (a shift made by 23 respondents) was associated with a reduction (or smaller gain) in travel time, with a magnitude of about 10 minutes. The coefficient for *car2myciti* has a negative sign, indicating the 47 respondents who switched from car to MyCiTi had travel time savings from the switch, although the relationship is not statistically significant.

If MyCiTi offered on average travel time savings over taxis for the 104 respondents who switched, we would expect the coefficient on *taxi2myciti* to be strongly negative. Instead, the coefficient of -2.4 suggests a small effect, only a couple minutes, and not statistically significant. It appears MyCiTi did not unambiguously provide travel time benefits for former taxi users.

In Model 2, adding location variables improves goodness-of-fit very slightly, as indicated by the slightly higher adjusted  $R^2$  and the slightly lower AIC and BIC values. The estimated coefficients for other variables did not change appreciably from Model 1.

The relationships between access to MyCiTi and travel time change are fairly weak, judging by the low levels of statistical significance of location variables. The coefficient for *home.in.N2* is significant at the 0.1 level, and has a positive sign, suggesting that living near an N2 Express stop has a small positive effect on travel time change, adding on average 3.4 minutes to one's commute. Having a destination with access to a Phase 1 feeder stop is also slightly associated with an additional 4.4 minutes.

The variable *OD.in.myciti* indicates whether or not the respondent's home and destination are in the MyCiTi service area, including both Phase 1 and the N2 Express. Adding this variable introduced slight collinearity with *home.in.T1*, so I removed the latter variable. The coefficient for *OD.in.myciti* is negative and suggests having both home and work in the MyCiTi area is associated with a travel time savings of about 4 minutes. However, like the



Table 6.33: OLS regression models for work travel. Dependent variable is change in work travel time, 2010-2015 travel.

	Model 1	Model 2
Intercept	29.855 (3.341)***	29.313 (3.850)***
dist_delta	0.001 (0.000)***	0.001 (0.000)***
ttime 2010	-0.604 (0.028)***	-0.619 (0.028)***
transfer TRUE	7.466 (1.716)***	8.105 (1.740)***
transfer2010 TRUE	-0.817 (1.921)	-1.106 (1.929)
race Indian/Asian	-3.017 (6.218)	-2.538 (6.217)
race Coloured	-0.476 (1.597)	-1.048 (1.639)
race White	5.138 (2.933)	5.460 (2.980)
mainMode Car	-9.345 (3.527)**	-9.154 (3.609)*
mainMode Golden Arrow	-1.212 (4.485)	-1.674 (4.521)
mainMode Minibus taxi	-9.346 (3.167)**	-9.328 (3.284)**
mainMode WalkBike	-27.959 (7.655)***	-25.990 (7.748)***
mainMode Other	-25.752 (8.580)**	-25.326 (8.596)**
mainMode Train	-2.899 (3.580)	-3.167 (3.716)
multMode TRUE	4.820 (1.711)**	4.208 (1.748)*
ga2myciti TRUE	-10.237 (3.101)**	-9.584 (3.103)**
taxi2myciti TRUE	-2.427 (3.218)	-1.823 (3.234)
train2taxi TRUE	-11.826 (3.477)***	-11.874 (3.473)***
car2myciti TRUE	-6.344 (3.861)	-4.516 (3.920)
walk2myciti TRUE	-9.947 (4.977)*	-8.608 (5.016)
ga2taxi TRUE	-4.997 (2.918)	-5.373 (2.929)
home.in_F1 TRUE		-1.128 (2.568)
home.in_N2 TRUE		3.431 (2.052)
dest.in_T1 TRUE		2.436 (2.125)
dest.in_F1 TRUE		4.389 (2.522)
dest.in_N2 TRUE		-7.489 (7.150)
OD.in_myciti TRUE		-4.020 (2.121)
R <sup>2</sup>	0.612	0.618
Adj. R <sup>2</sup>	0.602	0.604
Num. obs.	758	758
AIC	6555	6557
BIC	6557	6687

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ ,  $p < 0.1$ . Standard errors reported in parentheses

other location variables, this relationship is weak, with a statistical significance only at the 0.1 level.

**Non-work travel models** Results for the non-work travel models are shown in Table 6.34. Model 1 had an  $R^2=0.59$  and adjusted  $R^2 = 0.57$ . Change in trip distance is positively and significantly associated with travel time change, as we would expect. As in the commute travel model, travel time in 2010 is negatively associated with travel time change—the longer the 2010 trip, the greater the expected travel time savings. Having to transfer in 2015 was associated with greater travel time change, while having to transfer in 2010 has the opposite relationship. This is logical: people who add a transfer probably increase travel time, while those who remove a transfer probably reduce travel time.

The trip purpose variable (*shop\_visit*) is statistically significant at the 0.5 level, with social visits associated with more positive travel time change. The coefficient suggests people are willing spend about 3.2 additional minutes traveling to visit friends or family than they willing to spend going shopping, which makes sense intuitively.

In Model 1 for non-work, the race variables are not statistically significant. The coefficients for Coloured and White indicate that those respondents would be expected to have slightly greater travel time savings compared to blacks, but the relationships are weak.

Using Golden Arrow as the main mode in 2015 is associated with a 19-minute travel time gain compared to the reference mode, which is MyCiTi. This relationship is significant at the 0.01 level and may reflect worsening Golden Arrow service, or just the fact that if one switched to Golden Arrow it would likely be slower than the previous mode. The model shows a similar effect for train: using train as the main mode in 2015 was associated with a travel time gain of 14 minutes compared to using MyCiTi.

In contrast, switching from Golden Arrow to either taxi or MyCiTi is associated with travel time benefits. The coefficient for *ga2taxi* indicates the 27 (of 407) respondents who switched from Golden Arrow to taxi received a 7.6-minute travel time reduction from the switch, all else equal. This relationship was statistically significant at the 0.05 level. Switching from Golden Arrow to MyCiTi, a shift made by just 12 respondents has a similar effect, all else equal, with a reduction in travel time change of about 5.2 minutes, although the relationship is not statistically significant.

Switching from taxi to MyCiTi, a shift observed in 42 respondents, does not appear to have a significant effect on non-work travel time. The coefficient is positive, which suggests, for non-work travel at least, a shift from taxi to MyCiTi did not bring travel time savings.

The addition of location variables in Model 2 increases the model fit just slightly, and without notable changes in other variables. The statistically significant coefficient on *dest.in.T1* suggests that having a destination in the Phase 1 trunk area is associated with a travel time increase (or reduction in savings) of about 6.4 minutes. This appears to contradict the hypothesis that having access to a MyCiTi trunk route reduces travel time. However, this effect may be due to some respondents combining their shopping or visiting trips with commute trips, which are more likely to have a destination in the Phase 1 area (such as the city center),

Table 6.34: OLS regression models for non-work travel. Dependent variable is change in non-work travel time, 2010-2015

	Model 1	Model 2
Intercept	7.374 (4.333)	8.930 (4.723)
distance_change	0.001 (0.000)***	0.001 (0.000)***
ttime 2010	-0.531 (0.034)***	-0.556 (0.035)***
transfer TRUE	7.411 (2.317)**	7.043 (2.338)**
transfer2010 TRUE	-10.362 (2.461)***	-9.793 (2.452)***
shop_visit Visit	3.172 (1.534)*	3.694 (1.637)*
race Indian/Asian	5.722 (6.829)	6.299 (6.799)
race Coloured	-2.458 (1.647)	-1.721 (1.662)
race White	-3.477 (3.062)	-3.009 (3.133)
mainMode Car	1.282 (4.271)	-0.751 (4.458)
mainMode Golden Arrow	18.714 (6.100)**	14.639 (6.308)*
mainMode Minibus taxi	5.709 (4.210)	3.247 (4.437)
mainMode WalkBike	-3.508 (4.813)	-4.687 (5.005)
mainMode Other	-10.432 (14.105)	-9.953 (14.416)
mainMode Train	13.597 (5.605)*	11.167 (5.751)
multiMode TRUE	3.995 (2.024)*	3.382 (2.048)
ga2myciti TRUE	-5.177 (5.635)	-7.083 (5.618)
ga2taxi TRUE	-7.673 (2.998)*	-8.296 (3.025)**
taxi2myciti TRUE	6.319 (4.515)	4.919 (4.535)
home_in_F1 TRUE		-0.074 (2.915)
home_in_N2 TRUE		3.423 (1.960)
dest_in_T1 TRUE		6.352 (2.196)**
dest_in_F1 TRUE		3.249 (3.663)
dest_in_N2 TRUE		-0.316 (2.163)
OD_in_myciti TRUE		-6.238 (2.372)**
R <sup>2</sup>	0.590	0.605
Adj. R <sup>2</sup>	0.571	0.580
Num. obs.	407	407
AIC	3282	3280
BIC	3362	3384

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ ,  $\cdot$   $p < 0.1$ . Standard errors reported in parentheses

and which are likely longer than stand-alone shopping or social visit trips. Having access to MyCiTi at both the home and destination ends of the trip is, in contrast, significantly associated with a 6.2-minute travel time savings, suggesting perhaps access to MyCiTi does bring travel time benefits.

Taken together the results from both the work and non-work models support findings from the descriptive analysis: having access to MyCiTi at both ends of the trip is associated with reductions in travel time, but mainly because travelers could switch to MyCiTi from bus and train, not because switching to MyCiTi from taxi saved time. In other words, the regression results suggest that while using MyCiTi or having access to to MyCiTi had a small effect on travel time savings, other factors, such as switching away from train and Golden Arrow or having to transfer had relatively larger effects.

### Did people move closer to MyCiTi?

One objective for MyCiTi was to spur economic development by making the areas around its stations more accessible. If MyCiTi did indeed increase accessibility in areas it served, it might have motivated people to move their home or work into those areas. If so, we would expect to see reduced travel times among those who moved and used MyCiTi. In fact, I found the opposite: as shown in Tables 6.13 and 6.14, MyCiTi users who moved their home or destination location actually increased their travel times, significantly so for work travel. All other groups in the table—non-movers and movers who did not use MyCiTi—reduced travel times. In contrast, movers who used minibus taxi as their main mode in 2015 decreased travel time.

Table 6.35: Change in commute time (mins) by 2015 mode for movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Minibus taxi	114	41.3	39.5	-1.82	-4.4%	0.50353
MyCiTi	179	39.3	49.5	10.23	26.0%	0.00003
Golden Arrow	19	40.0	61.8	21.84	54.6%	0.00483
Train	36	34.5	47.2	12.75	37.0%	0.00755
Car	49	35.6	33.6	-1.98	-5.6%	0.60100
Walk/Bike	8	19.4	12.4	-7.00	-36.1%	0.14057
Other	5	39.0	24.0	-15.00	-38.5%	0.15292
No response	3	41.7	38.3	-3.33	-8.0%	0.86577
All	413	38.6	44.1	5.47	14.2%	0.00029

We might also expect increased accessibility motivated relocation if respondents who moved into the MyCiTi area were more likely to use MyCiTi compared to those who already lived in the service area. However, Tables 6.39 and 6.40 show there is no significant difference between these two groups, for work or for non-work travel, as measured by Chi-squared tests.

Table 6.36: Change in shopping/personal visit travel time (mins) by 2015 mode for movers only

	Freq	Mean 2010	Mean 2015	Mean change	Pct change	p-value
Minibus taxi	174	32.2	29.0	-3.14	-9.8%	0.08019
MyCiTi	35	28.3	33.1	4.86	17.2%	0.26732
Golden Arrow	4	57.5	45.0	-12.50	-21.7%	0.66929
Train	10	38.0	41.5	3.50	9.2%	0.79508
Car	56	20.6	15.5	-5.09	-24.7%	0.02613
Walk/Bike	27	18.5	13.7	-4.74	-25.7%	0.00825
Other	2	25.0	5.0	-20.00	-80.0%	0.50000
No response	1	120.0	15.0	-105.00	-87.5%	
All	309	29.2	26.1	-3.07	-10.5%	0.02375

Table 6.37: Cross tabulation of moving and BRT use, work travel

	Did not move home or work	Pct	Moved home or work	Pct
Did not use MyCiTi	310	51.4%	219	53.3%
Used MyCiTi	293	48.6%	192	46.7%
Total	603	100.0%	411	100.0%
Pearson's Chi-squared test		X-Squared 0.273		p-value 0.6011

Table 6.38: Cross tabulation of moving and BRT use, shopping/personal visit travel

	Did not move home or work	Pct	Moved home or work	Pct
Did not use MyCiTi	163	65.7%	269	87.3%
Used MyCiTi	85	34.3%	39	12.7%
Total	248	100.0%	308	100.0%
Pearson's Chi-squared test		X-Squared 35.8		p-value 2.194e-09

Are those who moved their work into the MyCiTi area more likely to use MyCiTi than those who already worked in MyCiTi area? As suggested by Table 6.41 and 6.42, the answer is no. Did MyCiTi allow greater access to jobs? If so, we would expect that those who used MyCiTi would be more likely to have moved work location, even if travel time increased. As shown in Table 6.43, both MyCiTi users and non-users changed work location location at similar rates – 53% and 52%, respectively – not a significant difference.

The survey data suggest that, on the whole, the primary reason for respondents changing home or destination locations was not to take advantage of lower travel times from MyC-

Table 6.39: MyCiTi users who moved into the MyCiTi area vs. MyCiTi users who already lived in the MyCiTi area - work travel

	Did not use MyCiTi	Pct	Used MyCiTi	Pct
Moved home into MyCiTi area, from outside	15	10.1%	34	9.5%
Already lived in MyCiTi area	134	89.9%	325	90.5%
Total	149	100.0%	359	100.0%
Pearson's Chi-squared test		X-Squared 0.00178		p-value 0.9663

Table 6.40: MyCiTi users who moved their residence into the MyCiTi area vs. MyCiTi users who already lived in the MyCiTi area - non-work travel

	Did not use MyCiTi	Pct	Used MyCiTi	Pct
Moved home into MyCiTi area, from outside	21	13.6%	12	12.4%
Already lived in MyCiTi area	133	86.4%	85	87.6%
Total	154	100.0%	97	100.0%
Pearson's Chi-squared test		X-Squared 0.00942		p-value 0.9227

Table 6.41: MyCiTi users who moved job location into the MyCiTi area vs. MyCiTi users who already worked in the MyCiTi area - work travel

	Did not use MyCiTi	Pct	Used MyCiTi	Pct
Moved home into MyCiTi area, from outside	77	21.7%	64	14.5%
Already worked in MyCiTi area	278	78.3%	377	85.5%
Total	355	100.0%	441	100.0%
Pearson's Chi-squared test		X-Squared 6.47		p-value 0.01098

Table 6.42: MyCiTi users who moved destination location into the MyCiTi area vs. MyCiTi users who already shopped or visited in the MyCiTi area - non-work travel

	Did not use MyCiTi	Pct	Used MyCiTi	Pct
Moved dest into MyCiTi area, from outside	51	23.7%	8	6.8%
Already shopped or visited in MyCiTi area	164	76.3%	109	93.2%
Total	215	100.0%	117	100.0%
Pearson's Chi-squared test		X-Squared 13.6		p-value 0.0002206

Table 6.43: Work location moves vs. MyCiTi use - work travel

	Changed work	Pct	Did not change	Pct
Used MyCiTi	178	33.6%	157	32.4%
Did not use MyCiTi	351	66.4%	328	67.6%
Total	529	100.0%	485	100.0%
Pearson's Chi-squared test		X-Squared 0.187		p-value 0.9108

iTi, since on average changes in home and work location were associated with travel time increases. People of course have many motivations for moving—higher paying jobs, safer housing, and the like—that have little to do with accessibility, and this survey was not designed to identify those reasons.

## 6.4 Discussion

The survey findings suggest that, overall, the introduction of MyCiTi has allowed many users to save travel time, but the savings came mainly when MyCiTi replaced other formal modes—specifically train and conventional bus—rather than replacing informal modes—specifically, minibuses taxis. Controlling for changes in origin and destination, when survey respondents switched from train and conventional bus to minibus taxi, they saved just as much or even more time than respondents who switched from train and conventional bus to MyCiTi. According to the OLS regression results, having access to MyCiTi at both ends of the trip was associated with travel time reductions – about 5 minutes for work travel and 2 minutes for non-work. But it was switching from Golden Arrow to MyCiTi and from train to minibus taxi that significantly contributed to reductions in commute time: on average 10 minutes in savings for switching from Golden Arrow to MyCiTi and 12 minutes for switching from train to taxi.

I was surprised to find such large travel time reductions, on the order of 5 or 6 minutes on average, among non-movers. Normally one would not expect to find general travel time reductions in a city that is growing—we'd expect increased congestion to generally lead to longer commutes. As discussed in Chapter 5, however, the TomTom congestion index data shows that although congestion levels generally increased in Cape Town over the study period, during the peak period they remained relatively flat. Additionally, it is likely that, by oversampling MyCiTi and taxi users, the survey selected for travelers who have switched to faster modes. If I had sampled more train and Golden Arrow users, I probably would have found more respondents with worsening travel times, especially if, as the survey data tentatively show, travel times by modes generally grew longer. Meanwhile, those who continued using the same mode, or switched to slower ones, increased travel time and were underrepresented in the survey. The regression analysis confirmed respondents switching from from slow modes to fast ones had a large influence on travel times, suggesting the observed travel time reduction was in large part driven by this behavior.

Why was switching away from train and Golden Arrow associated with such large travel time savings? In the case of the train, the answer is very specific to the Cape Town context. In Cape Town, unlike in most other cities, the train is widely considered slow, unreliable, unsafe and uncomfortable. People use it mainly because it is very affordable. Moreover, its service appears to have declined over the timeframe of this study. The survey findings suggest many train passengers may have switched to MyCiTi or to minibus taxi in response to declining train service quality and saved travel time as a result. The cost of switching was higher fares, as both taxis and MyCiTi are more expensive than the train.

Golden Arrow, meanwhile, is a case of a regulated bus contractor being replaced by a new publicly-managed BRT system. In the MyCiTi Phase 1 area, Golden Arrow routes have been replaced by MyCiTi, and the Golden Arrow company itself participated in the reform by becoming a shareholder in one of the VOCs. In the case of the Phase 1 area, the travel time savings associated with switching from Golden Arrow to MyCiTi, but not from minibus taxi to MyCiTi, suggest that BRT was a clear improvement over conventional bus, at least in terms of travel time, but not clearly an improvement over informal minibuses. In the N2 Express area, MyCiTi did not replace Golden Arrow routes, but apparently many respondents found it faster and more convenient.

In both the Phase 1 and N2 Express areas, it appears that while access to MyCiTi did not have unique travel time benefits, the upgrading of conventional bus and train services – whether by replacing or adding to such services – did.

Initially I expected to find that MyCiTi would provide greater travel time savings for work travel than for shopping and social trips. Like many other BRT systems, MyCiTi's trunk-and-feeder network would be expected to serve long-haul commute trips more efficiently, while being less efficient at serving shorter trips within a neighborhood. However, I found, if anything, the opposite is the case. For work and school travel, MyCiTi did help many respondent reduce travel time, but it was no more effective in doing so than were minibus taxis. In contrast, for non-work travel the survey provided tentative evidence that switching to MyCiTi reduced travel times more than did switching to minibus taxis. To be



clear, respondents who used minibus taxi and MyCiTi both reduced their travel times for shopping and social trips, but those who used MyCiTi did so slightly more. It appears the MyCiTi design is more effective in serving non-work trips than expected, at least for survey respondents.

I also expected the trunk-and-feeder system to privilege residents who lived and worked along the trunk route, while offering fewer travel time benefits for those who had to use feeders to access the system. The OLS results did confirm that having to transfer was associated with smaller travel time savings, but even MyCiTi users who had to transfer, on average saved time in comparison to non-MyCiTi users. Transferring was better at explaining travel time change than was location.

As with any intercept survey, the responses are not representative of the population in general. I chose to oversample public transport users, and particularly MyCiTi and minibus taxi users, in order to ensure I collected sufficient data to analyze the impacts of MyCiTi on these users. Even among this population, the choice of intercept locations resulted in an oversample of people who travel through the selected locations. The sample likely over-represents those with an origin-destination pair that takes them through the city center. By choosing to employ a survey team in Khayelitsha, I also oversampled residents in that community.

In terms of travel time savings, MyCiTi appears inferior to minibus taxis for work travel. MyCiTi functions more effectively as an upgrade to existing formal transit than a replacement for informal transport. Compared to coloured and white respondents, black respondents benefited most from MyCiTi's travel time reductions. These results contrast with those from the model in Chapter 5, which suggested MyCiTi improved accessibility over taxi for the average resident. Whereas the model-based analysis measured accessibility changes as potential changes in travel time, the survey measured accessibility as realized changes in travel time. The combined findings begin to suggest a story. Compared with taxis, MyCiTi offered improved accessibility for residents in many areas. However, because of the spatial pattern of settlement and the network design, those who stood to benefit most from the BRT reforms were white and middle- to high-income groups, whereas taxis still served blacks better. With the actual implementation, those who chose to switch to MyCiTi were most likely to be non-white and lower-income users who previously had long commutes by conventional bus or train, while perhaps private car and minibus taxi users were more likely to keep their current mode of travel. Those who did switch from these modes to MyCiTi probably did for reasons other than travel time. Those other reasons are the subject of the next chapter, in which I use qualitative user interviews to investigate travelers' travel choices.

## Chapter 7

# Findings from user interviews

Travel time captures only one aspect of accessibility. Other factors, such as reliability, safety, cost, and comfort are obviously important in determining the ease in which residents can reach places they need to go. In this chapter, through interviews with users, I consider how Cape Town's transport formalization affected other aspects of accessibility.

The user interviews also help identify the reasons actual MyCiTi travel times did not improve on those of taxis as much as expected. In Chapter 5, I found that between 2010 and 2015, the introduction of MyCiTi would, in theory, lead to mostly improved accessibility compared to taxis. In Chapter 6, I also found that the changes mostly improved accessibility, but the improvements were explained by BRT being faster than train and conventional bus - not BRT being faster than taxis. The discrepancy in these findings is probably explained by the harder-to-measure factors that influence travel decisions. In talking with public transport users, I aimed to understand what motivated travelers to switch modes, and to shed light on their experiences using MyCiTi. Through these interviews I also sought to understand how public transport users relate to transport providers, and how this relationship changed with the MyCiTi reforms.

### **Hypotheses about the accessibility effects of BRT reform**

Why might Cape Town's reforms not achieve the accessibility benefits predicted by the simulation model in Chapter 5? Several aspects of accessibility are not represented in the model. Importantly, the model does not represent safety concerns that might influence travelers decisions, and which are better revealed through qualitative methods. In the Cape Town case especially, safety is an important issue. Other intangible factors, like perceptions about the type of person who rides taxis, are not represented in the quantitative data.

Another important factor is reliability. Travel times in the model assumed on-time performance, but it is very unlikely MyCiTi is 100% on-time, in which case travel times will be longer than predicted. Passengers experience uncertainty in travel times simply as longer travel times (Carrion and Levinson 2012). If my commute usually takes 45 minutes but

occasionally takes 60 minutes, I'll have to always allow 60 minutes in order to avoid being late.

Affordability is another important component of accessibility. As discussed in Section 5.4, MyCiTi fares are lower than taxis fares except for short, direct trips. Thus I do not expect affordability to be a large reason for MyCiTi having lower than expected accessibility relative to taxis, although it might contribute in some cases.

Finally, walking time may not be adequately represented in the model. Because the model assumed passengers walk from the zone centroid to the nearest stop, it masks variability in walk times within a zone, especially in large zones. In contrast, the travel choices measured by the survey reflect actual walking time to access transit stops.

The possibility that these factors influence travel decisions, but are not represented in the model, are hypotheses that I will address in this chapter using interviews of public transport users.

## 7.1 Interview methodology

Between September 19th and 23th, 2016, I completed 54 semi-structured interviews with users of minibus taxis and MyCiTi. I chose to focus on minibus taxi and MyCiTi users, rather than travelers more generally, because I was specifically interested in the differences between these modes. I targeted users within or near the MyCiTi service areas, who had access to both modes, in order to understand how the implementation of MyCiTi and the accompanying reforms had changed residents' travel experiences.

I recruited interviewees while they were waiting in line for either taxis or MyCiTi buses, or while on-board the vehicle. I chose this approach as the best among several alternatives. I had considered using an advertisement to recruit subjects, then prescreening individuals and scheduling interviews at a later date. I decided this method would yield fewer subjects at a higher cost. It would be difficult to schedule interviews with working people. I also considered asking community members to assist in assembling focus groups. The focus group approach might work where I had reliable ties – namely in Khayelitsha – but I would not be able to reach people in the Table View area, where I was aware of fewer community groups.

I discovered most people were receptive to being interviewed when I approached them, and many had sufficient time to talk while waiting in line or while on the vehicle. As with the intercept survey, this approach made it easier to interview people taking longer trips or traveling busy routes at peak times, while I was less likely to intercept people taking shorter trips or using less common routes. The interviews I obtained reflect this recruitment bias, although I was still able to interview some individuals with shorter trips and less common routes. Table 7.1 describes interviewees demographic traits, their travel mode, and the location where they were recruited.

To overcome language, racial and cultural barriers between myself and interview subjects, I hired two assistants, a coloured Afrikaans-speaking woman, and a black Xhosa-speaking man. Both were native to Cape Town and familiar with most local areas. Accompanied by

the woman, I targeted areas with majority coloured and white populations—specifically the Table View and Mitchell’s Plain routes. Only a few subjects we approached chose to use Afrikaans; most said they were comfortable with English. Nevertheless, I believe working with the assistant was critical, as coloured individuals seemed much more receptive when approached by someone of the same background. Many more Xhosa-speaking individuals chose to proceed with the interview in their first language. My assistant translated my questions and the subjects’ responses in real time. The assistant was not a professional interpreter, and the responses he provided were mostly paraphrases rather than direct quotes. (I did consider hiring a professional interpreter but found the cost prohibitive.) For this reason, I can report more direct quotes from white and coloured than black interviewees, but the black interviewees’ views are still represented in the analysis.

I conducted the interviews during periods that mostly coincided with peak travel times: 6:30AM to 9:30AM for the morning peak, and 3:30PM to 6:00PM for the afternoon peak. Each of these periods is a half hour outside the main peak time (a half hour later in the morning and a half hour earlier in the afternoon). Most of the people interviewed were traveling in the peak commute direction, but I also interviewed some traveling in the opposite direction. Thus while the majority of interview respondents were “typical” peak commuters, a minority were not. Most were traveling for work or school; a few were not.

The interview procedure was as follows. My assistant and I chose a specific MyCiTi or taxi route, then went to the corresponding line at the bus station or taxi rank. If there was a long line, we interviewed people in line. If there was no line, or if the line was short, we boarded the vehicle interviewed people while on board. We approached potential subjects by saying hi, introducing ourselves, and asking permission to interview them and audio record their responses. If they agreed, we proceeded with an interview guide. The guide included basic questions about the subject’s typical travel and their attitudes toward it. We adapted questions based on the situation and their responses. Interviews lasted from five to 25 minutes, depending on the respondents’ receptiveness to continued questions and on the time available. Sometimes interviews had to end when the subject reached his or her stop or moved ahead to board the vehicle. Where an interviewee’s age is not provided, it is usually because the interview had to end abruptly. (I asked their age at the end). After the interview, I offered the subject a granola bar as a thank you.

The aim was to represent a broad spectrum of users. As much as possible, we tried to alternate between interviewing men and women, and younger and older individuals. Where appropriate, we simply interviewed the last person in line, or simply the person sitting next to us on the taxi or bus. As with the survey, interviewees were required to be at least 20 years of age. We made one exception for a 19-year-old. My assistant and I identified the interviewees’ gender and race; in the few cases we were unsure, we asked how they identified. As shown in Table 7.1, I had fairly equal representation in terms of gender and coloured versus black. I only interviewed one white passenger. I interviewed more younger travelers than older ones, a reflection of who happened to be available in the interview locations. I interviewed more MyCiTi users (35, or 65%) than taxi users (18, or 33%) users because there were very few taxis in the Table View/Blaauwberg area—as expected, given taxis there were

Table 7.1: Summary of public transport interviewee characteristics

		Count	Percent
Gender	Female	29	54%
	Male	25	46%
Race	Black	26	48%
	Coloured	26	48%
	White	1	2%
	Unknown	1	2%
Age	19-29	20	37%
	30-39	16	30%
	40-49	8	15%
	50-59	5	9%
	60+	2	4%
	Unknown	3	6%
Language	Afrikaans	2	4%
	English	37	69%
	Xhosa	15	28%
Travel mode at time of interview	Minibus taxi	18	33%
	MyCiTi	35	65%
	Golden Arrow	1	2%
Interview location (corridor)	Cape Town-Table View/Blaauwberg	11	20%
	Cape Town-Mitchell's Plain	17	31%
	Cape Town-Khayelitsha	26	48%
	Total Interviews	54	100%

mostly removed.

The week I chose for the interviews was to be a typical week, with mild weather and during a non-holiday period. However, the week turned out to be somewhat atypical in one way. From Tuesday afternoon through Friday, Metrorail canceled all trains on its Central Line, which serves Mitchell's Plain, Khayelitsha, and much of the eastern part of the city. The trains were canceled due to infrastructure damage from violent demonstrations in the township of Langa that were unrelated to train service. (The protests were about housing conditions in that township.) As a result of the service disruption, the volume of passengers on taxis and MyCiTi buses was higher than usual and lines much longer. This made it easier to interview people waiting in line, and I did talk to several travelers who normally used trains but were forced to use alternative modes this week. At the same time, I made sure to also interview people who normally do not use the train. Although I was initially concerned I had chosen an atypical day, interviewees made it clear canceled train service

was not that unusual: although this disruption affected an unusually large number of trains, frequent delays and cancellations were typical of Metrorail service.

The interviews were audio recorded and later transcribed by the same Afrikaans-speaking assistant who helped conduct the interviews. I then personally coded the transcripts for themes relating to reasons for choosing one mode over another and to users' perceptions of transport modes and their relationships with them. Next, I grouped the responses by code and looked for common themes. Note that the quotations included in the following section cite the interviewee's gender, age, race, and the location of the interview.

## 7.2 Findings from user interviews

### Generally positive perceptions of MyCiTi as a replacement for taxis

Where taxis were replaced with MyCiTi in the Phase 1 area, I expected to find mixed perceptions of MyCiTi among those who would otherwise use taxis. Some would find MyCiTi an improvement over taxis; others would find it less convenient, and would be unhappy about having to switch. So I was surprised to hear few complaints about the removal of taxis. On the whole, users expressed positive perceptions of MyCiTi in relation to taxis, particularly in terms of speed and comfort.

We're only taking the buses now because the taxis stopped for the buses to drive. So that's why we're traveling with the MyCiTi bus. . . . The bus stop is just up the road from my house so it's quick-quick. It's like a minute or two tops to get to the bus stop. [Male, 25, Black, MyCiTi queue]

A university student said he felt his current MyCiTi commute was better than his previous commute with taxi:

[Using a taxi] was quite stressful as well because there's no schedule that you have to follow. . . . The taxi driver is always rude. [Male, 25, Coloured, on MyCiTi bus]

For some though, the removal of taxis meant longer walks. One man, who commuted from Steenberg (outside the MyCiTi area) to Montague Gardens (in the Phase 1 area) by a combination of train and taxi said the removal of taxis meant he had to walk an extra ten minutes at the Montague Gardens end.

Actually I have to walk there where the taxi picked me up now [near Montague Gardens], I have to walk from Montague Drive so we're quite far down there so I have to walk up to that garage, and otherwise I don't get a taxi there in the Main Road. I don't know, for some reason they [the taxis] don't come down there anymore. [Male, 40-49, Coloured, in taxi]

Perhaps because he lived far from the MyCiTi area, this man did not know that taxis were removed as part of the MyCiTi reforms, which may be why he did not have a negative perception of MyCiTi.

Since I was interested in the effects of formalization, my initial intent was to ask interviewees to compare MyCiTi to taxis. However, as also illustrated by the user survey, those who used MyCiTi switched from all other modes, not just taxi but also from Golden Arrow, train, and car. When asked about MyCiTi, many users compared it to modes other than taxi. Several interviewees who would otherwise use Golden Arrow saw MyCiTi as an improvement. A woman who had switched from Golden Arrow to MyCiTi for her commute from Table View to Civic Centre told me:

This [MyCiTi] is very comfortable. And what works for me is that I host foreign students so it's peace of mind for me. I teach them to use MyCiTi and they can get on everywhere. It's the best thing they could have done for South Africa. [Female, 47, Coloured, MyCiTi bus]

What I like about MyCiTi (is) you sit comfortable. Everything is comfortable. . . The [MyCiTi] bus drops me in front of my workplace. If I use Golden Arrow I have to walk; 22 minutes, 25 minutes' walk. [Male, 29, Coloured, MyCiTi bus]

## Users shed light on determinants of travel time

Not surprisingly, most users named some aspect of travel time as a top consideration in making travel decisions, regardless of which mode they chose. Their explanations, though, reveal a more complicated set of factors than conveyed by travel time alone. Many respondents said they preferred taxis because they could reach their destination faster than by other modes, but recognized taxis' speed was a result of unsafe driving. Indeed, most respondents felt taxis were unsafe, regardless of whether they used taxis regularly. They worried about reckless driving, and complained that drivers were just trying to maximize fares.

I take a bus but if I run late I take a taxi. . . . The main thing is because they drive faster than the bus. . . . The way the taxis drive; sometimes they drive very recklessly. [Female, 20-29, Coloured, taxi queue]

Yes [I worry about accidents] because during the peak they want to drive to get money and they drive as they want to, so for me a taxi is a bit dangerous but sometimes I have to take a taxi; I don't have a choice. [Male, 45, Coloured, MyCiTi queue]

Now and then I like taking taxi because it's faster and quicker, but it's just a bit dangerous. . . . The taxi drivers don't care how they drive, which way they go around. [Male, 39, Coloured, taxi queue]

You want to get to work fast but not die on the way to work. [Female, 20-29, Coloured, taxi queue]

Several interviewees chose MyCiTi over taxis for fear of their personal safety.

It's safer to travel with the buses than with taxis. Taxis will drive over you and don't care for your safety, whereas buses will first wait for each car to drive past and then leave the stop. Taxis just want to get home and make their target. [Male, 25, Black, MyCiTi bus]

At least one interviewee felt taxis were dangerous because the vehicles were "unroadworthy." All other travel modes were deemed relatively safe in terms of risk of accidents.

As discussed in the survey findings in Chapter 6, I was surprised by the magnitude of some respondents' travel time reductions, even among those who did not move. Interviews corroborated the survey findings by describing how switching to MyCiTi resulted in dramatic travel time savings.

Normally when I took Golden Arrow I used to take about two hours from Khayelitsha to here in Town because it passes Langa and all those places. But MyCiTi... it's only about 30 minutes or so. [Male, 27, Black, MyCiTi queue]

Opinions about MyCiTi wait times varied. Some MyCiTi users complained about how long lines in stations increased their travel time. However, most MyCiTi users said the lines were only long when something unusual happened; for example, if MyCiTi buses were canceled or if trains were not working and those passengers used MyCiTi instead.

Lines formed during peak periods even when buses ran with high frequencies, simply because demand exceeded capacity, especially on the N2 Express routes. Users who waited in these lines expressed positive opinions of MyCiTi in general. Their chief complaint was that there were not enough vehicles to meet high demands, resulting in long waits. A user on the MyCiTi Khayelitsha route said:

At the moment I'm happy [with MyCiTi] but the only problem is the line. You always wait for a long time. [Female, 30-39, Black, MyCiTi queue]

And on the Mitchell's Plain route:

User: Sometimes I have to wait up to half an hour to get into a bus.

Interviewer: Is the morning like this too?

User: Exactly the same in the morning. That has been my biggest challenge. I wait up to half an hour to get a seat on the bus. [Male, 51, Coloured, on MyCiTi bus]



Several interviewees who used the popular N2 Express routes felt the number of buses on their route was insufficient because the City was prioritizing other routes instead. These respondents expressed a sense of unfairness, and blamed the city for not allocating bus resources more equitably.

The one thing for the last month or so that they can improve though is get us more buses on this route – compared to that side [pointing to the Khayelitsha line]. They have more buses than us and I’ve seen a more than 50% increase in the commuters on the Mitchell’s Plain line over the last two years. [Male, 51, Coloured, on MyCiTi bus]

Specifically, several interviewees complained that MyCiTi ran buses at high frequency on a particular N2 Express route, the D01, which runs between the city center and the east side of Khayelitsha, whereas other N2 Express routes like the D02, which serves the west side of Khayelitsha, did not have sufficient capacity.

MyCiTi has a lot of problems. They don’t know how to control especially this queue. They only care about D01. . . . What’s happening to this D01 is sometimes they can give four buses while we are in the queue. The one who’s operating there knows that we have been standing there waiting for a bus for long. If D01 comes, they can take D01. . . and the next bus they can change it to be D02 instead. They don’t do that. They allow it. [Male, 38, Black, MyCiTi queue]

In this comment, the interviewee is expressing frustration with not just the low frequency of buses, but also the rigid schedules. He would prefer for MyCiTi officials to reallocate vehicles from one route to another. If they did, it would be much like how taxis operate, where if there is a higher demand in another route (still within the taxi’s operating license), rank marshals will direct some vehicles to move to that route.

### **Many users chose modes so as to reduce risk of crime**

The interviews suggest users’ decisions are very sensitive to walk time and distance, no matter which mode they used, in large part because of security concerns. Most respondents reported walking between five and ten minutes to access public transport. Many said they chose their particular mode because it was a very short walk from their home or work. Concerns after security motivated the preference for a short walk time; people felt unsafe walking longer distances. No mode was immune from this concern. Respondents felt less safe early in the morning and at night after dark, although they acknowledged crimes could happen at any time. In the CBD, which is considered relatively safe, people were willing to walk further; up to 20 or 30 minutes.

These respondents said they sometimes walked on the CBD end of their commute:

I walk from work but if I still have time in the mornings, I walk to Adderley Street, or take the small [MyCiTi] bus. I prefer to walk. [Male, 20-29, Black, MyCiTi queue]

User: From Town, I take the taxi sometimes to Granger Bay and sometimes I walk; 30 minutes to walk.

Interviewer: [asks to clarify]

User: Yes, I walk from Town to Granger Bay, depending on if I'm early. Granger Bay is in the Waterfront. [Female, 30-39, Black, in taxi queue]

In comparison, in less safe areas, interviewees felt unsafe walking even ten minutes. For this reason many respondents apparently chose their travel mode so as to minimize walking time.

I'm very fortunate in where I live. I walk past the police station so it leaves me with a sense of security. I don't ever feel unsafe. And, I'm very fortunate in the CBD that my office is directly opposite the [MyCiTi] station so I don't have to walk far. [Female, 31, White, MyCiTi bus]

Like I took the 5:10 AM bus. You know obviously Mitchell's Plain is terrible; the Tik [crystal methamphetamine] monsters walk around so it's always behind the houses. You can't look around you. You have to stand by the bus. [Female, (age not provided), Coloured, on MyCiTi bus]

User: [The train is] convenient for me because I stay opposite the station. If I have to take the bus then I have to walk a distance and they're shooting in Bonteheuwel, so if I take the bus, I have to pass the gangsters.

Interviewer: How long is the walk?

User: The walk [to the bus stop] is about ten minutes, but to the [train] station it's three minutes because I stay opposite the station. It's safer for me because I'm in the train, out of the train and in my house. I don't need to walk through the gang. [Female, 39, Coloured, in taxi]

If I start 9:00 I'm going to have to wake up 6:30 and then I'm going to have to walk over, so it is slightly a bit dangerous with some of the gangs and stuff like that in the areas. [Male, 31, Coloured, in taxi]

Those who walked further to access public transport said they did so despite feeling unsafe, because they could not afford to take a taxi instead.

Interviewer: Do you feel safe walking [to MyCiTi]?

User: It's not safe at all but because I don't have enough money I always walk in the morning; just like now I'm going to walk to my house. [Female, 30-39, Black, in MyCiTi queue]

Security was a concern not just while walking to or waiting at stops, but while traveling inside vehicles as well. Several interviewees told stories about being robbed while they were in public transport vehicles. Golden Arrow buses, taxis, private cars, and even sometimes MyCiTi buses were at risk of being hijacked or held up by gangs. Robberies and hijacking were apparently most likely on weekends, when roads and vehicles were emptier.

Interviewer: Have you ever witnessed a crime while taking a taxi?

User: Not really. In the [Golden Arrow] buses [I have]. I was on my way to work and then they stopped the bus and then they robbed the people that were in the bus.

Interviewer: Really, the whole Golden Arrow bus? The entire bus?

User: There weren't a lot of people but they always do it when it's quiet, just Sundays. That's the time when not a lot of people go to work... [Male, 20-29, Coloured, on taxi]

User: The problem is in the section where I am, people get robbed.

Interviewer: Even though it's only a five minute walk?

User: People get robbed in the [Golden Arrow] bus.

Interviewer: Has that happened to you?

User: No, but I witnessed someone get robbed.... They stopped the bus and took everybody's belongings. [Female, (age not provided), Black, MyCiTi queue]

Interviewees perceived the train as the most dangerous mode for in-vehicle crime. Some respondents had witnessed other passengers get stabbed and robbed while on the train. Those who used the train said they felt unsafe, but they took the risk because the train was so much cheaper than other modes.

[The train is] cheaper but it's full and dangerous. There are delays and it's not safe because of the skollies [gangsters]. You get mugged in the train. You can't escape. [Male, 20-29, Black, in MyCiTi queue]

User: Taxi's safe. No crime.

Interviewer: Compared to the train?

User: Train is not safe. There's always somebody getting on at a station, doing something, stabbing someone, taking their bags.

Interviewer: Have you seen that happen?

User: Yes, many times over weekends.

Interviewer: What do you do when that happens?

User: What can you do? They just get in, stab somebody, grab it, and get out. Even phones; they just get in and take. One is keeping the doors open. [Male, 39, Coloured, taxi queue]

Most users felt safer on MyCiTi than in other transport modes.

I feel safe in the [MyCiTi] bus. You can relax and you don't have to worry about anything and it's safe to sit on your phone. [Male, 28, Coloured, on MyCiTi bus]

Still, one interviewee was worried about crime while on MyCiTi buses, but felt the alternatives were even worse. He felt particularly unsafe because, as a Coloured man living in 98%-black Khayelitsha, he would be easily targeted for crimes.

User: Just the two incidents where they robbed the [MyCiTi] buses in Khayelitsha once or twice.

Interviewer: How did it happen?

User: I wasn't in the bus; I was in the next bus but we got the message while we were standing here – that they robbed the people in the bus. . . . At the moment I'll just have to get into the MyCiTi bus. As you know I'm a Coloured living in Khayelitsha so I don't have any other options at the moment. MyCiTi is safer for me at the moment. [Male, 58, Coloured, MyCiTi queue].

And even if MyCiTi vehicles are safer, the large spacing of stops was a problem for those worried about walking:

First there were a few stops in Mitchell's Plain but they've made more stops now, especially for people who travel at night because it's a bit dangerous. The stops are very far apart. They have put on more stops for the people, to make it more convenient for the people. [Male, 45, Coloured, on MyCiTi bus]

This interviewee is referring to how MyCiTi first opened the N2 Express with one route to Mitchell's Plain, but a year later added more routes with more stops.

### **Service design affected mode choice in predictable ways**

Users opinions about schedules and service frequency reflected trade-offs inherent transit service. MyCiTi has relatively few routes with high frequency peak service, compared to Golden Arrow, which has many different routes but relatively low frequencies. Some users found Golden Arrow's schedules useful in knowing when a bus would arrive, but most users felt burdened by the schedules, worrying they faced a long wait if they missed a bus.

Golden Arrow was actually a good experience. It's just the fact that you also need to wake up much, much earlier in order to get that specific transportation, and the express buses are the buses that drive no stop. In order for you to get an express bus is actually tough because you need to wake up at, at least 4:30AM to get done by 05:00AM, leave the [Mitchell's Plain] Town Centre by 05:30 and then get the bus at 06:00. It's like a half an hour time frame that you already have so you schedule yourself in the evening already so you're more exhausted when you come at home because now you need to prepare yourself for the next day so you rather shower in the evening. Yeah, you need to change your whole cycle. It's quite hectic, it's quite hectic. [Male, 31, Coloured, in taxi]

In comparison, users found MyCiTi more convenient because headways in the peak were three or five minutes, and at most ten. Missing a particular bus was no big deal.

For example, the Golden Arrow bus this morning was supposed to rock up at 6:45AM. He [the driver] arrived at 7AM and that's the only bus from where I live into Town so you're going to be late if the [Golden Arrow] driver is late. Whereas if you take the MyCiTi, there are frequent buses all the time. [Female, 25, Coloured, on MyCiTi bus]

However, those who had to commute in the off-peak periods and weekends were less happy with MyCiTi schedules.

Like now when they change the [MyCiTi] times to an hour apart during certain hours, so now it's an hour apart from there in Sea Point, and when you miss the bus then it's another hour and when you get here then you maybe just missed the bus and it's another hour you have to wait, especially in my hours. It's different because we work in retail so we are always going to work; whether it's a public holiday, whether it's a Sunday. [Female, 30-39, Coloured, in MyCiTi bus]

In the Phase 1 area where Golden Arrow service was removed, some missed the company's specialized routes. Abdul Bassier, the Transport for Cape Town Director of Regulation, explained how Golden Arrow previously ran two or three buses specifically for his son's school, but with the route's removal, students now had to walk further to overcrowded MyCiTi buses, or, more frequently, pay for an Uber ride.

Golden Arrow's low frequency schedules motivated some interviewees to chose taxi instead. These users felt that taxis were easier than other modes because they didn't have to worry about a schedule at all.

I take the taxi because it's much quicker, 'cause I tend to miss the [Golden Arrow] bus all the time. [Female, 20-29, Coloured, in taxi]

## Transfers were more of a burden for taxi users than MyCiTi users

I expected MyCiTi's trunk-and-feeder network to make it more difficult for users who had to transfer from a feeder route to the trunk, while in comparison taxi users would be able to take advantage of more direct route. Thus I was surprised to find interviewees generally did not think transfers on MyCiTi were a burden. Several users said they preferred MyCiTi because it provided direct service for their trips. This was especially true for those who used the N2 Express. Those MyCiTi users who did have to transfer generally did not complain about it.

[MyCiTi is] much easier because when I get off here [at Civic Centre] in the mornings, I just get into the other bus – into the Camps Bay one. [Female, 60-69, Coloured, in MyCiTi station]

It's easy because you just get onto the station and into another bus. It's not a walking distance or having to get out of that particular station. [Female, 25, Coloured, in MyCiTi bus]

In fact, one interviewee had to transfer from one MyCiTi bus to another during his commute, but didn't even consider it as a transfer, because he only had to pay one fare, whereas with a taxi he would have had to pay twice.

Interviewer: So why do you use MyCiTi?

User: For me it's more convenient.

Interviewer: How so?

User: With taxis, I must take two taxis. With MyCiTi, it's just one.

Interviewer: But that is two [buses] because you have to take the bus from Salt River to here, and then from here [to Mitchell's Plain].

User: But it's cheaper.

Interviewer: How much would a taxi cost?

User: From here to Mitchell's Plain, it's R15 and from Town Centre another taxi costs R7 so it's R22. [Male, 45, Coloured, in MyCiTi bus]

In contrast, respondents did complain about having to transfer on taxis – not because of the travel time but because of the cost. Unlike MyCiTi, on taxis one has to pay a separate fare for each leg of the trip.

Our fares [on MyCiTi] would be seven points which is R7, so I can come from my area and pay R7 from there until here and still travel further on for R7. So I can take any [MyCiTi] bus from here and still pay that same fee, so that's nice about the buses. [Male, 25, Black, MyCiTi queue]

One man who traveled for an astonishing three-and-a-half to four hours each way, from Mitchell's Plain to Bloubergstrand, said his commute with MyCiTi was now faster and cheaper, compared to his previous commute by taxi. Even though MyCiTi required him to take two different buses, the transfers were quick compared to transfers with taxis, where he would have to wait for each vehicle to fill.

Interviewer: Why do you use MyCiTi and not something else?

User: It's easy for me to get to work, direct, straight to my workplace, direct to my workplace.

Interviewer: If MyCiTi did not exist, how would you do that [get to work]?

User: Probably use taxi but more expensive [and] take four taxis. [Male, 29, Coloured, on MyCiTi bus]

Thus as long as users' origins and destinations were within the MyCiTi service area, the transfers did not seem to negatively affect perceptions of travel. The trunk-and-feeder network might still be less optimal than a taxi network if it covers a smaller area, and indeed I did talk to a few people who said they would use MyCiTi if it only stopped near their house.

### **Affordability was a top concern, and responses to cost varied**

Besides travel time, the most important factor for respondents in choosing a travel mode was cost. Interviewees mentioned cost more often than any other factor – a total of 58 times. The next most common factor, walk time, was mentioned 51 times. Respondents were highly conscious of cost: many noted the exact fares for different public transport modes available to them, suggesting they had performed the comparison calculations. They reported considering cost when make travel choices, although only a few people automatically chose the least expensive option; other factors remained important.

All agreed train was by far the cheapest. Most respondents considered MyCiTi relatively affordable, although some worried fares seemed to be increasing. Still, MyCiTi was far more expensive than the train, as much as ten times more. Taxis were generally cheaper than Golden Arrow and MyCiTi, except for users who had to transfer, because they had to pay a separate fare for each taxi. That said, users had better knowledge of fares for taxi, train, and Golden Arrow than for MyCiTi, probably due to MyCiTi's more complicated and opaque payment system.

Taxi was more expensive. . . . The only thing I like about it [MyCiTi] is affordability. [Male, 26, Black, MyCiTi queue]

Train is fine for me because it's not that expensive. You can buy a monthly for R150 and that's fine, that's good. [Male, 40, Coloured, in taxi]

My monthly [train ticket] is R194. . . . If I take [taxi] three times the same route, it's R180 for three days. [Male, 39, Coloured, taxi queue]

Interviewer: What made you change [from taxi to MyCiTi]?

User: The problem is the taxis are too expensive. I was using R1000 per month; at least this side sometimes it's R500 per month. [Female, 30-39, Black, MyCiTi queue]

For me, MyCiTi is about R700 [monthly] and train is R190. Golden Arrow is about R600. . . . Golden Arrow is better than MyCiTi for me. [Female, 25, Black, taxi queue]

I thought MyCiTi was much more affordable compared to Golden Arrow when it started but now with this peak hour time and after hours. For instance, now R30 lasts only a day. It won't last till tomorrow – so it's getting expensive. [Male, 20-29, Black, MyCiTi queue]

User: Yes, that's also another reason, because with MyCiTi I think I'll pay about R12.50 and a taxi is R16.50.

Interviewer: So within the month, the [MyCiTi] is R600?

User: I haven't checked how much exactly because I just put in R100.

Interviewer: How much was Golden Arrow? User: Golden Arrow was R132 per week; Monday to Friday. [Male, 27, Black, MyCiTi queue]

I was surprised to hear many respondents owned a car, but said they only used it on the weekends because it was too expensive to drive during the week. The cost came from paying for gas, and sometimes parking (although for many parking was free).

It costs about R600 a week to drive whereas this (MyCiTi) costs R600 per month. [Male, 28, Coloured, on MyCiTi bus]

Some respondents found it very important to have a way to budget for transport expenses. That is, they preferred to buy one pass for the entire month, or load a certain amount on a card, so that they would not run out of cash.

[The MyCiTi card] is better than the clip cards [weekly and monthly fare cards for Golden Arrow] because with the card system of MyCiTi, if you have a spare R50 in the pocket, you can load it up on the MyCiTi card. You can't preload a Golden Arrow bus ticket. Take for example the Golden Arrow clip card; if you didn't go to work for a week, then that card is a waste. With MyCiTi I can use it the following month or the following week. [Male, 20-29, Black, MyCiTi queue]



When asked why she always took MyCiTi, when sometimes a taxi would be more convenient, one user responded:

Sometimes you budget, because this is the transport that you take, so I load one time for the whole month. Because you don't have always that extra money to take a taxi, especially on Sundays. [Female, 30-39, Coloured, MyCiTi bus]

### **MyCiTi is seen as reliable, but this status may be slipping**

After travel time and cost, interviewees saw reliability was the next most important factor. Nearly all agreed the train was unreliable, and for this reason many refused to use it. Some former Golden Arrow users complained about major delays, which were a problem because the service's low frequencies meant users often relied on a single bus being on time.

MyCiTi users often described the service as reliable, using phrases like, "Always on time, reliable," "it brings me on time here in Town", "Arrives on time." A smaller number complained about delays with MyCiTi.

The only things I don't like sometimes are the delays... Sometimes it can take over 15 minutes. [Male, 25, Coloured, on MyCiTi bus]

A few suggested MyCiTi reliability was worsening. For example, a few interviewees said when MyCiTi first opened with new buses everything worked well, but over time buses starting breaking down more often, causing delays.

It [MyCiTi] was okay at the beginning but now the buses are also a bit late. [Male, 20-29, Black, MyCiTi queue]

I suppose the maintenance of the buses and the actual stations and the doors could be improved... Often times the doors don't open, there's a problem with the doors. It's on MyCiTi's part; they need to maintain it. [Female, 31, White, on MyCiTi bus]

One interviewee who happened to be a former MyCiTi intern explained the delays on the Table View route were due to the type of buses, whereas the N2 Express Volvo buses were more reliable, at least so far.

Scania buses like to break down and it causes delays... you have to wait for a mechanic from the depot to come and fix that; and imagine it's peak hour. The Volvo bus I haven't experienced problems. [Male, 20-29, Black, MyCiTi queue]

Another less frequent complaint was the fare machines would sometimes malfunction and cause delays.

The only thing I don't like about MyCiTi is when you put points on your card, the machine is very, very slow. [Female, 47, Coloured, MyCiTi bus]

## Worsening train service motivated many mode switches

If there was consensus on any one opinion, it was the poor quality of Metrorail. Problems cited included delays, cancellations, crowding, and crime. Perhaps interviewees more readily expressed their frustrations with the train because I happened to conduct some of the interviews on days when the train was canceled due to protests at one station. Even so, interviewees described the problems as typical, and believed the problems were getting worse.

Normally when I went for [job] interviews taking the train, it caused me problems because of coming late, and most of the trains are delayed and people are overcrowded in the trains. [Male, 20 – 29, Coloured, taxi queue]

I don't like train because it's very full sometimes. . . . It's risky when it's full so I prefer a taxi. [Female, 30 – 39, Black, taxi queue]

Compared to [train], MyCiTi is much better because trains are always crowded regardless of the time of day. [Male, 20-29, Black, MyCiTi queue]

As the years went by it got worse. Metro[rail] wasn't so but like now... Even now like today also, they are striking and half of the staff is not at work so the trains are really bad now. [Female, 30 – 39, Coloured, MyCiTi bus]

Reasons for delays with the train included: equipment breakdowns, civic protests, worker strikes, and theft of cables (that are part of the track infrastructure). One respondent told us Metrorail had earned the nickname “Metrofail.” More than one interviewee started their commute very early – as early as 4AM – not because they had to work very early, but because their commutes by train were so unreliable. One respondent who was using a taxi on the interview day because of train cancellations said the recent declines in train service had motivated him to look into permanently switching to another mode:

User: I'll first look at the prices of either Golden Arrow or MyCiTi and then decide between the two because I don't want to continue with the train anymore.

Interviewer: Why not?

User: The train is unreliable. When I go to work I don't know what time I'm going to get to work. [Male, 30 – 39, Black, in a taxi]

Still some respondents used the train because it was so much cheaper than other modes, and it was fast as long as there were no delays.

Interviewer: How often does this [train cancellations] happen to you?

User: This is the first time it's affecting us, with this protest. Other times it was just striking from the drivers. It happened once, a few months back. The

others (instances) were just like trains that had broken down and must be fixed. That's the only thing; and out of service. Other than that trains are okay; it's convenient, cheaper. It's convenient for me because I stay opposite the station. [Female, 39, Coloured, taxi queue]

It's just the fact that, because they fail you all the time, you tend not to want to travel train but you do have their reliable customers. . . . Look, I used to work in various areas, so where it is convenient, I would then take the train. [Male, 31, Colored, taxi queue]

### **MyCiTi and taxis each have advantages in off-peak hours**

In some cities, informal transport has a wider range of service hours than does formal transit. So I initially expected taxis would have an advantage over MyCiTi if they were available for more hours in the day. Indeed, some users said MyCiTi schedules were not well suited for people who worked in off-peak, especially on weekends. One interviewee said he liked being able to easily catch a taxi at any time during service hours, particularly in midday and weekends.

Interviewer: How easy is it to use a taxi to say, visit your family or go shopping?

User: It's easy; there are a lot of taxis during the day. [Male, 40-49, Coloured, in taxi]

However, MyCiTi in fact runs longer hours compared to taxis, particularly in more dangerous areas like Mitchell's Plain. Some respondents said they used MyCiTi because it ran until 10PM, whereas taxis stopped service between 7 and 8PM,

MyCiTi you can go where you want to any time of the day and night. You don't have to worry about for example taxis driving till 18H00 and having to get a taxi home by then. With MyCiTi it's convenient because they drive until 22H00. [Male, 45, Coloured, in MyCiTi bus]

### **Negative relationships with taxis; neutral relationships with MyCiTi**

Few interviewees praised customer service from taxis: most complained taxi drivers behaved rudely, treated passengers with disrespect, and sometimes lied to passengers.

Sometimes [taxi drivers] will smoke certain things in front of you and even in the taxi then you have to get in a taxi that smells horrible. Now you have to still take all that intoxications in—and the way they attire themselves as well. [Female, 20 – 29, Coloured, in taxi]

Interviewer: Anything you can think of that would make your commute easier?

User: If they don't overload the taxi and they are more respectful to the passengers. And they must know they are the drivers, they've got people's lives in their hands so they must be responsible when they drive the vehicle. [Male, 40 – 49, Coloured, in taxi]

The way [taxi drivers] behave towards passenger and the way they drive should change for the better. They don't treat people in a good manner when they talk to them. [Male, 40 – 49, Black, in taxi queue]

Several interviewees related experiences of being mistreated by drivers. One woman said a taxi driver gave her incorrect information, causing her to take the wrong taxi and end up far from her destination.

I was upset too much. I was angry at that driver... because he said he knew the place. [Female, 30 – 39, Black, in taxi queue]

A MyCiTi user described how she was once taking a taxi when the driver figured out one passenger didn't pay their fare. He drove the entire taxi to a "black area" and stopped to make the passenger pay. She felt very nervous for her safety and almost wanted to pay for that one person so everyone else could leave. [Female, 50-59, Coloured, in MyCiTi bus]. Another woman said she preferred not to take taxis, because taxi drivers "do not represent the community." [Female, 43, Coloured, MyCiTi queue].

Only one interviewee, who had moved to Cape Town from Zimbabwe one year ago, said taxi drivers were helpful. She explained, for example, if you have a new job you can ask the drivers to help find out how to get there. [Female, 30, Black, in taxi]

Interviewees had both positive and negative opinion of MyCiTi customer service. Several MyCiTi users complained about the payment system. Although some liked how the MyCiTi fare card allowed them to budget, many found the payment system inconvenient and confusing. One respondent didn't like that she could only load the cards at certain locations, and sometimes the machines at those locations did not work. Others were confused by the point system, which with which the fare is different depending on the distance, the time of day, and the payment method. In order to see how much value is on the card, the passenger has to use special machines at MyCiTi kiosks. For this reason, some respondents had experienced embarrassment when they arrived at a station to discover their card was out of credit.

Another common complaint about MyCiTi was the faceless customer service. Some interviewees felt that it was very difficult to have their voice heard with MyCiTi. Those respondents who had complained to MyCiTi staff or city officials perceived that their complaints went nowhere, and they felt powerless to change the things that caused them dissatisfaction.

The card system is not working right and nobody is doing anything about that. And then we spend a lot of money having to buy points each and every time and basically they just vanish and there's no explanation for that. They give us a

story that we can sign in a form and that will help and they will come back to you. They never get back to you. [Male, 26, Black, in MyCiTi queue]

I always phone the toll-free [customer service] number. They look into it. They always tell us that the more people phone– They can't change the buses for one person. [Female, 30 – 39, Coloured, in MyCiTi bus]

They've been telling us to use the internet if anyone has a query; we must email. We've been doing that but there's no response. Even if we tell them we are short of buses from D02 buses [a Khayelitsha route], they don't care. They just say okay, we are going to look at this thing. They don't do it at all. [Male, 38, Black, in MyCiTi queue]

I think it was when I said about sending more buses on routes so it's less crowded they told me to go to the offices and speak to the people there but I must go with the crowd, because if I go singly nothing happens; nothing will be solved. [Male, 25, Black, in MyCiTi queue]

Many did find that individual agents at stations were helpful, for example with giving directions, but if they had a complaint about a broader issue with the system, there was no way to make that complaint heard.

### **Taxis and MyCiTi each fill specific niches**

A few interviews illustrated how taxi and MyCiTi each filled niches by meeting specific needs. MyCiTi was designed to accommodate a range of physical abilities, and the design seems to have succeeded in this regard. One woman said she liked that it was easy to carry her baby on MyCiTi. I observed another passenger bring a bicycle in a bus. A man in a wheelchair said MyCiTi had improved, his own accessibility, because previously his only options were the Dial-a-Ride, which required a week's advance scheduling, or getting a ride with friends or family, who would charge him excessively for the gas used.

Taxis were able to accommodate other specific needs by being flexible. One woman said that she preferred taxi to go shopping because, for an extra R4, the driver would drop her and her groceries directly at her door.

### **Public transport vs. private car**

Many public transport users said that although they had a car at home they did not drive, whether because of the cost or the level of traffic congestion. Instead, interviewees used taxi or MyCiTi or even train.

I've driven before and it's not fun. You sit in traffic for over an hour, an hour and a half actually and it costs about R600 a week to drive whereas this [MyCiTi] costs R600 per month. [Male, 28, Coloured, on MyCiTi bus]

Interviewer: So why don't you use your car?

User: Because of traffic – I'll have to leave at 05:00 [to reach work at 8:30]. MyCiTi is very convenient because sometimes when there's no traffic on the road, it's always on time. [Female, 20-29, Black, MyCiTi queue]

Interviewer: How do you normally go out shopping or visit friends?

User: With the car.

Interviewer: Is there a reason you didn't drive here today?

User: For the peak. I start past 7:00 and finish now, so coming to Town, it's peak and going home, it's peak. I don't do it [drive] in the peak. [Female, 30, Coloured, taxi queue]

For some, the cost of parking was prohibitive; for example, one user said he would have to pay R75 per day; another said R1,300 a month. Even if it wasn't necessarily about travel time, some users said they preferred their time on the bus to sitting in traffic.

Interviewer: Why don't you drive?

User: [MyCiTi is] more convenient. I don't like sitting in traffic and it's a nightmare to sit in traffic from Town from Mitchell's Plain

Interviewer: Even with this wait wouldn't it be faster to drive?

User: The reason I travel on this bus is so I can read my emails and whatsapp messages. Leave the headaches to the driver. [Male, 51, Coloured, on MyCiTi bus]

Well, it was more stressful [before MyCiTi] because of traffic and looking for parking also. [With] MyCiTi, no parking—you can get out of the bus; you don't have to worry about parking and traffic. [Male, 39, Coloured, in MyCiTi bus]

One woman who was using a taxi for the first time felt she didn't need a car anymore:

Interviewer: In all the years that you're staying in Mitchell's Plain, you've always used your car?

User: Yes, but when I turned 60 I sold the car because I'm old now. What do I want to do with a car? The children have cars. [Female, 64, Coloured, in taxi queue]

That interviewees would forgo driving in favor of taxi, bus and even train – not just MyCiTi – suggests that MyCiTi is not necessarily unique in allowing users to avoid traffic congestion, even if it does so to a larger degree than for other modes. Because the N2 highway has a dedicated lane for all public transport vehicles, all public transport users may be able to bypass at least some traffic. Similarly, the train, even with all its reliability problems, is not delayed by road congestion.

## Comfort

Interviews touched on a few other themes as well. Respondents associated MyCiTi with comfort, except when it was crowded and people had to stand. Taxis were also uncomfortable when they were overloaded. No one associated the train with comfort – trains were always seen as too crowded.

### 7.3 Discussion and conclusions from user interviews

Officials hoped MyCiTi would attract users not just from taxis but also from private car, conventional bus, and train. The user interviews, along with the user survey, demonstrate that MyCiTi did in fact meet a sufficiently wide range of needs for many travelers to make the switch from other modes.

Of course, many travelers continue to use the other modes. As the interviews revealed, reasons for switching or not switching are complex and specific to people's individual circumstances. Overall travel time and costs were very important for interviewees, but balanced with other factors. Travelers in Cape Town, no matter their racial background, gender, age, or travel mode, are almost universally concerned with security and risk of crime. This concern often leads people to choose the mode that minimizes walking distance to their origin and destination. When it came to crime in the vehicle, MyCiTi was seen as safer than taxis: MyCiTi stations were perceived more secure than waiting on the road for a taxi and MyCiTi runs later at night. However, MyCiTi stops are further apart, while taxis stop more frequently, so taxis have an advantage when it comes to walking distance.

I initially expected transfers on MyCiTi to be a burden for travelers, but in fact interviewees generally did not experience them as problematic, largely because they were free of cost and transferring between vehicles that stopped at the same station was easy.

I expected to hear more complaints regarding the removal of taxis, but most interviewees expressed neutral to positive opinions about the change. Perhaps this is because so many people harbored negative feelings toward taxis to start with, and they felt no sentimentality about their removal. While plenty of people found taxis convenient and suited to their travel needs, they generally viewed the drivers' interests as at odds with those of passengers – and those of the community. Many interviewees did not feel MyCiTi authorities worked on their side either – not due to an actively antagonistic relationship, but to the perceived lack of interest on the part of the authorities.

In previous chapters, I focused on the accessibility – mainly travel time – impacts of MyCiTi, and found that while many MyCiTi users experienced travel time savings, MyCiTi did not necessarily improve travel times in comparison with taxis. Yet the user interviews suggest MyCiTi has other advantages over taxis. All these factors prompted many users to switch to MyCiTi from taxi even if it increased their travel time.

# Chapter 8

## Conclusions

### 8.1 Summary

Cities around the world are adopting BRT and reforming or replacing informal modes. Given that informal transport is so often associated with problems like congestion, accidents, and crime, it's not surprising governments would want to assert more control over the industry. But informal have benefits: they are often fast, convenient, and affordable for residents. Existing research provides less than a full understanding of how formalization through BRT affects accessibility for residents. In this dissertation, I have investigated how BRT reform has affected accessibility for residents in one particular case, in Cape Town, where the City has replaced taxis with BRT in a section of the city. I did so using a variety of methods, including a simulation model, a user survey, and interviews.

The case study described Cape Town's transport reforms, which included transformation of the minibus taxi industry and implementation of a BRT system. In the Phase 1 section, the City of Cape Town induced minibus taxi owners to trade in their businesses for shares in the new BRT operating companies. It removed most – but not all – minibus taxis from the streets and replaced them with a BRT system. I showed how reforms shifted how transport providers relate to government and how they relate to users, and how they shifted internal relationships, including how owners relate to employees, the structure of the industry, and its business practices.

In Chapter 5, I used a network model of the informal transport and BRT systems in Cape Town to measure how accessibility changed before and after MyCiTi for residents in different parts of the city, as determined by changes in system design. I measured accessibility in terms of the amount of office, retail, and hospital floor area that can be reached via the transport system within a certain travel time. The findings suggested the introduction of MyCiTi increased accessibility for residents within its service area, but by only a small amount. The greatest changes, in percentage terms, were for white and upper income households and for access to retail. The BRT improved accessibility for lower income and nonwhite households as well, especially when measured at the 60 minute threshold. The distribution



in accessibility benefits was largely determined by Cape Town's highly segregated pattern of land-use.

The user survey, presented in Chapter 6, measured changes in travel time actually experienced by residents. The findings revealed that, on average, respondents reduced their travel times between 2010 and 2015, controlling for changes in origin and destination. As the regression model showed, much of this reduction was explained by respondents switching to BRT from slow transport modes, train and conventional bus, and not to BRT from taxis. There was little evidence BRT significantly improved travel times over taxis. In fact, for work travel, those who switched from taxi to BRT actually increased to their travel time on average. Contrary to expectations, MyCiTi performed better in relation to taxi for non-work travel than it did for commuting. The survey findings also suggested BRT users have travel time reductions even when they had to transfer between vehicles, suggesting transfers required by BRT less of a burden than might be expected.

My interviews of users provided a more complete picture of how accessibility has changed with Cape Town's formalization. In chapter 7, I discussed how users experienced the transport reforms. I found that, on the whole, public transport users had positive perceptions of MyCiTi, compared to their negative opinions of minibus taxis. While people found minibus taxis convenient, few people held positive opinions of them and were not sad to see them replaced. Still, echoing findings from the survey, the interview suggested the greatest benefits from MyCiTi came from upgrading poor quality formal public transport, specifically conventional bus and train, rather than from improving upon taxis. Interviews offered more evidence that taxis and MyCiTi each fill specific needs. Furthermore, whereas users generally had a negative relationship with the taxi industry, their relationship with MyCiTi would best be described as weak or nonexistent.

The BRT network did in theory offer greater accessibility over taxis for most residents, as shown by the network model. The city designed many of the BRT feeder routes to mimic taxi routes, so there would be little drop in service coverage. But MyCiTi's potential advantages – the ability to bypass congestion – were enough to make up for its disadvantages – increased transfers, rigid schedules, and rigid stop locations – to improve travel time over taxis, on average. The user survey and interviews found the largest benefits from MyCiTi came not from MyCiTi vis-à-vis taxis, but vis-à-vis other existing formal modes.

## 8.2 Discussion

### Explaining how and why MyCiTi reforms affected accessibility

Which aspects of Cape Town's reforms best explain these accessibility outcomes? Are they a result of physical changes to the public transport system: a trunk-and-feeder network with fixed routes and schedules, rather than a point-to-point network with flexible routes and service? Do shifts in organizational structure and incentives also explain the effects? In

the Cape Town case study, I investigated three ways in which transport reforms may have affected accessibility. The following paragraphs reflect on the evidence for those themes.

### **Multiple goals vs. single goal**

One explanation for the observed outcomes highlights changes in motivations and objectives. As I showed in the case study, informal taxi owners and drivers had a single goal: revenue. In Cape Town, as in other cities, taxis developed to fill an unmet need in the transport system. When heavily resource-constrained, government-subsidized public transport failed to adequately serve travelers, taxis grew to fill the vacuum (Wilkinson 2010; Walters 2013). As short-term revenue-driven businesses, taxis went where the passengers were. As my interviews found, informal operators served the basic travel needs of their users well—competition incentivized them to do so—while they neglected other concerns, like the safety and comfort of passengers, and societal concerns like accidents and pollution. They focused on the ridership they had, the transit-dependent, with little attention to expanding ridership to those with more of a choice, to the long-term sustainability of the business.

With MyCiTi, though, the City of Cape Town held primary responsibility for providing transport, even if through private service contractors. Elected officials aimed to win election and maintain legitimacy, and planners to advance their careers, leading to transport initiatives having multiple goals. In order to generate and maintain political support, the City had to respond to multiple interests of constituents. MyCiTi promised to meet travel needs but also further many other objectives, like alleviating congestion, reducing pollution, improving road safety, furthering social integration, and spurring economic development. MyCiTi had to cater to multiple groups, not just traditional public transit users. Decision makers in the city had personal motivations as well, like strengthening municipal-level planning capacity, and showing Cape Town was prepared for the World Cup. While the shift in responsibility from private operators to the City brought into the transport realm several additional and clearly worthy societal goals, it also diffused focus on responding to travel demand. These goals sometimes even came into conflict with travel demand, as demonstrated by the choice of the Blaauwberg corridor for Phase 1. These conflicting goals and the diffusion of goals negatively impacted the ability to improve accessibility.

The shift from single to multiple goals echoes experiences in other cities. As Flores-Dewey (2013) argued based on cases in Mexico City and Santiago, BRT reforms are ultimately about bringing what has become a private sector issue into the public realm. This involves shifting the attention from first-order to second-order concerns, from immediate needs of existing users to the larger public good. Informal transport services catered to the transit-dependent, while “choice” riders opted out of the system.

MyCiTi reforms, like those in Mexico City, Santiago, Bogotá, and others, reoriented the focus of public transport provision toward higher-order concerns. It made transport about more than narrowly serving the transit-dependent’s basic travel needs—now, public transport would provide all residents with high-quality service, it would serve broader societal goals.

Even with greater public investment, it should not be surprising that achieving those goals would come at some cost to the convenience informal transport provided to its existing users.

The shift in objectives also helps explain who benefited from MyCiTi. In terms of spatial accessibility by MyCiTi, the model showed that although Phase 1 benefited all racial and income groups, whites and high-income residents would benefit disproportionately, a consequence of the choice of service area and the city's residential segregation. The case study suggested the City chose the Blaauwberg corridor for Phase 1 for several reasons, but most of all because it was the most politically expedient, and it was politically expedient because it simultaneously served multiple goals. In this corridor, BRT would face the least political resistance from the taxi industry and from residents, it could stimulate economic development in older industrial area, it could attract middle-class car owners, and it would align with World Cup objectives. That the corridor contained a mix of population groups in terms of incomes and races was both deliberate – in order to secure political support from those groups – and coincidental – there were many other reasons for choosing the corridor.

Notably, although one motivation for MyCiTi was originally to further social integration and address inequalities in transportation, during Phase 1 planning that objective receded, while others, like accommodating disabled passengers and attracting car users, received more attention. As a result, the Phase 1 network ultimately served low-income and non-white residents, but perhaps fewer than it would have had greater network coverage been a priority. In Phase 2, having already demonstrated the value of BRT, the City could place more emphasis on goals of serving travel demand and reducing accessibility inequality. The N2 Express route, chosen to provide accessibility to and gain the support of transport-disadvantaged residents, served mainly non-white and lower income communities.

### **Informality and flexibility**

A second explanation for the accessibility outcomes is that the replacement of informal transport provision with more formal regulations, public investment, labor relations, and organization structure resulted in a less flexible system that did not respond as readily to demand. My interviews with stakeholders suggested MyCiTi struggled with operational flexibility in ways minibus taxis did not. A system with fixed routes and schedules is clearly less flexible than one without, but MyCiTi's more formal labor agreements, financing structures, and information systems also contributed to its relative inflexibility. BRT pre-boarding, for example, required compatibility between buses and stations, and when MyCiTi's high-floor Phase 1 buses were not interchangeable with the N2 Express stops it was more difficult to shift vehicle capacity in response to demand.

If reduced flexibility explains why MyCiTi failed to improve on the accessibility provided by taxis, it also why its most substantial benefits came from improvements over train and conventional bus. These previously existing fixed route, fixed schedule services did not rely on flexibility—their advantage was low fares, thanks to public subsidies. Although Golden Arrow was a private company, it operated with formal sector finance and business practices, it followed formal sector regulations. It could not take advantage of the low operating costs

that would allow small vehicles and more flexible service. Relative to Golden Arrow and Metrorail, MyCiTi's reforms improved management capacity, renewed public investment, and replaced old equipment with new.

### **Understanding of user needs and user travel demand**

Third, changes in how transport providers learn about and understand users' needs affected accessibility outcomes. Informal taxi operators learned about users' travel demands directly through the market and through personal interaction with customers, while the City used less direct, more 'professional' means of gathering information about user needs. It relied more on travel demand models and international best practice rather than local knowledge or strong public engagement. As a result, the City did not have a complete picture of user needs, especially early in the planning process. City planners did understand some general user priorities well, like the priority for MyCiTi fares to be affordable and users' poor opinions of taxi customer service. Planners' understanding fell short on several more specific issues—like which locations local residents considered safe for feeder stops. Processes for gathering feedback and understanding user needs improved over time, though, and there are signs planners are not repeating the same mistakes in Phase 2. Still, initial lack of understanding on some issues negatively impacted users' experience of the system and probably negatively impacted ridership.

Additionally, the population defined as 'users' also shifted. Taxi operators focused on the needs and preferences of only their existing customers, mostly the transit-dependent, and most often residents from the operators' own community and background. MyCiTi planners, in contrast, needed consider all types of users, including residents of different races, income levels, first languages, countries of origin, ages, genders, and ability levels. I found some evidence that the planning process that favored needs of users demographically similar to those who planned the system. Specifically, most planners were middle- to upper-income professionals who drove cars, and did not understand the needs of low-income public transport users as well. For example, city officials underestimated the extent to which low-income MyCiTi users would worry about costly penalties incurred from forgetting to tap out—an expense that for middle-income users would be merely annoying but for the poor could be detrimental.

Compared with other cities undertaking BRT reforms, Cape Town's public engagement processes and understanding of user needs were not unusual. In Bogotá, despite rhetoric about BRT as a democratic initiative, transport professionals' views on user needs and priorities apparently differed in a few substantial ways from those of citizens (Kash and Hidalgo 2014). For instance, although the experts and public both agreed on the need to organize chaotic traffic conditions, but experts prioritized reliability and safety, while potential users were more concerned with crowding and affordability. Even those BRT reforms where strong public engagement and feedback allowed a very good understanding of user needs, problems can still arise. Ahmedabad, for example, has been praised for its consultation efforts during the design process (Rizvi and Sclar 2014). While these efforts

translated into positive public opinion and high ridership (both which are very important!), needs of other road users, specifically bicyclists and pedestrians, were apparently neglected (Shah and Adhvaryu 2016).

Kash and Hidalgo (2014) argued transport professionals should aim for a better understanding of user needs when planning BRT systems. Of course, a better understanding of user needs can only help. At the same time, transport professionals also need to look out for higher-order goals that may not be a priority for individual users. Many of the benefits of BRT reforms will come from the reformed system's ability to address concerns not addressable by the private sector.

### **Formalization: intention vs. reality**

In Cape Town, the City initially intended for MyCiTi reforms to restructure the minibus taxi sector and for BRT to eventually replace minibus taxis. The City also envisioned MyCiTi as a one-size-fits-all public transport system that would draw users from all modes. My findings suggest, at least in terms of accessibility benefits, MyCiTi has been more successful in the latter than in the former. The greatest accessibility benefits came not from MyCiTi replacing taxis, but from MyCiTi as an alternative to previously existing, and poor quality, formal modes.

Other cities have also found BRT reforms to be less effective as a replacement for informal services than originally intended, although for different reasons that depend largely on the alternative modes available. In many Latin American cities, when travelers continued to choose informal transport over BRT, it was typically due to price. In Bogotá, BRT did not fully replace existing informal bus operators because many travelers continued to use the cheaper private bus operators (Gilbert 2008). In that city, the traditional buses were often slowed by congestion and, compared to informal modes in other countries, used relatively large vehicles that did not offer as much of a speed advantage. Their main advantage was low fares.

In South Africa, the informal minibus taxi offers more of a convenience advantage than a cost one. In Johannesburg, one study found it was difficult for BRT to provide much accessibility improvement over taxis, because the latter is already so ubiquitous (Venter 2016). In both Cape Town and in Johannesburg, BRT does very often have a price advantage over minibus taxis, given the subsidized fares, free transfers, and relatively lower fares for long distances (Vaz and Venter 2012). The explanation lies in South Africa's unique Apartheid-era policies, which heavily subsidized formal public transport in order to supply white urban areas with non-white workers, but which neglected service quality. As a result, formal, subsidized buses and commuter train offered very cheap but rudimentary service, while informal minibus taxis competed on convenience rather than price. This dissertation shows that although BRT improved the quality of formal transit, and easily out-competes conventional bus and train, it has not matched the convenience or service coverage of minibus taxis, and it appears travelers still choose the latter for those reasons.

In many other cities, especially those in Asia, existing informal transport comes in more options, usually including much smaller vehicles. In these cases, BRT systems have often been added on top of existing informal services with little or no reform of the latter. In Jakarta and Delhi, for example, BRT joined existing small-vehicle informal modes and conventional bus and metro systems (Rizvi and Sclar 2014; Ernst 2005; Kumar, Zimmerman, and Agarwal 2012). In Ahmedabad, BRT was not intended to replace informal autorickshaws, and many residents continued to use the latter, due to both convenience and price.

Cities with large motorcycle use have had still a different experience. BRT is typically intended to provide an attractive alternative to private motorcycle use, but has had difficulty competing. For example, in smaller cities in Indonesia and Colombia, BRT ridership has lagged as potential riders instead choose motorcycles (Guerra and Taylor 2017; Estupiñán et al. 2013; Hagen, Pardo, and Valente 2016). Like small-vehicle informal transport, motorcycles are slowed less by congestion and offer point-to-point mobility.

In its upgrading over existing formal modes, Cape Town's BRT reforms is similar to cases in India, where BRT is often added alongside existing conventional bus and commuter train. In Ahmedabad, for example, prior to BRT, subsidized municipal buses limped along with outdated equipment, declining service quality, and continuous financial problems, without the resources or political will needed to improve service, let alone take on larger public good concerns. Ahmedabad's BRT replaced existing municipal bus routes in the areas it served, without attempts to reform the conventional buses—if anything, the BRT redirected public resources away from the existing buses. There, BRT offered a more comfortable, higher quality alternative. Still, many residents, especially lower-income ones, continued to use the existing buses due to the latter's lower fare and greater service coverage (Shah and Adhvaryu 2016). Cape Town's experience has been similar, with the exception that MyCiTi did involve reform of Golden Arrow.

Furthermore, even though the BRT reforms in Cape Town did more to upgrade existing formal transit than to replace informal modes, the results in terms of travel time savings should not be ignored. In a context of growing population and employment, and likely increased travel as a result, we would expect generally growing travel times. The fact that so many survey respondents reduced their travel times is notable. Although we can't generalize from the survey to the general population, it still appears that Cape Town's political commitment and investment in public transport helped to keep travel times from growing longer, at least among a subset of the population that uses public transport.

## Heterogeneity and standardization

An important aspect of the MyCiTi reforms was the standardization of taxi operators' previously heterogeneous business and organizational models. Initially, the taxi industry consisted of many small-scale operators, which each differed from each other in several ways. The taxi associations, too, each operated differently; for example, associations had varying levels of self-organization. With MyCiTi Phase 1, the affected taxi operators were consolidated into fewer VOCs with much more standard business models. This standardization had both

upsides and downsides. On the one hand, it became easier for the City to interact with operators that are more homogeneous and fewer in number – in this case, government regulation and oversight was easier. On the other hand, the consolidation and loss of diversity may mean less competition and lower probability of transport operators being able to tailor their service to a given community’s needs.

To the extent that MyCiTi replaced train and conventional bus, as well as minibus taxis, it represented a shift from multiple modes with different service characteristics, fare levels, and organization structures to a single, one-size-fits-all system. With physical and institutional designs modeled after BRT in Bogotá and other cities, MyCiTi itself has many elements that can be considered standard (Wood 2014b).

The role of standardization in BRT reforms has not been widely discussed in the literature, but existing case studies suggest standardization is often involved. BRT planning tends to follow international standards even when customized to each city (Hidalgo and Hermann 2004; Hook 2005; Rizvi and Sclar 2014; Wood 2015b). Meanwhile, most informal transport industries are characterized by diversity in vehicle types, business models, and organizational structures, both within and between modes (Cervero and Golub 2007). A few implications follow. First, the diversity of informal transport makes it difficult to generalize about formalization efforts across cities, and even within cities. Second, the literature has documented the diversity of informal modes in cities worldwide, but future research should also recognize the heterogeneity within each mode. Finally, when BRT replaces informal transport, the latter’s heterogeneity is lost, for better or worse.

### **Partial formalization is a more typical case**

In Cape Town, like many other cities with BRT reforms, transport formalization remains incomplete. In the Phase 1 area, despite intentions MyCiTi did not replace all taxis, and in the N2 Express, at the time of this study, did not replace taxis at all. Phase 2 is being planned to incorporate taxis in a way that formalizes some characteristics, like corporate management structure, without changing others, like responsibility for operational details.

The City of Cape Town has itself acknowledged fully replacing informal transport with BRT may be neither practical nor desirable. It has proposed as an alternative a hybrid formal-informal transport system, in which, for future phases, BRT would provide the main trunk service, while minibus taxis would serve as feeders (Transport for Cape Town 2015). The plan would formalize certain aspects of taxis – they would have to adopt more corporate practices, agree to some form of contract with the city, and participate in the MyCiTi fare payment system – but in theory the taxis would retain much of their flexibility and demand-responsiveness. In order for this system to work, taxi drivers would need to be incentivized to pick up additional passengers, as they are now. Whether the economics are feasible without subsidies is an open question. In any case, all evidence indicates Cape Town’s system will continue to be partially formalized.

When I began this research, I intended to study the effects of transport formalization through BRT. The reality is BRT reforms are usually gradual (Wood 2015b; Hidalgo and

King 2014) and, in cities with limited government resources, BRT has rarely resulted in full formalization. Case studies in Latin America highlight Santiago, Chile as one of the only cities to transition from informal operators to BRT in a short time frame, a transition that, while ultimately successful in restructuring transport provision, came at great expense to public opinion (Paget-Seekins, Dewey, and Muñoz 2015; Figueroa 2013). In other Latin American cities that have paired formalization with BRT, like Bogotá, and Mexico City, reform has been gradual (Paget-Seekins, Dewey, and Muñoz 2015; Hidalgo and Gutierrez 2013). Even in Bogotá, the BRT and accompanying reforms of bus transport provision have spanned several decades (Gilbert 2008). One of BRT's selling points – that it can be implemented in an election cycle (Hook 2005) – apparently only applies to smaller sections of a system. Despite BRT advocates cautioning against phased implementation—for example, Hidalgo and King (2014) cautioned argued changing political priorities would prevent the completion of reforms—that seems to be the norm in most cities.

The accessibility impacts I found in this study would likely be greater if transition from taxis to MyCiTi had been more complete. But the fact that Cape Town's reforms have been partial is precisely the point. During the period, often decades-long, when BRT systems are planned and built, and informal services are reformed, people still need to get around. This dissertation presents a snapshot of accessibility changes at one point in the course of a gradual reform, and it represents the transport changes actually experienced by users.

### Timing of MyCiTi phases

MyCiTi's limited accessibility impacts as observed in my analysis may be in part due to phasing: the MyCiTi Phase 1 was chosen more for its political expediency than for its potential to satisfy travel demand. The Phase 1 corridor was chosen *because it lacked density and demand*, which translated into lower political resistance from the taxi industry and from residents. MyCiTi has had the largest effects on accessibility in the Phase 2 area with the N2 Express, where high travel demand more heavily motivated its choice.

Another assessment at the end of Phase 2 would be valuable and could very well show different results. However, the Phase 1 analysis illustrates how formalization diffuses demand-responsiveness because it shifts incentives from pure profit-driven market competition to political accountability and higher-order concerns. The latter is less likely to have great travel time benefits because it inevitably means bringing other objectives into the equation that may dilute or even conflict with the focus on travel demand.

In addition, in the case of MyCiTi, choosing a low-demand corridor for the first phase influences the effectiveness of future phases. The City of Cape Town says it has applied lessons learned from mistakes in Phase 1 to planning for Phase 2. For example, its approach to community engagement for Phase 2 has been more comprehensive. However, the biggest criticism of Phase 1 is that it was too costly, especially considering how few passengers were served. These criticisms—and financial reality—have created political pressure to cut back on spending for Phase 2 (Transport for Cape Town 2015). The second phase will use lower cost infrastructure and rely on taxis as feeders.



## Distribution of impacts

The spatial coverage of the Phase 1 area explains why MyCiTi, compared to taxis, had the greatest spatial accessibility benefits for higher income and white residents. In terms of the distribution of population served, the phasing of Cape Town's BRT appears typical. Venter et al. (Venter et al. 2017) suggested BRT accessibility impacts generally become more equitable over time, since the first phases of BRT systems tend to serve more middle-income areas and subsequent phases reach more neighborhoods of varying income levels. In Cape Town, MyCiTi's Phase 1 area included low-income areas as well as higher-income ones, but overall disproportionately served high-income households. The N2 Express already had begun reaching the city's largest and most disadvantaged areas; the full Phase 2 will expand this access.

In terms of travel time savings realized, the user survey suggested blacks had the greatest benefits from MyCiTi, mostly due to the N2 Express serving a majority-black neighborhood. In many other cities, BRT ridership tends to skew toward middle-income residents more than low-income (Venter et al. 2017). In Bogotá and Ahmedabad, BRT ridership is proportionally more middle-income, while the lowest income residents continued use informal traditional buses and shared autorickshaws with lower fares (Shah and Adhvaryu 2016; Gilbert 2008; Combs 2017). In these cities, the differential use by income appears due to both BRT's relatively high fares and its spatial coverage. In Cape Town, while MyCiTi ridership is mixed racially, the user survey and interviews suggest the poorest residents cannot afford the fare and still choose the cheaper train. MyCiTi's difficulties in reaching the poorest residents thus echo the experience of BRT in other cities, but in the Cape Town case BRT's competitor is different: here, the low-cost alternative is the formal, government-run train rather than informal modes.

## Government capacity and its role in formalization

I began with the argument that BRT reforms would be more likely to result in accessibility benefits when government capacity is greater. In the case study, government capacity in terms of transport planning began at a moderate level. As reforms unfolded, institutional changes, particularly devolution of transport responsibilities, meant the City's capacity in transport planning grew. At the beginning of MyCiTi planning, capacity for transport planning mostly existed at the national level, and the City had no transport department and little experience in transport planning. Early lack of capacity at the city level, especially in public participation, negatively affected the ability of MyCiTi to serve travel demand in Phase 1. Over the next several years, though, the City established Transport for Cape Town, and was to a large extent able to grow into its new planning, design, public participation, contracting, and enforcement responsibilities.

This case illustrates it may be more useful to think of government capacity not as an exogenous variable, but as potentially part of the formalization process. In Cape Town, increased government capacity at the city level is both an outcome of the reforms and a factor

in the reforms' success. The City's efforts to reinvigorate public transport through MyCiTi were a clear improvement over existing formal, government-subsidized modes, especially the nationally-managed commuter rail. At this the time of this study, corruption and financial mismanagement in South Africa's national government was proving detrimental to the ability of national state-run companies like Metrorail to provide public transportation, or even electricity and water (Onishi 2015; England 2014; Crowley 2015). With such a low bar, it's not surprising shifting responsibility to the comparatively well-managed city government resulted in better service.

The need for continued investment in and maintenance of MyCiTi infrastructure as the system ages will test Cape Town's institutional reforms. Early accessibility improvements from any new BRT system may be only temporary if maintenance is neglected. In São Paulo and Jakarta, for example, maintenance issues appeared early after implementation (Hook 2005; Ernst 2005). In Cape Town, problems with malfunctioning station and vehicle doors are already reducing the system's speed and reliability and are negatively affecting public opinion. The City will have to keep a strong commitment to continual investment and upkeep of the system to maintain accessibility benefits long-term, especially as expansion of the system strains resources further.

### 8.3 Limitations

As discussed throughout this dissertation, this research contains several limitations. In the analysis, data availability was a constant challenge. Critically, I was not able to obtain data on actual travel times before and after MyCiTi implementation. My methodology aimed to measure likely travel time changes by surveying travelers and by modeling the transportation network. As discussed in the corresponding chapters, these methodologies required several assumptions.

Another important limitation is that I did not specifically investigate whether or not BRT reduced congestion for other travelers by taking cars off the road. Ideally, BRT is expected to attract car drivers, therefore reducing car use, reducing congestion, and improving travel times for all road users. Some percentage of former car drivers did switch to MyCiTi, and some taxis were removed from the West Coast highway, but data limitations prevented me from estimating how many, and the extent to which this may have reduced congestion. The best data I could obtain on changes in congestion was citywide congestion index data, as discussed in Chapter 5. This gives us a rough idea of congestion changes in the entire city, but does not specifically isolate effects in the MyCiTi area. Future research should specifically analyze the congestion impacts.

This study only considers the effects of MyCiTi Phase 1 and the N2 express. As discussed in Chapter 4, Phase 1 was somewhat limited because it was chosen more as a demonstration for political reasons, whereas Phase 2 will serve higher density demand. A similar study conducted after the completion of Phase 2 will likely show greater accessibility effects. However

Phase 2 is not scheduled to be complete for several years. I chose this time to study Phase 1 because five years was a reasonable timeframe to conduct a retrospective survey.

This study does not consider an important factor in evaluating formalization through BRT: the cost to taxpayers. Even though BRT is inexpensive relative to rail transit, Cape Town's MyCiTi project was not cheap. Operational expenses exceed the amount originally predicted, and the city has had to request additional funding from the national government (Transport for Cape Town 2015). For Phase 2, the city is being forced to scale back plans in order to control costs. Whether or not the long-term benefits of reforms like MyCiTi exceed the financial cost is outside the scope of this dissertation. Even in the short term, it's clear that the Phase 1's financial burden on the government was too high to be sustainable in future phases.

## 8.4 Generalizability

As always with a single case study, care should be taken in generalizing to other cases. Several characteristics make Cape Town similar to other cases and should increase our confidence in its generalizability. First, many elements of Cape Town's informal transport echo those in other countries. Like informal transport elsewhere, minibus taxis arose in response to the inadequacy of government-subsidized public transport. The system is demand-responsive, it uses smaller vehicles and inexpensive labor. The minibus taxi industry is perhaps slightly more regulated and more highly organized than the typical informal system, but in character it is similar to many others.

Second, in BRT, Cape Town has used a typical approach to formalization. MyCiTi was explicitly and deliberately based on international models, with planning influenced by international experts. As a BRT system, MyCiTi is very typical of those found elsewhere. The means for formalization, incorporating informal operators into the BRT system through negotiation, is also a typical approach.

Third, Cape Town has moderate government capacity, making it similar to many cities that have already adopted BRT or are contemplating BRT as a means of formalization. BRT as formalization is in fact most likely to appeal to cities with moderate government capacity. Cities with high government capacity are unlikely to have significant informal transport in the first place, and those with very high government capacity struggle to plan and implement BRT at all.

Cape Town also has some atypical characteristics. Most significantly, its land use patterns make BRT, and perhaps formal transport in general, less efficient than in other cities. Cape Town has relatively low population density, which translates to relatively low density of travel demand. Its land use, segregation, and inequality patterns are similar in quality to those in other cities, but extreme in magnitude.

With these typical and atypical traits in mind, the findings about what's changed with BRT – the relationships between actors – are generalizable to other cities. The arguments about the role of government in BRT planning and operation are likely generalizable to

cities with similar levels of government capacity and similarly organized informal transport industries. The findings about accessibility impacts and who benefits from MyCiTi may be less generalizable. Since Cape Town's land use is likely to make BRT less efficient, it may be that BRT vis-a-vis informal transport would have greater accessibility benefits in cities with higher density and less segregation. The fact that MyCiTi's Phase 1 network served a relatively linear corridor, rather than a more spread out area may result in more unique outcomes. For example, I found transfers to be little disadvantage to MyCiTi users' accessibility, but a similar study in Barranquilla suggested transfers in that city's BRT imposed a bigger time cost on users (Rayle and Palacios 2017).

Another factor affecting Cape Town's generalizability is the type of operator contract. Cape Town's choice of service-based contracts, rather than performance-based contracts, is typical of BRT systems. But this choice determined the incentives faced by operators, and thus heavily influenced accessibility outcomes. A performance-based contract would create a different incentive structure and likely different outcomes. A similar case study investigating formalization with performance-based contracts would be a beneficial next step.

## 8.5 Contributions

Existing research on the accessibility impacts of BRT has investigated how BRT affects travel time, but mostly only within BRT corridors, not in other parts of the city. Previous survey-based analyses in other cities have not specifically studied how the need to transfer affects BRT travel time, nor have they accounted for changes in travelers' origins and destinations. This dissertation contributes to the literature an analysis using custom survey data to measure travel time changes before and after formalization, controlling for moving behavior. I analyzed changes in both work and non-work travel, an improvement on previous surveys that focused on only one or the other.

Previous spatial analyses of the accessibility impacts of BRT have not compared accessibility by BRT with that provided by existing informal transport. This dissertation is the first study of which I am aware to specifically model the spatially distributed accessibility by informal transport. This analysis made use of multiple novel data sources, and despite limitations imposed by necessary assumptions, represents an advance in accessibility analysis.

This dissertation also contributes to both theoretical and empirical research on informal transport. While descriptive accounts of informal transport modes in various cities are common in the literature, few authors connect these descriptions to broader theory on informality, much less what changes with BRT reforms. In this study, I presented an empirical case study of how the transport system changed with formalization in a way that helps explain accessibility impacts.

Existing literature on the nature of informality and transportation is scarce. It does not fully explain what constitutes informal transport. This dissertation raises the question, is formalization really just about forcing a private sector activity into the public sector? In the

case of Cape Town, it does appear that moving from private-sector incentives – profit – to public-sector objectives – congestion, safety, crime – explains much of the changes resulting from MyCiTi reforms. Paget-Seekins (2015) and Flores (2013) make this argument: formalization means addressing higher-order objectives, the public good and externalities not addressed by the market. I agree, but I would add, as illustrated by this dissertation, that the shift from private sector incentives to public sector is accompanied by shifts in industry organization, business practices, labor arrangements, and relationships with the public. These changes are in turn inseparably linked to changes in vehicle and service characteristics. The contribution of this study has been to detail what specifically formalization involves, as well as to ask how those shifts impact accessibility for residents.

## 8.6 Policy implications

Several policy implications come out of this research. The findings suggest BRT can be effective as an upgrade to existing formal public transport, but does not necessarily improve upon informal modes, at least in terms of travel time. It also implies formal and informal modes serve different travel demand niches, suggesting perhaps a hybrid system that combines the strengths of both informal and formal modes may be more effective. This is of course what Cape Town is already considering. The big question with such a hybrid system is whether or not bringing informal modes into the system will raise their operational costs so much that they lose the advantages of informality, specifically flexibility. It is also unclear whether or not the addition of a BRT trunk corridor would take away business from informal operators and render their businesses economically unsustainable. Cape Town’s attempt to implement a hybrid system is a bold move and it will be interesting to see the outcomes.

One of the reasons transport reform in Cape Town did not greatly improve upon informal transports’ ability to serve travel demand is that the service-based contracts between the VOCs in the city removed any incentives for operators to try to understand user needs, or to adapt their operations to serve it. In theory, performance-based contracts keep those incentives in place, and hence encourage contracted operators to behave more like profit-driven private sector actors. Cities planning transport formalization should carefully consider the benefits of performance-based contracts.

In my interviews, Cape Town planners repeatedly explained that they were trying to improve the efficiency of MyCiTi by changing the city’s land use. Land use policies that encourage more balanced development – that is, that reduce the one-way peaked travel flows – would certainly go a long way to improve cost efficiency in this case. Land-use change is slow though, and on a different timescale than is this research.

Interestingly, the most unambiguously beneficial part of MyCiTi was the N2 Express. Although designed simply as a pilot for the system’s Phase 2, the N2 Express improved travel times greatly for users at relatively little capital cost compared to full-scale BRT. Ridership demand exceeded capacity even though it competed with taxis. Of course this

corridor had higher demand than other places in the city. But its success and popularity does suggest accessibility benefits can be achieved quickly through low cost simple bus upgrading.

## 8.7 Future research

Rather than relying on a single case, this line of research would be improved with case studies of other cities, preferably cities with varying levels of government capacity and varying land use patterns, especially density. Because the type of contract with the operating companies determines the nature of the relationship between the transport operator in the government, and between the transport operator in the public, it would be useful to study cities that have pursued formalization through BRT and used performance-based contracts. Case studies of such cities would help to isolate the influence of variables such as population density, government capacity, and contract type.

Future research could also make use of higher-quality travel data. This study was limited by the lack of accurate travel times before and after formalization. Better data could be collected in a couple ways. A simple way would be to use a traveler survey similar to the one used in this study, but administer it in advance, such as before the MyCiTi Phase 2 opens, and after. Another way would be to use smartphone GPS technology to track study participants and gather more accurate data on their travel patterns. This would have to be paired with a questionnaire that collects sociodemographic information. More accurate data, especially before and after data, would allow for a more rigorous analysis of the accessibility impacts.

A longer timeline for the study in Cape Town would allow for investigation of how the accessibility impacts of BRT reform change over time. For example, it may be that MyCiTi operates more effectively now, when equipment is new, than it will later as more maintenance problems arise. A longer timeline for the study would also enable investigation of how future BRT phases affect accessibility. Of particular interest, in the Cape Town case, are outcomes of the formal-informal hybrid system currently in planning stages. Transfer interventions also affect land use, and a study with a longer timeframe would capture how land-use changes resulting from BRT reforms affect accessibility in the long-term.

Future research could also focus on how transport reform affects racial segregation, a topic especially important in the Cape Town context. My findings tentatively indicated MyCiTi reforms to some extent reduced gaps in accessibility between races. The MyCiTi reforms may have affected inequality and segregation in Cape Town in another way too: they brought residents from different racial and economic groups together in one space. With the minibus taxis, each route and, indeed, each taxi association tended to serve a single neighborhood, and as a result minibus taxis typically held passengers of mostly a single race and single economic class. In contrast, MyCiTi routes pass through many different neighborhoods. My research was not specifically designed to study this, but during my field research I observed MyCiTi buses, at least in the Phase 1 area, are typically filled with passengers of many different racial and economic backgrounds. One effect of MyCiTi may be bringing

people from different races together in one public space, a relatively rare phenomenon South Africa, and not usually seen on its public transport. Future research could investigate this hypothesis, and explore how it affects social relationships among residents.

What is lost when we formalize informal transport? When I began this research, I expected to find informal transport operators to have a special knowledge of their passengers because they were “closer” to the community. Perhaps informal transport is a better fit for places like Cape Town’s townships because it is a grassroots solution that grew out of the local community. In my fieldwork in Cape Town I looked for evidence supporting this idea but did not find it. While taxis are a “homegrown” mode of transport, and operators often do have personal ties to the community they serve, in Cape Town at least, relationships between the community and taxi industry appear to be more often negative than positive. I came away skeptical about the idea of informal transport in Cape Town as somehow more community-oriented. It may also be that in South Africa the taxi industry has an unusually negative relationship with communities stemming from its history with the taxi wars. However, the homegrown nature of informal transport also gives rise to diversity in form and organizational structure, which is often lost with BRT reforms. Finally, future research on BRT reforms could focus on the implications of standardization and consolidation.

If they are not completely replaced by formalization in the near future, and they probably will not be, what is on the horizon for minibus taxis, and other forms of informal transport? They may continue to operate as they have for the past several decades. However, there is a great deal of interest in both the transportation and technology sectors in applying new technology to informal transport modes. In the short term, smartphones could potentially allow informal transport operators to be much more formal in some respects, without losing the flexibility that makes them so popular. For example, smartphone and GPS has allowed ride-hailing to efficiently match supply to demand, potentially lowering operational cost while still maintaining large-scale and formal business practices. Smart phone-enabled fare payments and routing could allow informal operators like minibus taxis, to integrate with formal transport like BRT, without raising operational costs so much that the businesses are no longer financially sustainable. In the longer term, autonomous vehicle technology promises to permanently change the relationship between transport operators and labor, dramatically lowering labor costs, which would make it formal like flexible transport more economically feasible.

In these worlds, what counts as formal and what counts as informal? Clearly the lines will be blurred to some degree. It will be interesting to see whether the dimensions of informality I identified in this dissertation are still relevant. Specifically, are the important relationships still those between transport operators and the public and the government? And the labor and organizational relationships within the industry? This will be an important question for future research.

# Appendix A: Details of the accessibility model

## Details on estimating minibus taxi travel times

### Performance issues

I computed the zone-to-zone travel times using the function *pgr\_dijkstraCostMatrix* provided in the pgRouting package. I chose this package because I wanted an open-source option that would be compatible with the geospatial data available in the original shapefiles. The pgRouting algorithms are faster than other available implementations, for example, those in Python. Performance is an important factor because each travel time calculation requires running the shortest path algorithm  $n^2$  times, where the number of travel zones,  $n$  happens to be 1787. The shortest path algorithm's running time scales as a factor of  $V \log V + E$ ; in this case the number of vertices (V) is 42,954 and the number of edges (E) is 114,683.

The *pgr\_dijkstraCostMatrix* function uses the Dijkstra algorithm to find the shortest path through a network between each pair of specified input nodes. The package's core algorithms use the Boost library written in C++, and are faster than many other available implementations. I ran the travel time model on an Amazon Web Services Elastic Compute Cloud (AWS EC2) instance with 8GB of RAM.

### Preparing the minibus taxi network

Preparing the graph to represent the minibus taxi network followed these steps:

1. Create “real” street network topology from original shapefiles
2. Create route network “layer” and transfer links
3. Assign time-cost to each link.

To use the pgRouting package, I first created a network topology within a PostgreSQL database with a PostGIS extension. The network topology represents taxi routes based on data supplied by the city in the form of ESRI shapefiles, which the city originally created for its EMME2 travel model. Fortunately, the edge and node geometry available in the shapefiles



was compatible with pgRouting. I restricted the street network to only links where taxis were available. I then used the topology functions available in pgRouting to create network nodes and verify the integrity of the network. Following pgRouting conventions, the link cost in the “reverse” direction is set to -1.

Next, I performed several steps to verify the street network graph was a reasonable representation of reality. First, I verified the integrity of the graph’s topology by running the `pgr_analyzeGraph` and `pgr_analyzeOneway` functions, which check for dead ends, un-noded intersections, gaps in the network, or flipped segments. Second, I tested the shortest path algorithm, `pgr_dijkstra`, on several pairs of nodes, and verified the returned total time-cost was very close to the driving time estimated by Google Directions. Third, I visually inspected the graph to look for problems with intersections, and check whether or not it still appeared to match the original street network and minibus taxi network shapefiles.

I also prepared a network to represent car travel, for use in the validation step. This network uses the full street network, rather than just segments with taxi routes, and the weight of each link is defined in the same way as for the street links in the taxi network. The car network has only street links, no route or transfer links.

**Estimating in-vehicle travel time cost** To estimate speed, I first defined a free-flow speed that varies with road type. The road type was supplied in the edges shapefile as a two-digit number assigned to each road segment. Upon inspection, I determined the first digit represented the road class and the second digit represented urban vs. rural. I matched these classifications with South African officially specified road design speeds (Committee of Transport Officials 2012).

Table 1: Initial road segment speeds

Road type		Official Classification		Design speed (km/h)
First digit	Second digit			
1	1	Class 1	Rural	120
1	2	Class 1	Urban	120
2	1	Class 2	Rural	120
2	2	Class 2	Urban	80
3	all	Class 3	all	70
4	all	Class 4a	all	60
5	all	Class 4b	all	50
6	all	Class 5	all	50
7	all	Class 5	all	50

Peak morning traffic will reduce the speed for each link from  $i$  to  $j$  below the free-flow

speed according to:

$$speed_{ij,traffic} = \theta * speed_{ij,free-flow}; 0 < \theta \leq 1 \quad (8.1)$$

where  $\theta$  is the congestion delay factor. I estimated the value of  $\theta$  using driving time data from Google Maps for validation. Ideally, the value of  $\theta$  will vary for each edge, but with over 6000 edges, some of which are very small, it was not practical to calculate speed for each one. Instead, I grouped edges into five categories, according to expected traffic delay: from light or no traffic, to heavy traffic. The value of  $\theta$  will be estimated separately for each category. I assigned edges a category based on the Google traffic map for a typical Tuesday at 7:45AM, since this would represent peak morning traffic on a typical weekday. It turns out the original edges shapefile already had a column to indicate traffic delay that fairly closely matched the Google map, so I only needed to manually edit the category of some edges using QGIS, making sure to choose the correct direction for each one.

Next, using a Python script, for each category I selected edges longer than 0.5 km, sent the start and end coordinates of each edge to the Google Maps API, and compared the resulting travel time for “in traffic” and “without traffic.” I used a minimum edge length because longer edges would be less likely to have large errors. I set the departure time to a Tuesday morning at 7:45AM. Then, for each edge,  $\theta = tt_{notraffic}/tt_{intraffic}$ . As expected,  $\theta$  was smallest for the “heavy traffic” category, and close to 1 for the “light traffic” category.

I set  $\theta$  equal to the mean value for each category. I then calculated speed for each edge according to 5.5. It might seem more straightforward to simply get the travel time for each edge from Google Maps and use that value to directly as the edge cost in my model. However, this is not feasible because the location coordinates are not sufficiently precise. Transforming coordinates from the edges shapefile to Google Maps results in errors of about 100-200m, which means we cannot guarantee the Google Maps result actually corresponds to the edge used for input; for example, it’s possible the directions required going around a block rather than traveling a straight edge. Thus the travel time returned by Google may be several times greater than the actual travel time for the input edge, whereas the ratio of travel time in traffic to travel time without traffic is likely to be fairly accurate for that locale.

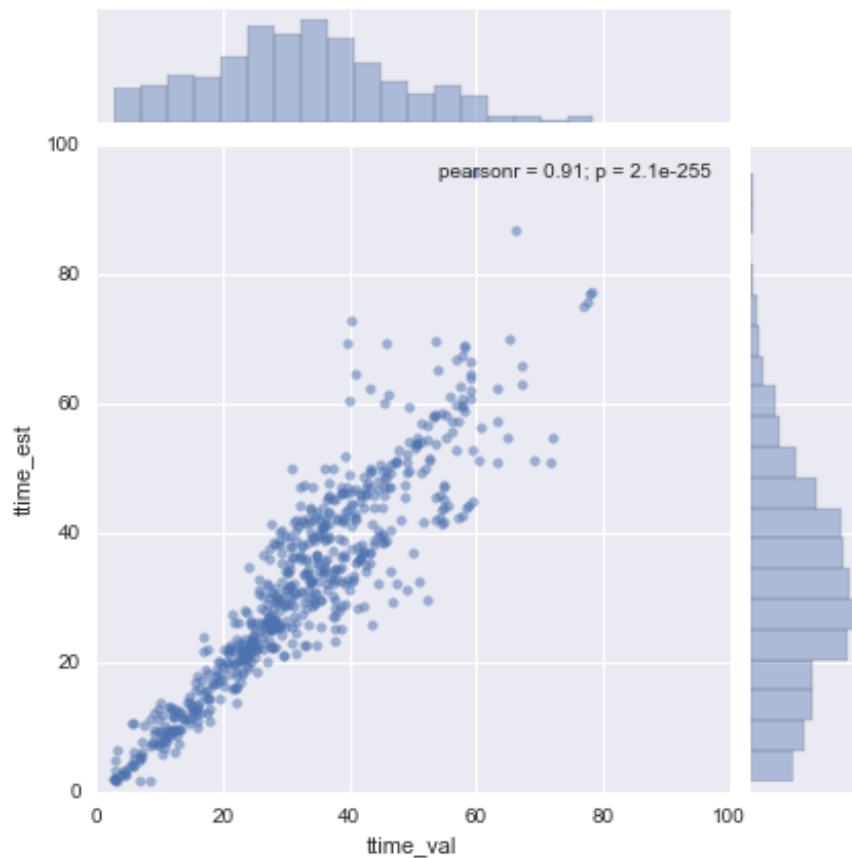
The next step was to choose values for  $\theta$  so that the in-vehicle travel times in the model match real in-vehicle travel as closely as possible. To do this, I again used the travel times as predicted by Google Maps’ traffic model as validation data. Since I only had current traffic data, the validation step calibrates the model for 2015 conditions. This time, instead of finding travel times in and out of traffic on selected road segments, I asked Google to return the travel time between a random sample of 2500 pairs of TAZ centroids. As before, I asked for the predicted travel time on a Tuesday at 7:45AM. I performed these queries in late 2016, so the validation data best represents actual traffic conditions at that time. After obtaining these validation data, I calculated a travel time cost matrix for the car network in pgrouting and compared the resulting travel times with the validation data. The objective is to minimize the error between the estimated travel times for the car network and the

validation data from Google, over all TAZ pairs in the sample, measured as the root mean squared error (RMSE).

I considered using an optimization algorithm to minimize the error, but this would be very computationally expensive since each travel time matrix calculation requires computing the shortest path  $1787^2$  times. It turned out that manually finding values to minimize the errors was sufficient. (I did actually implement a gradient descent optimization but it was easier to find good-enough values manually.) I also had to manually adjust the congestion categories slightly to improve the fit.

The best estimate of the congestion delay factor ( $\theta = [0.350.40.60.80.30]$ ) resulted in an RMSE of 6.55 and a mean error of -0.60. The plot in 1 shows a fairly close alignment between the estimated and validation values. The plot of errors vs. estimated values (2) suggests the errors grow with trip length, as expected, but are not systematically over- or under-estimated. Similarly, the histogram of errors (3) shows the errors are fairly normally distributed, with a slight bias toward underestimation.

Figure 1: Estimated vs. validation travel time values - Car model



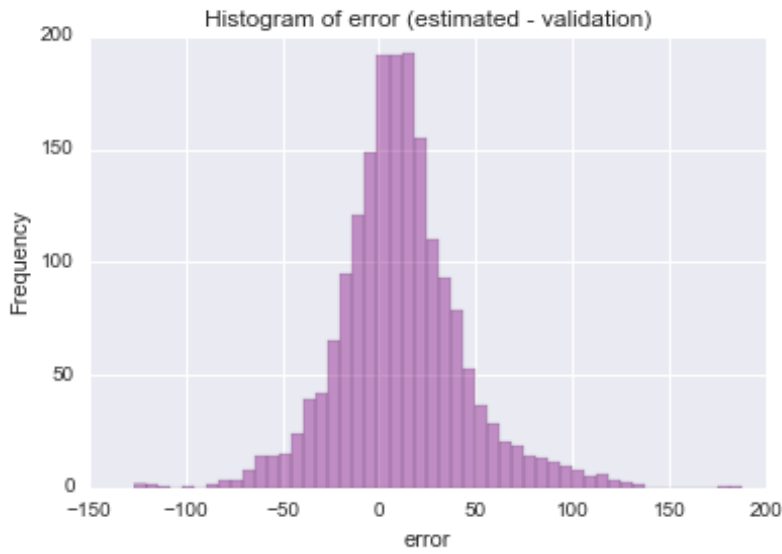
car model, n=650

Figure 2: Error vs. estimated values - Car model



car model, n=650

Figure 3: Histogram of error (estimated-validation) - Car model



car model, n=650

**Representing taxi routes and transfers** After preparing the network’s street links and assigning them costs, it was time to add links to represent transfers and taxi routes. I added these links as additional “layers” to the graph. The route information comes from the original taxi route shapefiles, which contained 1419 taxi routes, nearly half of which were simply the reverse direction of the baseline route. Since the reverse routes had the same headways and virtually identical geometry as the baseline route, I omitted reverse routes, leaving 709 forward routes. (In some cases geometry of the reverse direction differed slightly from the forward direction because of one-way streets, but these differences were very small.) The purpose of leaving out reverse routes was to reduce the computational complexity of the pathfinding algorithms.

For each taxi route, I made a “copy” of the baseline street network edges and nodes that intersected the route. These “copied” edges are the route edges, and they have different unique ids, but the same time-cost and occupy the same space as the baseline street network (although to save database memory, they do not have a geometry). Then, for each node in the “copied” nodes, I created a new transfer edge between the copied node and the original.

The transfer edge’s reverse cost is zero, so there is a cost associated only with transferring *to* a route; there is no cost to transfer *from* a route. Because transfers are not possible along highways, I removed transfer edges along all streets with a type equal to ‘11’ or ‘12’.

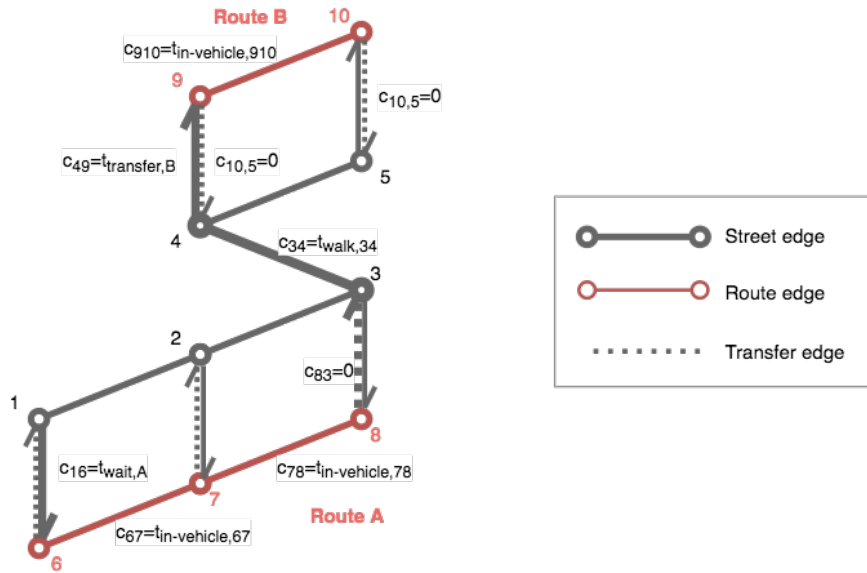
Finally, after creating the route and transfer edges, I needed to handle cases where connecting taxi routes do not overlap, and a passenger might need to walk a small distance to catch the second taxi. To do this, I modified the original street edges so that the cost represents walking time rather than driving time. I assumed a constant walk speed of 4.8 km/hr. Therefore, walking is possible along any street in the network, but there is no private car travel. A limitation of this model is that walking can only occur along streets that are in the taxi route network, as it would be too computationally expensive to include all the original street edges. Through visual inspection I verified that the edges in the taxi network fully connect, and connections are available at all major taxi hubs. There may still be some cases, for example, changing to another taxi route by walking to a parallel street, where possible real-life transfers are not possible in the graph.

To see how costs are assigned to the network graph, refer to 4. Imagine a passenger traveling from node 1 to node 5. They would first wait for the taxi along Route A, with cost  $c_{16}$  equal to the wait time for Route A. They would take a taxi from node 6 to node 8, with cost  $c_{67} + c_{78}$  equal to the total in-vehicle travel time. They would alight at node 8. Note edge 8-3 has zero cost. The passenger would then walk from node 3 to 4 with cost  $c_{34}$  equal to the walking time along that edge. They would transfer to Route B at node 4 with cost  $c_{49}$  equal to the transfer time for Route B. Finally, they would travel to node 10, alight, and arrive at node 5.

## Taxi route headways analysis

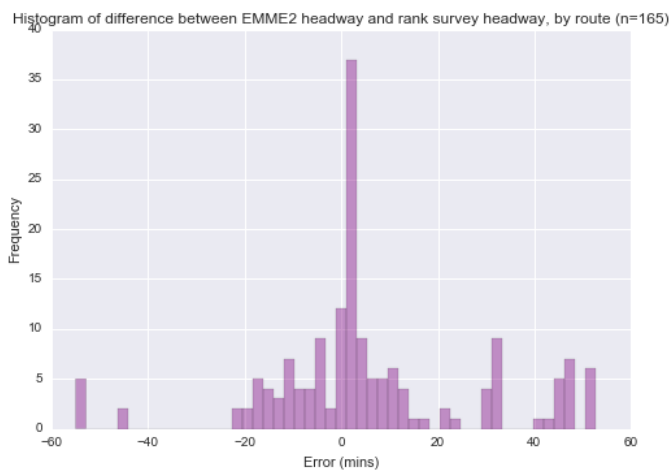
5 shows the histogram of difference between the EMME2 headways and the rank survey headways for those routes for which data are available. As we can see, for many routes the

Figure 4: Example of costs assigned to edges in the taxi network graph



difference is very small, but there are some routes for which there are larger discrepancies.

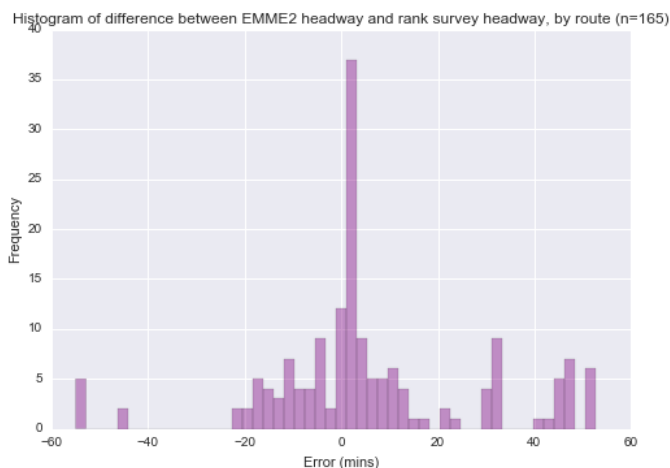
Figure 5: Histogram of difference between headway values from EMME2 data and rank survey data



As is evident in 6, there are a few routes for which the rank survey data suggest the headway is 60 mins, but the EMME2 data suggests a much lower value. (An alternative approach is to use the minimum of both values. )

For the model, I decided to use the headways calculated from raw survey data because their derivation is more transparent, except where those routes were not in the rank survey

Figure 6: Histogram of difference between headway values from EMME2 data and rank survey data



sample, in which case I used the EMME2 data. The other exception was when the discrepancy between the rank survey and EMME2 data was very high (greater than 40 minutes), in which case I manually inspected the data. In these cases, I chose the value that I believed was most correct based on the data quality (e.g., number of observations and potential for origin/destination inaccuracies) and my knowledge of the taxi system.

The model assumes routes have constant headways. In reality, headways vary, especially because taxi do not follow schedules. Assuming vehicle arrivals follow a negative exponential distribution, it can be shown the expected wait time is given by  $E[h]/2 + \frac{\sigma^2}{2E[h]}$  where  $E[h]$  is the expected headway and  $\sigma^2$  is the variance of the headway. Future extensions of this model might consider changes in headway variance. For this model, though, I did not find reason to suspect the MyCiTi reforms changed variance in taxi headways.

## Assumptions about accessing the taxi network

In the minibus taxi network model, each journey begins and ends at a TAZ centroid, and I assume the passenger walks between the centroid point and the node in the taxi network at which they board the vehicle. I needed a way to define the latter point.

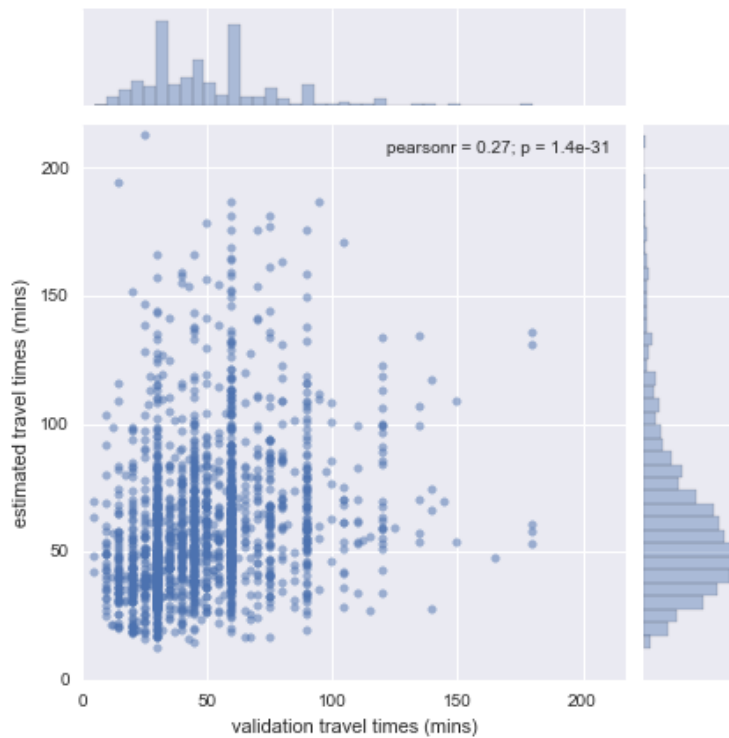
In choosing a point to board a taxi, a reasonable passenger would not just walk to the nearest road that happens to have a taxi route; he or she would consider both the walking distance to the stop and whether or not that stop has a taxi route headed in the correct direction. In the Cape Town context, walking to the nearest major road is very likely to bring the passenger to a taxi route with the shortest travel time.

In order to choose the “best” node, therefore, I used the following algorithm. First, within a certain radius (500m) of the TAZ centroid, I selected the five nearest nodes. Of

those five, I selected the node that served the greatest number of taxi routes. If there were no nodes within the first search radius, I expanded it (to 1000m) and selected the five nearest nodes within that radius. Of that selection, I chose the node with the most routes served. I repeated to 2000m, and if there were still no nodes within the radius, the TAZ is not considered to have access to taxis. This algorithm resulted in lower error in travel times than other forms I tried such as, for example, selecting 10 nearest nodes instead.

## Minibus taxi travel time model validation

Figure 7: Joint plot of estimated travel time vs. validation travel time - Taxi 2011 (base model) and HHTS data



**Sensitivity analysis** In order to better understand how potential inaccuracies in model input data affected results, I performed a series of sensitivity tests in which I varied input parameters. A summary of sensitivity tests and their findings is shown in 2.

## Full accessibility index results

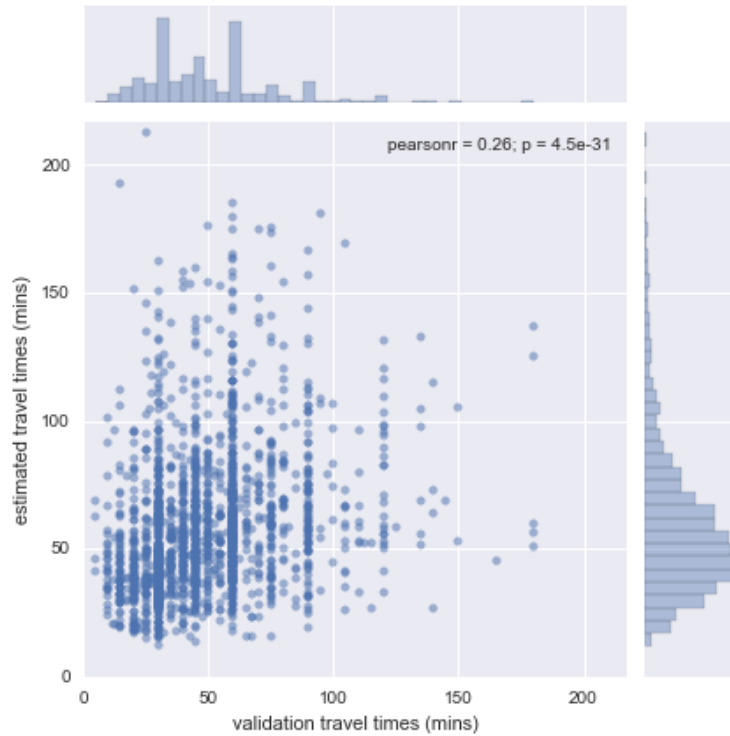
Patterns in accessibility scores to office uses echo those of retail uses (discussed in Chapter 5). When it comes to hospital use, the large concentration of hospital space in the Mitchell's



Table 2: Summary of sensitivity analysis tests for taxi travel time model

Parameter to test	Change to test	Expected result	Baseline values	New values	Findings
Congestion delay (theta)	decrease all theta	Decrease all A	[0.5 0.5 0.6 0.8]	[0.3 0.3 0.4 0.6]	Magnitude is sensitive to theta. Relative avg travel time threshold and land use same as baseline. Relative scores by race at 45-min level vary: at baseline, they are almost level (for office and retail); with high theta, black has highest A and with low theta, white has highest A. Same pattern with income. Whether coloured or blacks have the highest A for access to hospital at 60 mins depends on theta.
	increase all theta	Increase all A		[0.7 0.7 0.8 0.98]	
	make all classes equal	Increase A for more distant zones		[0.7 0.7 0.7 0.7]	
Headways	decrease all h	Increase all A	use rank survey if available, otherwise emme	Reduce all h by 50%	Relative A values for taxi 2011 between pop groups are robust to changes. Exception: In Baseline, A scores at 60 mins are highest for blacks, middle for coloured, and lowest for whites. (only for office and hospital; for retail relationships do not change w/ h.) In low h case, A is slightly higher for 60min threshold. Other exception: 45min A is always between 30 and 60 mins, but relative relationships at this level are not stable over ranges of h.
	increase all h	Decrease all A		Increase all h by 50%	
on-route headway multiplier (function of veh occ)	decrease all values	Increase all A	[0.82,0.67] for 2011, 2015	[0.5, 0.5]	Behaves as expected. Same results as headway, not surprisingly, since this is just a multiplier for headways.
	increase all values	Decrease all A		[1.0, 1.0]	
at-rank headway multiplier (function of queue length)	decrease all values	Increase all A	[0.94,0.94] for 2011,2015	[0.5, 0.5]	Behaves as expected. Same results as headway, not surprisingly, since this is just a multiplier for headways.
	increase all values	Decrease all A		[1.0, 1.0]	

Figure 8: Joint plot of estimated travel time vs. validation travel time - Taxi 2015 (base model) and HHTS data



Plain area results in fewer spatial disparities in accessibility, compared to retail and office uses. The Mitchell's Plain neighborhood and surrounding southeastern neighborhoods have relatively good accessibility by taxi, and limited zones in Mitchell's Plain have good accessibility by MyCiTi. As with office space and retail, in much of the Phase 1 corridor MyCiTi provides better accessibility than does taxi in either year.

Figure 9: Joint plot of estimated travel time vs. validation travel time - Taxi 2011 (base model) and WIMT data

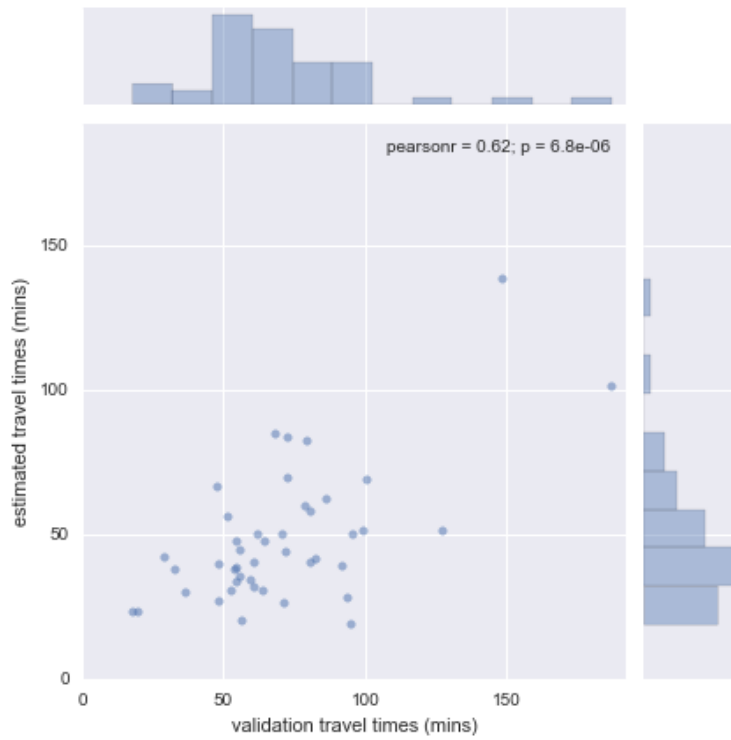


Figure 10: Joint plot of estimated travel time vs. validation travel time - Taxi 2015 (base model) and WIMT data

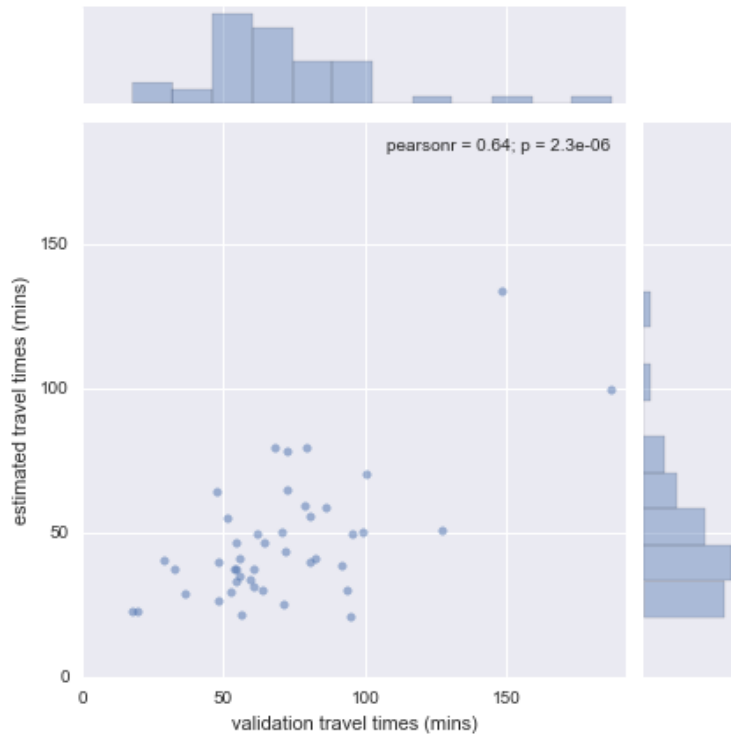


Figure 11: Histogram of validation errors - Taxi 2015 (base model) and HHTS data

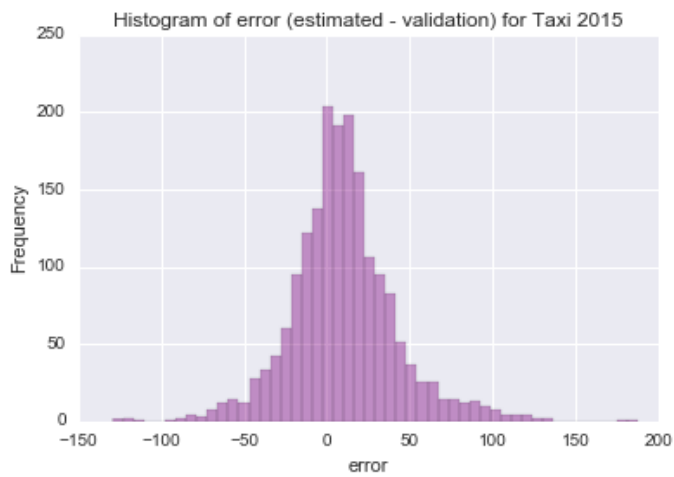


Figure 12: Histogram of validation errors - Taxi 2011 (base model) and HHTS data

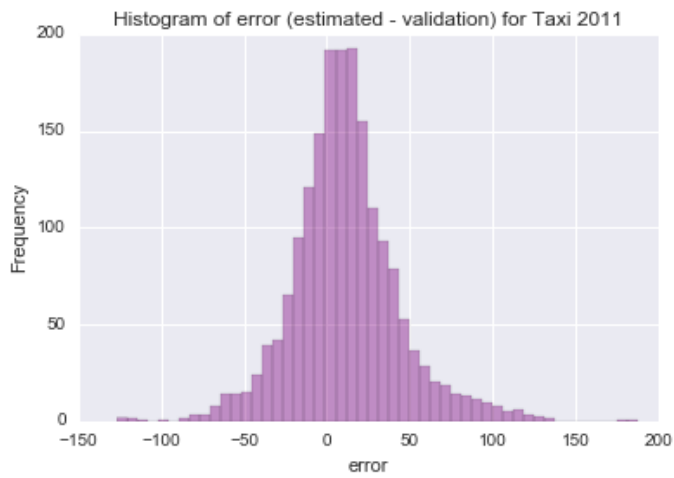
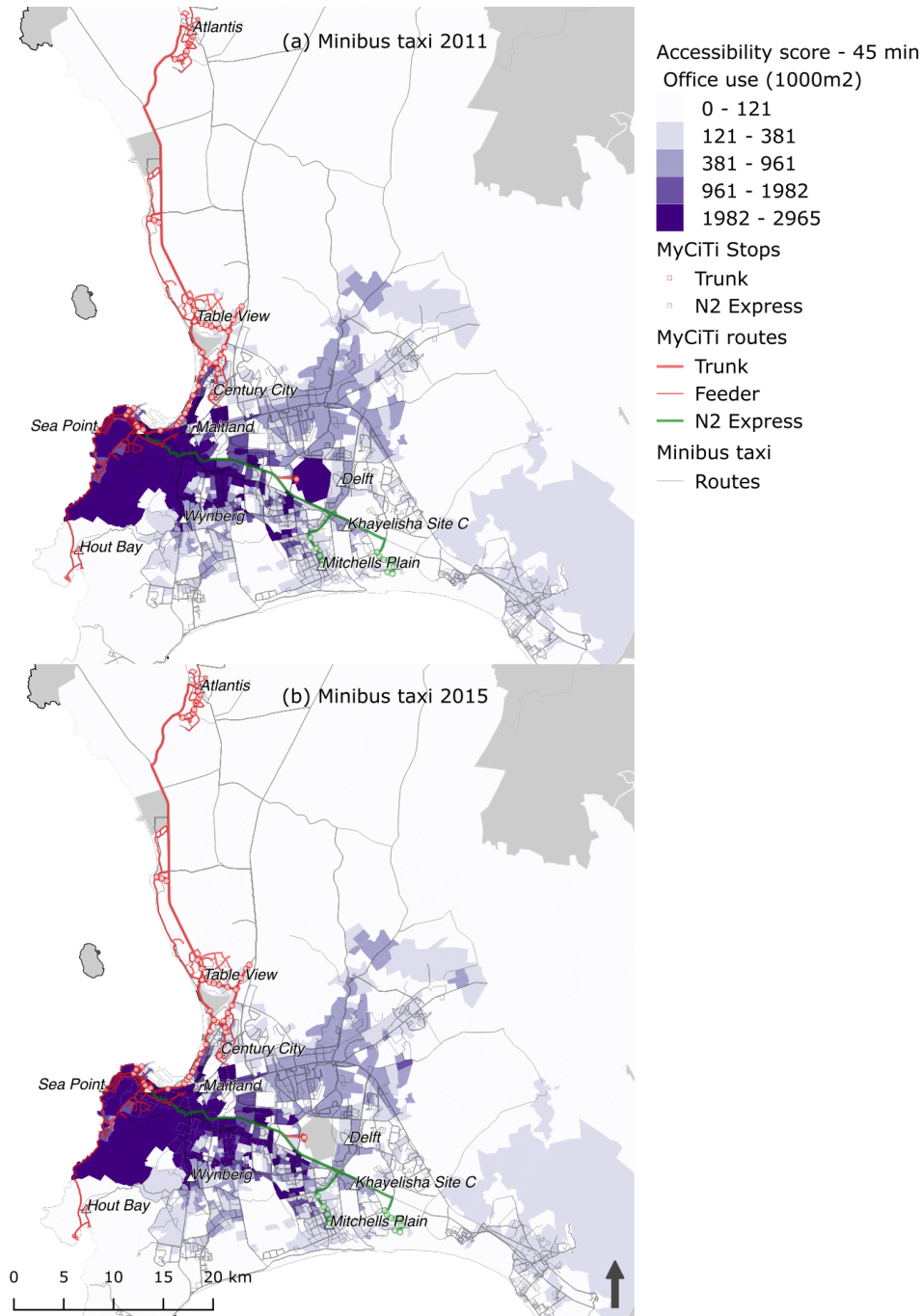
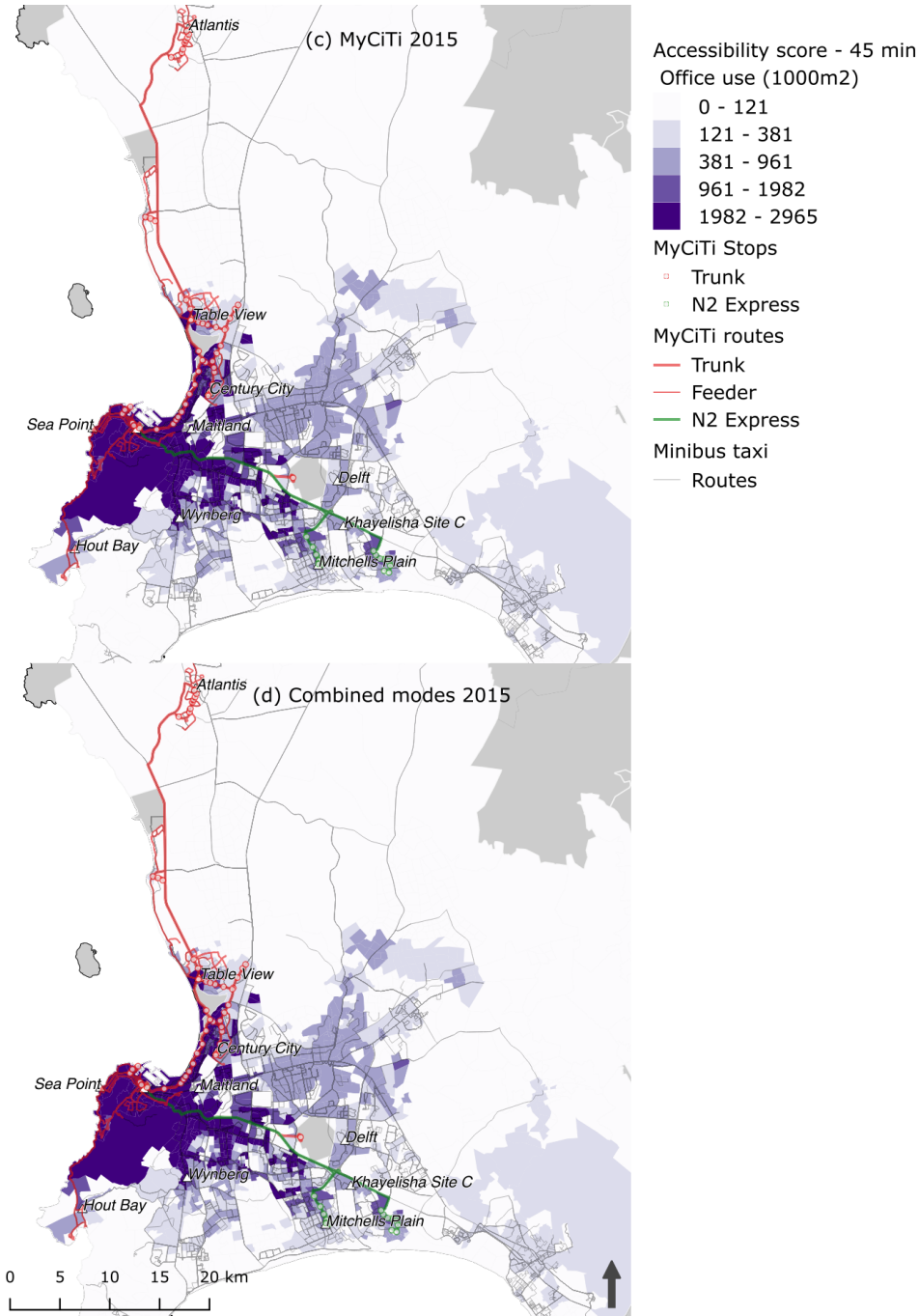


Figure 13: Accessibility scores to office uses within 45 min by minibus taxi in (a) 2011 and (b) 2015



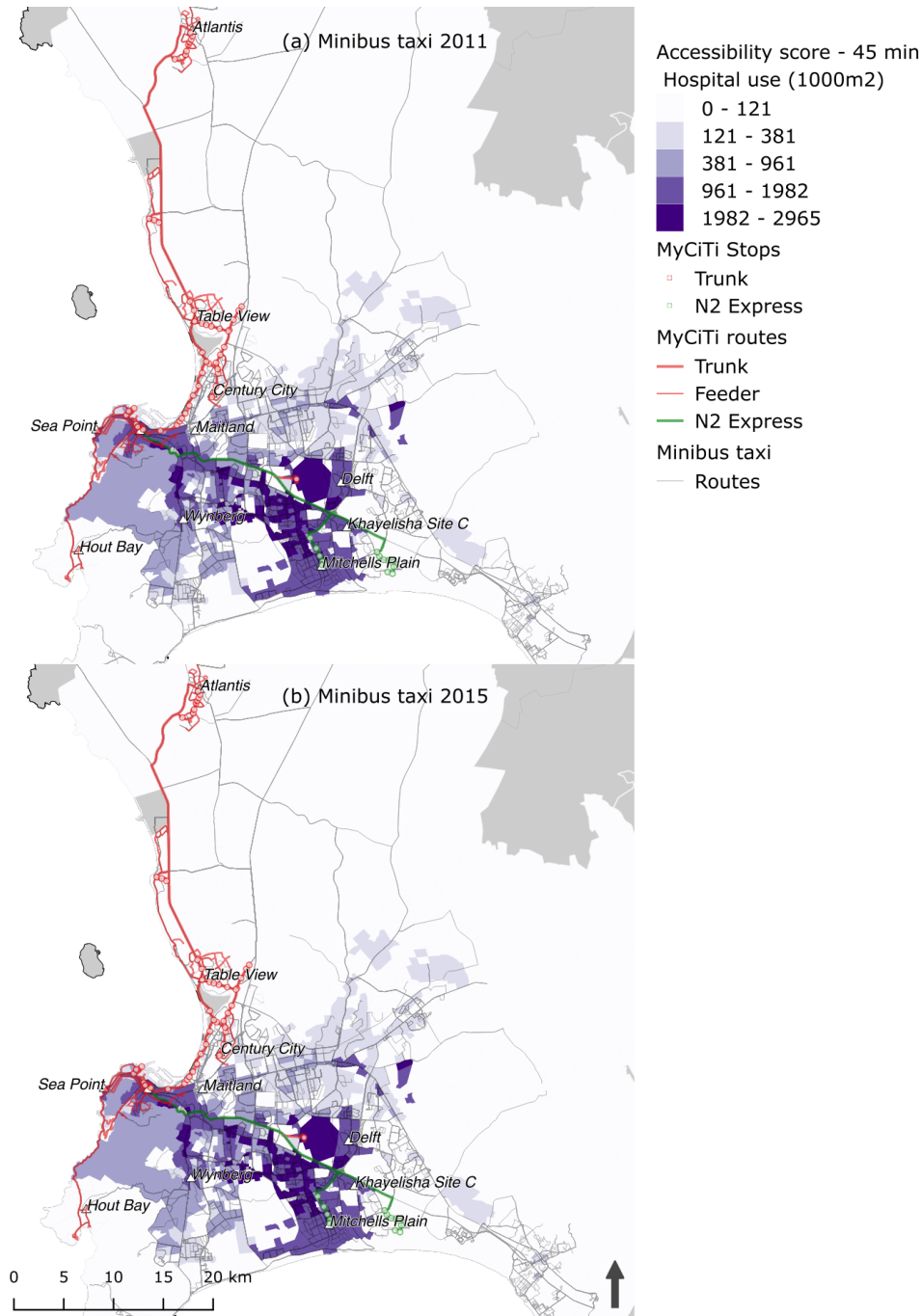
*Baseline values for taxi wait times*

Figure 14: Accessibility scores to office uses within 45 min by (c) MyCiTi in 2015 and (d) combined modes in 2015



*Baseline values for taxi wait times*

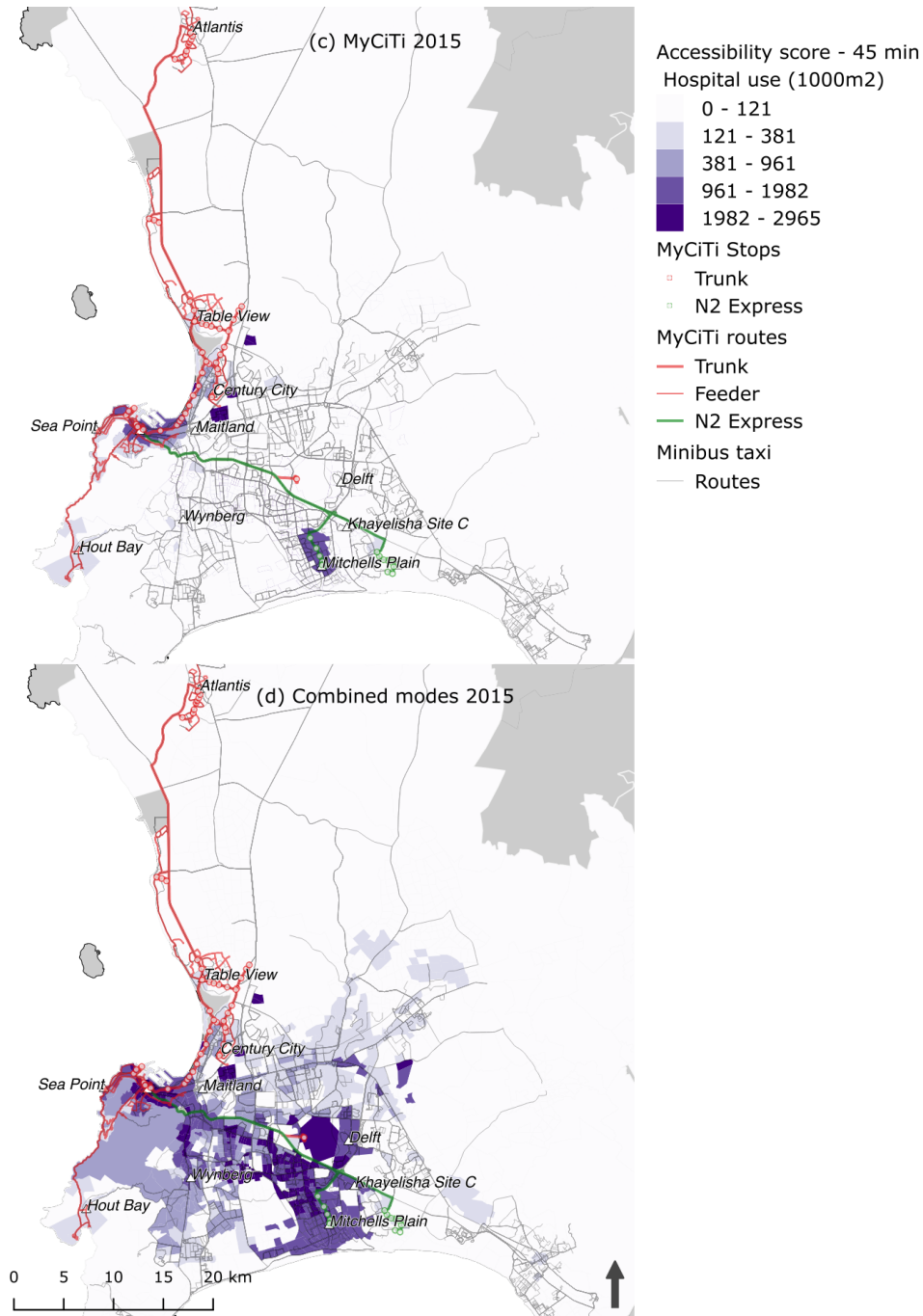
Figure 15: Accessibility scores to hospital uses within 45 min by minibus taxi in (a) 2011 and (b) 2015



*Baseline values for taxi wait times*



Figure 16: Accessibility scores to hospital uses within 45 min by (c) MyCiTi in 2015 and (d) combined modes in 2015



*Baseline values for taxi wait times*

Figure 17: Citywide accessibility scores by mode, assuming constant values for headway and wait time

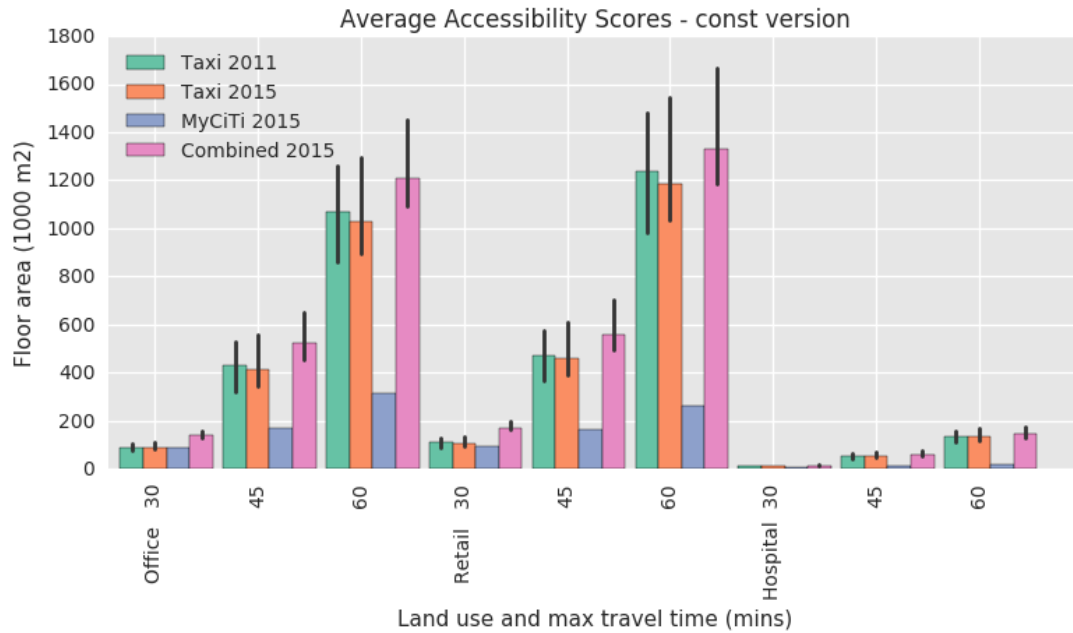


Figure 18: Accessibility scores by BRT area - Office space

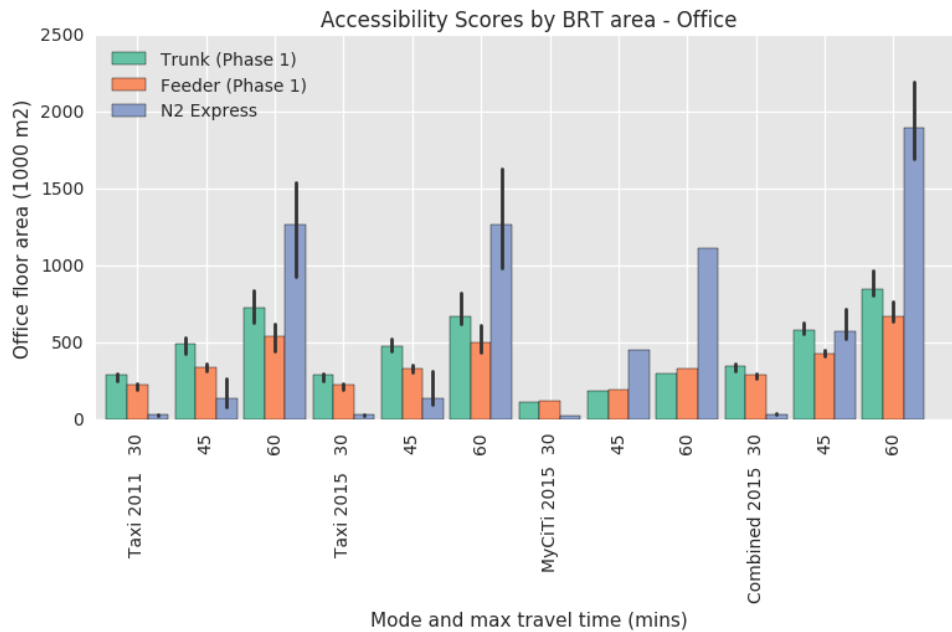


Figure 19: Accessibility scores by BRT area - Hospital space

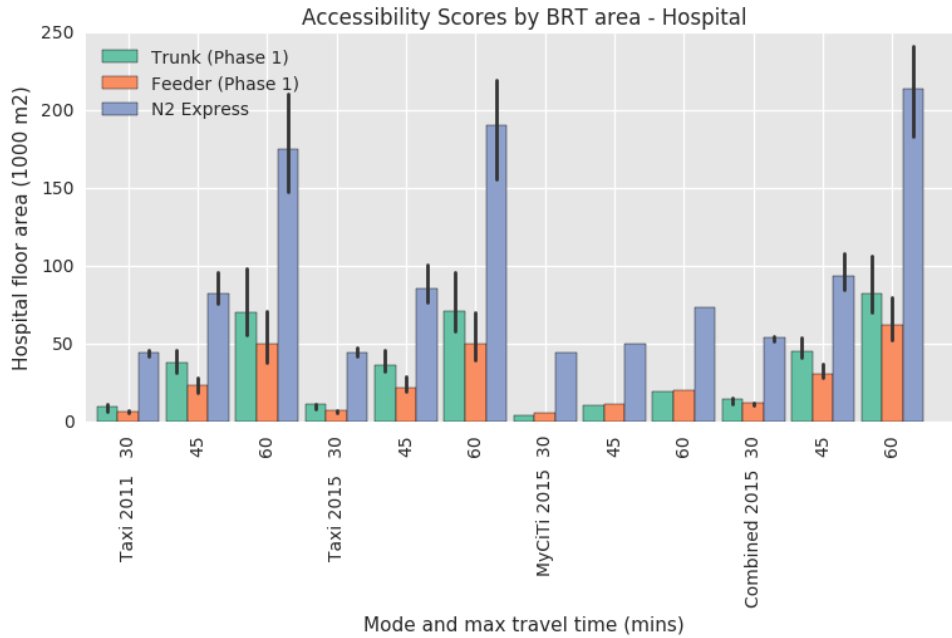


Figure 20: Accessibility scores by income - Office space

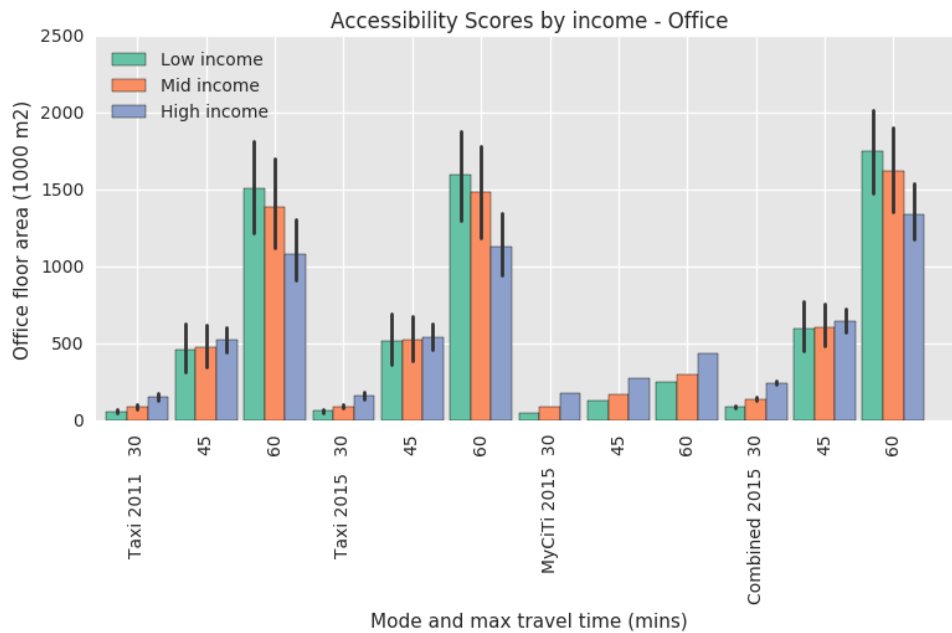


Figure 21: Accessibility scores by income - Hospital space

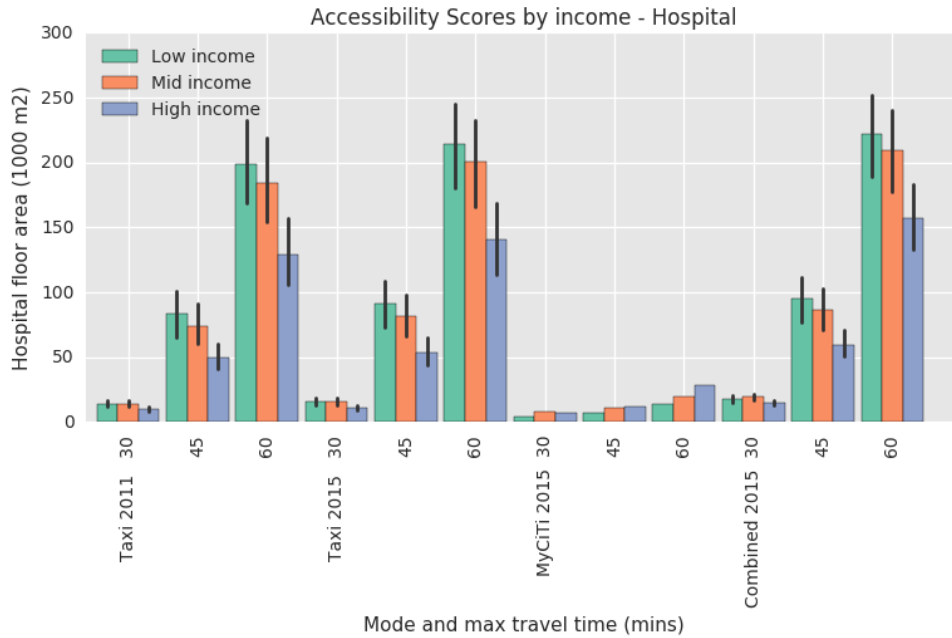


Figure 22: Accessibility scores by race - Office space

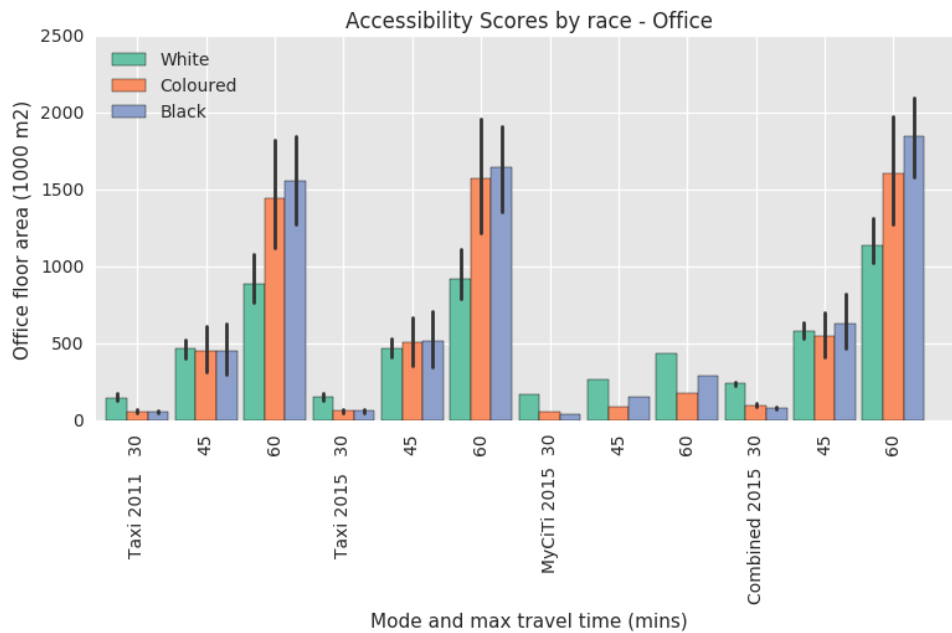


Figure 23: Accessibility scores by race - Hospital space

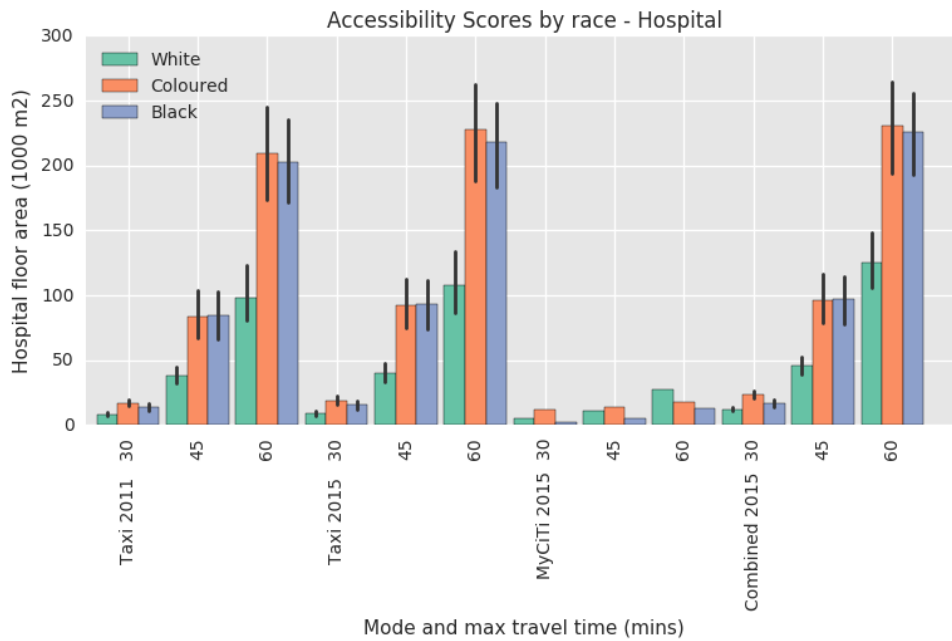
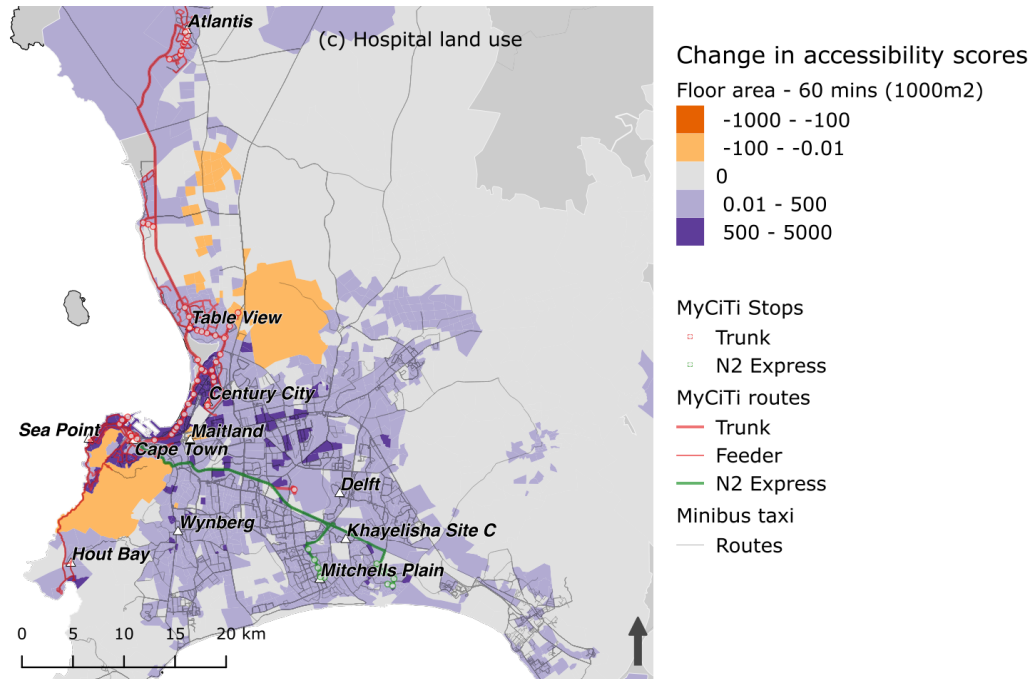


Figure 24: Change in accessibility scores for hospital use, 60 min



## Appendix B: Questionnaire

Questionnaire ID #: W-0-E-1701  
 Interviewer Initials: \_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/2015 Time: \_\_\_\_:\_\_\_\_  
 Location: \_\_\_\_\_

### WORK TRAVEL QUESTIONNAIRE

**PART A: CURRENT TRAVEL**

1. Where do you work or study? (The place you work most often. Be as specific as possible)

Address/ landmark:

Part of city:

2. Where do you live? (Primary residence. Be as specific as possible)

Address/ landmark:

Part of city:

3. How many days per week do you travel to work or study? (on average)

1    2    3    4    5    6    7

4. Do you usually make this trip from home to work/ study in the same way every day?

Yes, usually the same way  
 No, it depends on the day

5. What is the main way you make this trip? (choose the ONE you use for the LONGEST part of your trip)

MyCiTi bus    Train  
 Minibus taxi    Golden Arrow bus  
 Walk    Bicycle  
 Car as driver    Car as passenger  
 Other (specify) \_\_\_\_\_

6. For this same trip, do you use any other means of travel? (For example, how do you reach the train or bus? Choose ALL that apply.)

None    Train  
 MyCiTi bus    Golden Arrow bus  
 Minibus taxi    Bicycle  
 Walk    Car as driver    Car as passenger  
 Other (specify) \_\_\_\_\_

7. How long does this total trip take on a normal day?

minutes    Don't know

8. Do you have to change vehicles for this trip?

Yes    No    Don't know

**PART B: PREVIOUS TRAVEL**

*Think back to five years ago, in 2010. Remember that was the year of the World Cup.*

9. Have you moved since then?

Yes    No

-If Yes: where did you live in 2010? (Be as specific as possible)

Address/ landmark:

Part of city:

10. Did you travel for work or study in 2010?

Yes    No

-IF YES: Has your place of work/study changed since then?

Yes    No

-IF YES: Where did you work or study in 2010? (Be as specific as possible)

Address/ landmark:

Part of city:



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*Think about how you usually traveled from home to work/study in 2010. If your travel depended on the day, think about the trip you most often made.*

11. What is the main way you made this trip? (choose the ONE you use for the LONGEST part of your trip)

Train  
 Minibus taxi       Golden Arrow bus  
 Walk                       Bicycle  
 Car as driver       Car as passenger  
 Other (specify) \_\_\_\_\_  
 Don't know/Don't remember

12. For that same trip, did you use any other means of travel? (For example, how did you reach the train or bus? Choose ALL that apply.)

None  
 Train  
 Minibus taxi       Golden Arrow bus  
 Walk                       Bicycle  
 Car as driver       Car as passenger  
 Other (specify) \_\_\_\_\_  
 Don't know/Don't remember

13. How long did this total trip take on a normal day?

minutes       Don't know/Don't remember

14. Did you have to change vehicles for this trip?

Yes       No       Don't know/Don't remember

**PART C: COMPARISON**

15. Please think about how your travel to work/study has changed over the last five years, from 2010 to today.

How have the following changed, compared to 2010?

	Much worse	Worse	No change	Better	Much better	Don't know/ Not applicable
a. Comfort of trip	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Security from crime	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Safety from accidents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Affordability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Reliability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Ease of payment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**PART D: DEMOGRAPHICS**

16. In what range is your age?

20-34       35-59       60+  
 Prefer not to answer

17. How many vehicles are there at your household? (choose one)

none       1       2       3 or more

18. In 2010, How many vehicles were there at your household? (choose one)

none       1       2       3 or more

19. Do you have a MyCiti card?

Yes       No

20. How many people are in your household?

21. What is the highest level of education you have completed?

Less than primary       Secondary (Grade 10/12)  
 Primary                       Tertiary education  
 Prefer not to answer  
 Other (specify) \_\_\_\_\_

22. What is your household's total monthly income, before deductions?

No income                       R 6 401–R 12 800  
 R 1–R 400                       R 12 801–R 25 600  
 R 401–R 800                       R 25 601–R 51 200  
 R 801–R 1 600                       R 51 201–R 102 400  
 R 1 601–R 3 200                       R 102 401–R 204 800  
 R 3 201–R 6 400                       R 204 801 or more  
 Prefer not to answer       Don't know

23. Race of respondent:

Black African       White  
 Coloured       Indian/Asian  
 Other       Prefer not to answer

24. Gender of respondent:

Female       Male       Other

Questionnaire ID #: N-0-E-1701  
 Interviewer Initials: \_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/2015 Time: \_\_\_\_:\_\_\_\_  
 Location: \_\_\_\_\_

### NON-WORK TRAVEL QUESTIONNAIRE

**PART A: CURRENT TRAVEL**

1. Where do you live? (Primary residence. Be as specific as possible)  
 Address/landmark:   
 Part of city:

*Think about where you usually go to buy food/groceries. If you never shop for food or groceries, think about where you go to visit family or friends. If you usually go to more than one place, pick the one you went to most recently.*

2. This place is:  
 shop for food OR  visit people

3. What is the name and location of this place?  
 Name:   
 Location:   
 OR  
 I never shop for food or visit people --> [Skip to PART D]

*Think about how you usually travel from home to this place. If you travel in different ways, pick your most recent trip.*

4. What is the main way you make this trip? (choose the ONE you use for the LONGEST part of your trip)  
 MyCiTi bus       Train  
 Minibus taxi       Golden Arrow bus  
 Walk       Bicycle  
 Car as driver       Car as passenger  
 Other  
 (specify) \_\_\_\_\_

5. For this same trip, do you use any other means of travel? (For example, how do you reach the train or bus? Choose ALL that apply.)  
 None       Train  
 MyCiTi bus       Golden Arrow bus  
 Minibus taxi       Bicycle  
 Walk       Car as driver       Car as passenger  
 Other  
 (specify) \_\_\_\_\_

6. How long does this total trip take on a normal day?  
 minutes       Don't know

7. Do you have to change vehicles for this trip?  
 Yes       No       Don't know

**PART B: PREVIOUS TRAVEL**

*Think back to five years ago, in 2010. Remember that was the year of the World Cup.*

8. Have you moved since then?  
 Yes       No  
 -If Yes: where did you live in 2010? (be specific)

Address/landmark:   
 Part of city:

*-If answered "shop for food" above: Try to remember where you usually went to buy food in 2010.  
 -If answered "visit people" above: think about where you usually went to visit family or friends in 2010.  
 If you went to more than one place, pick the one you went to most often.*

9. What is the name and location of this place?  
 Same as above  
 OR  
 Name:   
 Location:



*Think about how you usually traveled from home to this place. If you traveled in more than one way, think about the one trip you made most often.*

10. What is the main way you made this trip? (choose the ONE you use for the LONGEST part of your trip)

Train  
 Minibus taxi  
 Walk  
 Car as driver  
 Don't know/Don't remember

Golden Arrow bus  
 Bicycle  
 Car as passenger

11. For that same trip, did you use any other means of travel? (For example, how did you reach the train or bus? Choose ALL that apply.)

None  
 Train  
 Minibus taxi  
 Walk  
 Car as driver  
 Other (specify) \_\_\_\_\_  
 Don't know/don't remember

Golden Arrow bus  
 Bicycle  
 Car as passenger

12. How long did this total trip take on a normal day?

minutes     Don't know/Don't remember

13. Did you have to change vehicles for this trip?

Yes     No     Don't know/Don't remember

**PART C: COMPARISON**

14. Please think about how your travel to buy food (or to visit people, if applicable) changed over the last five years, from 2010 to today. How have the following changed, compared to 2010?

	Much worse	Worse	No change	Better	Much better	Don't know/Not applicable
a. Comfort of trip	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Security from crime	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Safety from accidents	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Affordability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Reliability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Ease of payment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**PART D: DEMOGRAPHICS**

15. In what range is your age?

20-34     35-59     60+  
 Prefer not to answer

16. How many vehicles are there at your household? (choose one)

none     1     2     3 or more

17. In 2010, How many vehicles were there at your household? (choose one)

none     1     2     3 or more

18. Do you have a MyCiti card?

Yes     No

19. How many people are in your household?

20. What is the highest level of education you have completed?

Less than primary     Secondary (Grade 10/12)  
 Primary     Tertiary education  
 Prefer not to answer  
 Other (specify) \_\_\_\_\_

21. Do you work or study outside your home?

Yes     No     Prefer not to answer

22. What is your household's total monthly income, before deductions?

No income     R 6 401–R 12 800  
 R 1–R 400     R 12 801–R 25 600  
 R 401–R 800     R 25 601–R 51 200  
 R 801–R 1 600     R 51 201–R 102 400  
 R 1 601–R 3 200     R 102 401–R 204 800  
 R 3 201–R 6 400     R 204 801 or more  
 Prefer not to answer     Don't know

23. Race of respondent:

Black African     White  
 Coloured     Indian/Asian  
 Other     Prefer not to answer

24. Gender of respondent:

Female     Male     Other

# Bibliography

- Abrantes, Pedro A. L. and Mark Wardman (2011). “Meta-Analysis of UK Values of Travel Time: An Update”. In: *Transportation Research Part A: Policy and Practice* 45.1, pp. 1–17.
- Adhikari, Mohamed (2009). *Burdened by Race: Coloured Identities in Southern Africa*. en. Juta and Company Ltd.
- Afrika, Siphon (2016). *Personal Communication*.
- Albalade, Daniel, Germà Bel, and Joan Calzada (2012). “Governance and Regulation of Urban Bus Transportation: Using Partial Privatization to Achieve the Better of Two Worlds”. en. In: *Regulation & Governance* 6.1, pp. 83–100. (Visited on 05/06/2016).
- Ardila, Arturo (2008). “Limitation of Competition in and for the Public Transportation Market in Developing Countries: Lessons from Latin American Cities”. In: *Transportation Research Record: Journal of the Transportation Research Board* 2048, pp. 8–15. (Visited on 05/06/2016).
- Ardila-Gómez, Arturo (2004). “Transit Planning in Curitiba and Bogotá. Roles in Interaction, Risk, and Change. Diss. Massachusetts Institute of Technology, 2004.” Doctoral Dissertation. Cambridge, MA: Massachusetts Institute of Technology.
- Bargain, Olivier and Prudence Kwenda (2009). *The Informal Sector Wage Gap: New Evidence Using Quantile Estimations on Panel Data*. SSRN Scholarly Paper ID 1434620. Rochester, NY: Social Science Research Network. (Visited on 10/25/2016).
- Barter, Paul A. (2008). “Public Planning with Business Delivery of Excellent Urban Public Transport”. In: *Policy and Society* 27.2, pp. 103–114. (Visited on 05/06/2016).
- Bassier, Abdul (1989). “The Impact of Kombi-Taxis on Public Transport”. Master’s Thesis. Cape Town: University of Cape Town.
- (2016). *Personal Communication*.
- Beesley, M. E. and S. Glaister (1985). “Deregulating the Bus Industry in Britain—(C) a Response”. In: *Transport Reviews* 5.2. (Visited on 06/02/2016).
- Beesley, Michael (1989). “Bus Deregulation: Lessons from the UK”. In: Thredbo, Australia.
- Behrens, Roger, Dorothy McCormick, and David A. Mfinanga, eds. (2016). *Paratransit in African Cities*. New York: Routledge.
- Behrens, Roger and Romano Del Mistro (2010). “Shocking Habits: Methodological Issues in Analyzing Changing Personal Travel Behavior Over Time”. In: *International Journal of Sustainable Transportation* 4.5, pp. 253–271. (Visited on 08/02/2016).

- Ben-Akiva, Moshe and Steven Lerman (1985). *Discrete Choice Analysis: Theory and Application to Travel Demand*. Cambridge, MA: MIT Press.
- Berechman, Joseph (1983). "Costs, Economies of Scale and Factor Demand in Bus Transport: An Analysis". In: *Journal of Transport Economics and Policy* 17.1, pp. 7–24. (Visited on 05/09/2014).
- Bernardo, Carla (2016). *City of Cape Town Rated the Best Financially Managed Metro — IOL*. <http://www.iol.co.za/capetimes/city-of-cape-town-rated-the-best-financially-managed-metro-2012286>. (Visited on 02/22/2017).
- Besteman, Catherine Lowe (2008). *Transforming Cape Town*. en. University of California Press.
- Beukes, Eddie (2015). *Personal Communication*.
- Bly, P. H. and R. H. Oldfield (1986). "Competition between Minibuses and Regular Bus Services". In: *Journal of Transport Economics and Policy* 20.1, pp. 47–68. (Visited on 10/18/2016).
- Bocarejo, Juan Pablo and Daniel Ricardo Oviedo (2012). "Transport Accessibility and Social Inequities: A Tool for Identification of Mobility Needs and Evaluation of Transport Investments". In: *Journal of Transport Geography*. Special Section on Theoretical Perspectives on Climate Change Mitigation in Transport 24, pp. 142–154. (Visited on 01/31/2017).
- Börjesson, Maria (2012). "Valuing Perceived Insecurity Associated with Use of and Access to Public Transport". In: *Transport Policy* 22.Supplement C, pp. 1–10.
- Bornman, Elirea (2010). "Emerging Patterns of Social Identification in Postapartheid South Africa". en. In: *Journal of Social Issues* 66.2, pp. 237–254. (Visited on 08/19/2016).
- Botha, Thabiso (2015). *Personal Communication*.
- Burkhardt, Jon E. (1969). *The Transportation Needs of the Rural Poor*. Tech. rep. U.S. Bureau of Public Roads.
- Caldeira, T. (2001). *City of Walls: Crime, Segregation, and Citizenship in São Paulo*. University of California Press.
- Carrion, Carlos and David Levinson (2012). "Value of Travel Time Reliability: A Review of Current Evidence". In: *Transportation Research Part A: Policy and Practice* 46.4, pp. 720–741.
- Cervero, Robert (2000). *Informal Transport in the Developing World*. UN-Habitat.
- Cervero, Robert and Aaron Golub (2007). "Informal Transport: A Global Perspective". In: *Transport Policy* 14.6, pp. 445–457. (Visited on 04/03/2014).
- Chavis, Celeste and Carlos F. Daganzo (2013). "Analyzing the Structure of Informal Transit: The Evening Commute Problem". In: *Research in Transportation Economics*. THREDBO 12: Recent developments in the reform of land passenger transport 39.1, pp. 277–284. (Visited on 09/04/2014).
- Chiguvare, Bernard (2016). *Taxi Industry Shrugs off Minimum Wage*. <http://www.groundup.org.za/article/taxi-industry-shrugs-minimum-wage/>. (Visited on 07/29/2016).
- Christopher, A. J. (2005). "The Slow Pace of Desegregation in South African Cities, 1996–2001". en. In: *Urban Studies* 42.12, pp. 2305–2320. (Visited on 02/27/2015).

- City of Cape Town (2007). *Five-Year Plan for Cape Town - Integrated Development Plan 2007/8-2011/12*. Tech. rep. Cape Town: City of Cape Town.
- (2009). *Integrated Transport Plan 2006-2011 Review 2009*. Tech. rep. Cape Town: City of Cape Town.
- (2010). *Business Plan for Phase 1A of Cape Town's MyCiTi Integrated Rapid Transit System*. Tech. rep. Cape Town: City of Cape Town.
- (2012). *2012 MyCiTi Business Plan: Phases 1A, 1B and N2 Express of Cape Town's MyCiTi IRT System*. Tech. rep. Cape Town: City of Cape Town.
- (2015). *City to Withdraw Remainder of Minibus-Taxis Affected by MyCiTi Phase 1*. <https://www.tda.gov.za/en/news-and-events/press-releases/articles/city-withdraws-minibus-taxis-myciti/article-copy/>. (Visited on 12/07/2017).
- Clark, Nancy L. and William H. Worger (2004). *South Africa: The Rise and Fall of Apartheid*. en. Longman.
- Cohn, Nick (2014). “TomTom Traffic Index: Toward a Global Measure”. In: *44ème Congrès ATEC ITS France*. Paris.
- Combs, Tabitha S. (2017). “Examining Changes in Travel Patterns among Lower Wealth Households after BRT Investment in Bogotá, Colombia”. In: *Journal of Transport Geography* 60, pp. 11–20. (Visited on 02/23/2017).
- Committee of Transport Officials (2012). *TRH 26: South African Road Classification and Access Management Manual*. Tech. rep. Pretoria, South Africa: The South African National Roads Agency Limited.
- Cook, Gillian P. (1992). “Khayelitsha: New Settlement Forms in the Cape Peninsula”. In: *The Apartheid City and Beyond: Urbanization and Social Change in South Africa*. Ed. by David M Smith. London; New York: Routledge, pp. 125–135.
- Crankshaw, Owen (2012). “Deindustrialization, Professionalization and Racial Inequality in Cape Town”. en. In: *Urban Affairs Review* 48.6, pp. 836–862. (Visited on 08/09/2016).
- Crowley, Kevin (2015). “South Africa Risks Water Shortages as Drought Cuts Reserves”. In: *Bloomberg.com*. (Visited on 11/30/2017).
- De Soto, H. (2000). *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. New York: Basic Books.
- Delmelle, Elizabeth Cahill and Irene Casas (2012). “Evaluating the Spatial Equity of Bus Rapid Transit-Based Accessibility Patterns in a Developing Country: The Case of Cali, Colombia”. In: *Transport Policy* 20, pp. 36–46.
- Deng, Taotao and John D. Nelson (2010). “Recent Developments in Bus Rapid Transit: A Review of the Literature”. In: *Transport Reviews* 31.1, pp. 69–96. (Visited on 09/04/2014).
- Department of Transport (2007). *Public Transport Strategy*. Tech. rep. South Africa Department of Transport.
- Dillman, Don A., Jolene D. Smyth, and Leah Melani Christian (2014). *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. en. John Wiley & Sons.
- DTI (2003). *A Strategy for Broad-Based Black Economic Empowerment*. Tech. rep. Pretoria: Department of Trade and Industry.

- Dugard, Jackie (2001). "From Low Intensity War to Mafia War: Taxi Violence in South Africa (1987 - 2000)". In: *Violence and Transition Series* 4. (Visited on 07/05/2016).
- Echeverry, Juan Carlos et al. (2005). "The Economics of TransMilenio, a Mass Transit System for Bogotá [with Comments]". In: *Economia* 5.2, pp. 151–196. (Visited on 10/03/2014).
- EMBARQ (2016). *Global BRT Data*. <http://www.brtdata.org/>. (Visited on 06/14/2016).
- England, Andrew (2014). *Worsening Electricity Crisis Adds to South Africa's Economic Woos*. <https://www.ft.com/content/69aa4a9e-7f89-11e4-b4f5-00144feabdc0>. (Visited on 11/30/2017).
- Ernst, John (2005). "Initiating Bus Rapid Transit in Jakarta, Indonesia". In: *Transportation Research Record: Journal of the Transportation Research Board* 1903, pp. 20–26. (Visited on 10/03/2014).
- Estache, Antonio and Andrés Gómez-Lobo (2005). "Limits to Competition in Urban Bus Services in Developing Countries". In: *Transport Reviews* 25.2, pp. 139–158. (Visited on 05/06/2015).
- Estupiñán, Nicolás et al. (2013). *Motorcycle Ownership and Use: The Case of Latin America*. Tech. rep. CAF- Development Bank of Latin America. (Visited on 12/01/2017).
- Farrell, C. R. (2008). "Bifurcation, Fragmentation or Integration? The Racial and Geographical Structure of US Metropolitan Segregation, 1990-2000". In: *Urban Studies* 45.3, pp. 467–499.
- Fernández Koprach, Daniel (1994). "The Modernization of Santiago's Public Transport: 1990–1992". In: *Transport Reviews* 14.2, pp. 167–185. (Visited on 11/02/2016).
- Fernández, J. Enrique and Juan Carlos Muñoz (2007). "Privatisation and Deregulation of Urban Bus Services: An Analysis of Fare Evolution Mechanisms". In: *Journal of Transport Economics and Policy* 41.1, pp. 25–49. (Visited on 05/06/2016).
- Figuroa, Oscar (2013). "Four Decades of Changing Transport Policy in Santiago, Chile". In: *Research in Transportation Economics*. Urban Transport in Developing Countries: CODATU Special Issue 40.1, pp. 87–95. (Visited on 11/03/2016).
- Finn, Brendan (2008). "Market Role and Regulation of Extensive Urban Minibus Services as Large Bus Service Capacity Is Restored – Case Studies from Ghana, Georgia and Kazakhstan". In: *Research in Transportation Economics*. Reforms in Public Transport 22.1, pp. 118–125. (Visited on 10/19/2016).
- (2012). "Towards Large-Scale Flexible Transport Services: A Practical Perspective from the Domain of Paratransit". In: *Research in Transportation Business & Management*. Flexible Transport Services 3, pp. 39–49. (Visited on 10/03/2014).
- Flores Dewey, Onésimo A. (Onésimo Alberto) (2013). "Expanding Transportation Planning Capacity in Cities of the Global South : Public-Private Collaboration and Conflict in Chile and Mexico". eng. Thesis (Ph. D. in Urban and Regional Planning)–Massachusetts Institute of Technology, Dept. of Urban Studies and Planning, 2013. Thesis. Massachusetts Institute of Technology. (Visited on 06/27/2014).
- Foth, Nicole, Kevin Manaugh, and Ahmed M. El-Geneidy (2013). "Towards Equitable Transit: Examining Transit Accessibility and Social Need in Toronto, Canada, 1996–2006". In: *Journal of Transport Geography* 29, pp. 1–10. (Visited on 11/23/2016).

- Freemantle, Iriann (2015). *Mobility and Anti-Outsider Sentiment in Informal Settlements: Blind Spots in South Africa's Social Cohesion Strategy*. Tech. rep. Johannesburg: African Centre for Migration and Society, Wits University.
- Galster, George and Erin Godfrey (2005). "By Words and Deeds: Racial Steering by Real Estate Agents in the US in 2000". In: *Journal of the American Planning Association* 71.3, pp. 251–268.
- El-Geneidy, Ahmed M. and David M. Levinson (2006). "Access to Destinations: Development of Accessibility Measures". In: (visited on 11/23/2016).
- Geurs, Karst T and Bert van Wee (2004). "Accessibility Evaluation of Land-Use and Transport Strategies: Review and Research Directions". In: *Journal of Transport Geography* 12, pp. 127–140.
- Geyer, H. S. and Faizel Mohammed (2015). "Hypersegregation and Class-Based Segregation Processes in Cape Town 2001–2011". en. In: *Urban Forum* 27.1, pp. 35–58. (Visited on 08/09/2016).
- Gilbert, Alan (2008). "Bus Rapid Transit: Is Transmilenio a Miracle Cure?" In: *Transport Reviews* 28.4, pp. 439–467. (Visited on 01/30/2015).
- Glaister, Stephen (1985). "Competition on an Urban Bus Route". In: *Journal of Transport Economics and Policy* 19.1, pp. 65–81. (Visited on 02/16/2015).
- Goldwyn, Eric (2016). "A Transit System Hiding in Plain Sight". Doctoral Dissertation. New York: Columbia University.
- Golub, Aaron and Karel Martens (2014). "Using Principles of Justice to Assess the Modal Equity of Regional Transportation Plans". In: *Journal of Transport Geography* 41, pp. 10–20. (Visited on 08/26/2014).
- Gomez-Ibanez, Jose A. and J. R. Meyer (1993). "Going Private. The International Experience with Transport Privatization". In: (visited on 04/07/2014).
- Gómez-Lobo, Andrés (2007). "Why Competition Does Not Work in Urban Bus Markets: Some New Wheels for Some Old Ideas". In: *Journal of Transport Economics and Policy* 41.2, pp. 283–308. (Visited on 05/06/2016).
- Grengs, Joe (2015). "Nonwork Accessibility as a Social Equity Indicator". In: *International Journal of Sustainable Transportation* 9.1, pp. 1–14. (Visited on 12/08/2016).
- Grey, Peter (2015). *Personal Communication*.
- Gronau, Reuben (2000). "Optimum Diversity in the Public Transport Market". In: *Journal of Transport Economics and Policy* 34.1, pp. 21–41. (Visited on 02/16/2015).
- Guerra, Erick and John Taylor (2017). "Bus Rapid Transit Gone Awry in Solo, Indonesia? Lessons for Sustainable Transportation in a Motorcycle City". In: (visited on 11/28/2017).
- Gwilliam, Ken (2008a). "A Review of Issues in Transit Economics". In: *Research in Transportation Economics*. Transit Economics 23.1, pp. 4–22. (Visited on 05/01/2014).
- (2008b). "Bus Transport: Is There a Regulatory Cycle?" In: *Transportation Research Part A: Policy and Practice*. Institutional Reform in Land Passenger Transport 42.9, pp. 1183–1194. (Visited on 05/06/2015).



- Hagen, Jonas Xaver, CarlosFelipe Pardo, and Johanna Burbano Valente (2016). "Motivations for Motorcycle Use for Urban Travel in Latin America: A Qualitative Study". In: *Transport Policy* 49.Supplement C, pp. 93–104. (Visited on 12/01/2017).
- Handy, Susan L and D A Niemeier (1997). "Measuring Accessibility: An Exploration of Issues and Alternatives". In: *Environment and Planning A* 29.7, pp. 1175–1194.
- Hansen, Walter G. (1959). "How Accessibility Shapes Land Use". In: *Journal of the American Institute of Planners* 25.2, pp. 73–76. (Visited on 11/26/2016).
- Hart, Keith (1970). "Small-scale Entrepreneurs in Ghana and Development Planning". In: *The Journal of Development Studies* 6.4, pp. 104–120. (Visited on 04/28/2016).
- (1973). "Informal Income Opportunities and Urban Employment in Ghana". In: *The Journal of Modern African Studies* 11.01, pp. 61–89. (Visited on 04/28/2016).
- Hauser, Edwin W., FHA, and Research Triangle Institute (1974). *The Use of Existing Facilities for Transporting Disadvantaged Residents of Rural Areas*. Tech. rep. Washington, D.C.: Federal Highway Administration.
- Hensher, David A. (2007). "Sustainable Public Transport Systems: Moving towards a Value for Money and Network-Based Approach and Away from Blind Commitment". In: *Transport Policy* 14.1, pp. 98–102. (Visited on 05/06/2016).
- Hensher, David A. and John Stanley (2010). "Contracting Regimes for Bus Services: What Have We Learnt after 20 Years?" In: *Research in Transportation Economics*. Reforming Public Transport throughout the World 29.1, pp. 140–144. (Visited on 11/04/2016).
- Hensher, David A. and Ian P. Wallis (2005). "Competitive Tendering as a Contracting Mechanism for Subsidising Transport: The Bus Experience". In: *Journal of Transport Economics and Policy (JTEP)* 39.3, pp. 295–322.
- Herron, Brett (2016). *Personal Communication*.
- Hidalgo, Dario (2001). "Transmilenio: El Sistema de Transporte Masivo de Bogotá". In: *Planeación y Desarrollo* 32, pp. 173–186.
- Hidalgo, Dario and Aileen Carrigan (2010). *Modernizing Public Transportation, Lessons Learned from Major Bus Improvements in Latin America and Asia*. Tech. rep. Washington, D.C.: World Resources Institute.
- Hidalgo, Dario and Pierre Graftieaux (2008). "Bus Rapid Transit Systems in Latin America and Asia: Results and Difficulties in 11 Cities". In: *Transportation Research Record: Journal of the Transportation Research Board* 2072, pp. 77–88. (Visited on 11/09/2016).
- Hidalgo, Dario and Luis Gutierrez (2013). "BRT and BHLS around the World: Explosive Growth, Large Positive Impacts and Many Issues Outstanding". In: *Research in Transportation Economics*. THREDBO 12: Recent developments in the reform of land passenger transport 39.1, pp. 8–13. (Visited on 11/09/2016).
- Hidalgo, Dario and Gabrielle Hermann (2004). "The Bogotá Model for Sustainable Transportation; Inspiring Developing Cities throughout the World". In: *Dialog* 82, pp. 11–15.
- Hidalgo, Dario and Cornie Huizenga (2013). "Implementation of Sustainable Urban Transport in Latin America". In: *Research in Transportation Economics*. Urban Transport in Developing Countries: CODATU Special Issue 40.1, pp. 66–77. (Visited on 08/05/2014).

- Hidalgo, Dario and Robin King (2014). “Public Transport Integration in Bogotá and Cali, Colombia – Facing Transition from Semi-Deregulated Services to Full Regulation City-wide”. In: *Research in Transportation Economics*. Competition and Ownership in Land Passenger Transport (selected papers from the Thredbo 13 conference) 48. Supplement C, pp. 166–175. (Visited on 11/29/2017).
- Hidalgo, Dario, Liliana Pereira, et al. (2013). “TransMilenio BRT System in Bogota, High Performance and Positive Impact – Main Results of an Ex-Post Evaluation”. en. In: *Research in Transportation Economics* 39.1, pp. 133–138. (Visited on 07/25/2016).
- Holderness, Claire (2016). *Personal Communication*.
- Hollingworth, Brian and Eric Miller (1996). “Retrospective Interviewing and Its Application in Study of Residential Mobility”. In: *Transportation Research Record: Journal of the Transportation Research Board* 1551, pp. 74–81. (Visited on 08/26/2014).
- Hook, Walter (2005). “Institutional and Regulatory Options for Bus Rapid Transit in Developing Countries: Lessons from International Experience”. In: *Transportation Research Record: Journal of the Transportation Research Board* 1939, pp. 184–191. (Visited on 10/03/2014).
- Hunter van Ryneveld (2014). *Expenditure and Performance Review of South Africa’s Public Transport and Infrastructure System*. Tech. rep. Cape Town: Presidency and National Treasury.
- Institute of Public Administration (1975). *Transportation Service for the Elderly: Planning Handbook*. Tech. rep.
- International Labour Office (1973). *Employment, Incomes and Equality: A Strategy for Increasing Productive Employment in Kenya; Report of an Inter-Agency Team Financed by the United Nations Development Programme*. Tech. rep. International Labour Office.
- ITDP (2013). *The BRT Standard 2013*. Tech. rep. New York: Institute for Transportation and Development Policy.
- Joewono, Tri Basuki and Hisashi Kubota (2007). “User Satisfaction with Paratransit in Competition with Motorization in Indonesia: Anticipation of Future Implications”. en. In: *Transportation* 34.3, pp. 337–354. (Visited on 09/08/2014).
- Kahn, Alfred E. (1988). *The Economics of Regulation: Principles and Institutions*. MIT Press Books. The MIT Press. (Visited on 04/03/2014).
- Kash, Gwen and Dario Hidalgo (2014). “The Promise and Challenges of Integrating Public Transportation in Bogotá, Colombia”. en. In: *Public Transport* 6.1-2, pp. 107–135. (Visited on 11/28/2017).
- Kaufmann, Daniel, Aart Kraay, and Massimo Mastruzzi (2011). “The Worldwide Governance Indicators: Methodology and Analytical Issues”. en. In: *Hague Journal on the Rule of Law* 3.2, pp. 220–246. (Visited on 02/21/2017).
- Kerr, Andrew (2016). *Personal Communication*.
- Khosa, Meshack M. (1992). “Routes, Ranks and Rebels: Feuding in the Taxi Revolution”. In: *Journal of Southern African Studies* 18.1, pp. 232–251. (Visited on 05/12/2015).
- (1995). “Transport and Popular Struggles in South Africa”. en. In: *Antipode* 27.2, pp. 167–188. (Visited on 05/05/2015).

- Khosa, Meshack M. (1998). “‘The Travail of Travelling’: Urban Transport in South Africa, 1930–1996”. In: *Transport Reviews* 18.1, pp. 17–33. (Visited on 05/05/2015).
- Kumar, Ajay, S Zimmerman, and O.P. Agarwal (2012). *International Experience in Bus Rapid Transit (BRT) Implementation: Synthesis of Lessons Learned from Lagos, Johannesburg, Jakarta, Delhi, and Ahmedabad*. Tech. rep. Washington, D.C.: World Bank.
- Leggett, Ted (2006). “WHAT’S UP IN THE CAPE? Crime Rates in Western and Northern Cape Provinces”. In: *South African Crime Quarterly* 7.
- Lemanski, Charlotte L. (2006). “Desegregation and Integration as Linked or Distinct? Evidence from a Previously ‘White’ Suburb in Post-Apartheid Cape Town”. en. In: *International Journal of Urban and Regional Research* 30.3, pp. 564–586. (Visited on 08/09/2016).
- Levine, Jonathan et al. (2012). “Does Accessibility Require Density or Speed?” In: *Journal of the American Planning Association* 78.2, pp. 157–172.
- Levinson, H et al. (2003). *Bus Rapid Transit, Volume 1: Case Studies in Bus Rapid Transit*. Tech. rep. Washington, DC: Transportation Research Board.
- Lewis, Anél (2014). *Cape Town Tops Service Delivery Survey — IOL*. <http://www.iol.co.za/news/politics/cape-town-tops-service-delivery-survey-1683455>. (Visited on 02/22/2017).
- Lindau, Luis Antonio, Dario Hidalgo, and Daniela Facchini (2010). “Curitiba, the Cradle of Bus Rapid Transit”. In: *Built Environment* 36.3, pp. 274–282.
- Liu, Gang (2007). “A Behavioral Model of Work-Trip Mode Choice in Shanghai”. In: *China Economic Review* 18.4, pp. 456–476.
- Lucas, Karen, Bert van Wee, and Kees Maat (2016). “A Method to Evaluate Equitable Accessibility: Combining Ethical Theories and Accessibility-Based Approaches”. en. In: *Transportation* 43.3, pp. 473–490. (Visited on 12/08/2016).
- Mabin, Alan (1992). “Dispossession, Exploitation and Struggle: An Historical Overview of South African Urbanization”. In: *The Apartheid City and Beyond: Urbanization and Social Change in South Africa*. Ed. by David M Smith. London; New York: Routledge, pp. 13–24.
- Mackie, Peter, John Preston, and Chris Nash (1995). “Bus Deregulation: Ten Years On”. In: *Transport Reviews* 15.3, pp. 229–251. (Visited on 05/06/2015).
- Marcouiller, Douglas, Veronica Ruiz de Castilla, and Christopher Woodruff (1997). “Formal Measures of the Informal-Sector Wage Gap in Mexico, El Salvador, and Peru”. In: *Economic Development and Cultural Change* 45.2, pp. 367–392. (Visited on 10/25/2016).
- Massey, Douglas S. and Nancy A. Denton (1993). *American Apartheid: Segregation and the Making of the Underclass*. Harvard University Press.
- Mazaza, Maddie (2016). *Personal Communication*.
- McCormick, Dorothy, Herrie Schalekamp, and David A. Mfinanga (2016). “The Nature of Paratransit Operations”. In: *Paratransit in African Cities*. Ed. by Roger Behrens, Dorothy McCormick, and David A. Mfinanga. New York: Routledge, pp. 59–78.
- Molefe, Thabang (2015). *Personal Communication*.

- Monson, Tamlyn (2015). "Everyday Politics and Collective Mobilization against Foreigners in a South African Shack Settlement". In: *Africa* 85.01, pp. 131–153. (Visited on 08/16/2016).
- Montero, Sergio (2016). "Study Tours and Inter-City Policy Learning: Mobilizing Bogotá's Transportation Policies in Guadalajara". en. In: *Environment and Planning A*. (Visited on 11/08/2016).
- Moser, Caroline O. N. (1978). "Informal Sector or Petty Commodity Production: Dualism or Dependence in Urban Development?" In: *World Development* 6.9–10, pp. 1041–1064. (Visited on 12/02/2015).
- Moss, Louis and Harvey Goldstein, eds. (1979). *The Recall Method in Social Surveys. Vol. 9. William Heinemann Limited, 1979*. London: University of London Institute of Education.
- Mukhija, Vinit and Anastasia Loukaitou-Sideris (2014). *The Informal American City: Beyond Taco Trucks and Day Labor*. en. MIT Press.
- (2015). "Reading the Informal City Why and How to Deepen Planners' Understanding of Informality". en. In: *Journal of Planning Education and Research* 35.4, pp. 444–454. (Visited on 11/16/2015).
- Munoz-Raskin, Ramon (2010). "Walking Accessibility to Bus Rapid Transit: Does It Affect Property Values? The Case of Bogotá, Colombia". In: *Transport Policy* 17.2, pp. 72–84. (Visited on 01/29/2015).
- National Transport Policy Forum (1994). *Transport Policy, Fifth Draft*. Tech. rep. Johannesburg: National Transport Policy Forum.
- NDoT (2007). *Public Transport Strategy*. Pretoria, South Africa.
- Neutens, Tijs et al. (2010). "Equity of Urban Service Delivery: A Comparison of Different Accessibility Measures". In: *Environment and Planning A* 42, pp. 1613–1635.
- Nyoka, Babalwa (2015). *Personal Communication*.
- (2016). *Personal Communication*.
- Obeng, Kofi (1985). "Bus Transit Cost, Productivity and Factor Substitution". In: *Journal of Transport Economics and Policy* 19.2, pp. 183–203. (Visited on 10/26/2016).
- Oldfield, Sophie (2004). "Urban Networks, Community Organising and Race: An Analysis of Racial Integration in a Desegregated South African Neighbourhood". In: *Geoforum*. Themed Section on: Differentiation in South Africa and Indian Cities 35.2, pp. 189–201. (Visited on 08/18/2016).
- Onishi, Norimitsu (2015). "Jacob Zuma Appoints Third Finance Minister of South Africa in a Week". en-US. In: *The New York Times*. (Visited on 11/30/2017).
- Otter, Steven (2016). *Personal Communication*.
- Paget-Seekins, Laurel, Onesimo Flores Dewey, and Juan Carlos Muñoz (2015). "Examining Regulatory Reform for Bus Operations in Latin America". In: *Urban Geography* 36.3, pp. 424–438. (Visited on 09/14/2015).
- Paget-Seekins, Laurel and Manuel Tironi (2016). "The Publicness of Public Transport: The Changing Nature of Public Transport in Latin American Cities". In: *Transport Policy* 49, pp. 176–183. (Visited on 05/11/2016).
- Parliament of South Africa (1950a). *Group Areas Act, 1950*.

- Parliament of South Africa (1950b). *Population Registration Act, 1950*.
- (1952). *Natives (Abolition of Passes and Co-Ordination of Documents) Act, 1952*.
- Parry, Kevin and Amanda van Eeden (2015). “Measuring Racial Residential Segregation at Different Geographic Scales in Cape Town and Johannesburg”. In: *South African Geographical Journal* 97.1, pp. 31–49. (Visited on 08/09/2016).
- Peattie, Lisa (1987). “An Idea in Good Currency and How It Grew: The Informal Sector”. In: *World Development* 15.7, pp. 851–860. (Visited on 12/02/2015).
- Portes, Alejandro (1983). “The Informal Sector”. In: *Review* 7.1, pp. 151–174.
- Portes, Alejandro and Saskia Sassen-Koob (1987). “Making It Underground: Comparative Material on the Informal Sector in Western Market Economies”. In: *American Journal of Sociology* 93.1, pp. 30–61. (Visited on 12/02/2015).
- Preston, John and Talal Almutairi (2013). “Evaluating the Long Term Impacts of Transport Policy: An Initial Assessment of Bus Deregulation”. In: *Research in Transportation Economics*. THREDBO 12: Recent developments in the reform of land passenger transport 39.1, pp. 208–214. (Visited on 11/04/2016).
- Rakowski, Cathy A. (1994). “Convergence and Divergence in the Informal Sector Debate: A Focus on Latin America, 1984–92”. In: *World Development* 22.4, pp. 501–516. (Visited on 12/02/2015).
- Rayle, Lisa and Manuel Santana Palacios (2017). “The Impact of Bus Rapid Transit on Travel Time in Two Cities”. In: (visited on 12/01/2017).
- Rendall, Alastair (2016). *Personal Communication*.
- Republic of South Africa (1998). *Employment Equity Act, 1998*.
- (2009). *National Land Transport Act*.
- Rimmer, Peter (1989). “A Tale of Four Cities: Competition and Bus Ownership in in Bangkok, Jakarta, Manila, and Singapore”. In: Thredbo, Australia.
- Rizvi, Andrea and Elliott Sclar (2014). “Implementing Bus Rapid Transit: A Tale of Two Indian Cities”. In: *Research in Transportation Economics*. Competition and Ownership in Land Passenger Transport (selected papers from the Thredbo 13 conference) 48, pp. 194–204. (Visited on 09/14/2015).
- Rolim, Fernando, Anisio Brasileiro, and Enilson Santos (2010). “Competition in Brazilian Bus and Coach Services – The Results of Recent Competitive Tendering Processes”. In: *Research in Transportation Economics*. Reforming Public Transport throughout the World 29.1, pp. 45–51. (Visited on 11/08/2016).
- Roy, Ananya (2009). “Why India Cannot Plan Its Cities: Informality, Insurgence and the Idiom of Urbanization”. en. In: *Planning Theory* 8.1, pp. 76–87. (Visited on 05/18/2016).
- Roy, Ananya and Nezar Alsayyad, eds. (2004). *Urban Informality: Transnational Perspectives from the Middle East, Latin America, and South Asian*. Lanham: Lexington Books.
- Royal HaskoningDHV Team and City of Cape Town (2014). *Household Survey Report*. Tech. rep. Cape Town: City of Cape Town - Transport for Cape Town.
- Salazar Ferro, Pablo, Roger Behrens, and Aaron Golub (2012). “Planned and Paratransit Service Integration through Trunk and Feeder Arrangements: An International Review”. In: Pretoria.

- Salazar Ferro, Pablo, Roger Behrens, and Peter Wilkinson (2013). "Hybrid Urban Transport Systems in Developing Countries: Portents and Prospects". In: *Research in Transportation Economics*. THREDBO 12: Recent developments in the reform of land passenger transport 39.1, pp. 121–132. (Visited on 05/01/2014).
- SARPAC (2017). *Main Collective Agreement*.
- Schalekamp, Herrie (2015a). "Paratransit Operators' Participation in Public Transport Reform in Cape Town: A Qualitative Investigation of Their Business Aspirations and Attitudes to Reform". PhD Thesis. Cape Town: University of Cape Town.
- (2015b). *Personal Communication*.
- Schalekamp, Herrie and Roger Behrens (2010). "Engaging Paratransit on Public Transport Reform Initiatives in South Africa: A Critique of Policy and an Investigation of Appropriate Engagement Approaches". In: *Research in Transportation Economics*. Reforming Public Transport throughout the World 29.1, pp. 371–378. (Visited on 08/19/2014).
- (2013). "Engaging the Paratransit Sector in Cape Town on Public Transport Reform: Progress, Process and Risks". In: *Research in Transportation Economics*. THREDBO 12: Recent developments in the reform of land passenger transport 39.1, pp. 185–190. (Visited on 08/19/2014).
- Schalekamp, Herrie, Aaron Golub, and Roger Behrens (2016). "Approaches to Paratransit Reform". In: *Paratransit in African Cities*. Ed. by Roger Behrens, Dorothy McCormick, and David A. Mfinanga. New York: Routledge, pp. 100–124.
- Schensul, Daniel and Patrick Heller (2011). "Legacies, Change and Transformation in the Post-Apartheid City: Towards an Urban Sociological Cartography". In: *International Journal of Urban and Regional Research* 35.1, pp. 78–109. (Visited on 12/11/2014).
- Seekings, Jeremy (2008). "The Continuing Salience of Race: Discrimination and Diversity in South Africa". In: *Journal of Contemporary African Studies* 26.1, pp. 1–25. (Visited on 03/12/2016).
- Seekings, Jeremy and Nicoli Nattrass (2005). *Class, Race, and Inequality in South Africa*. New Haven: Yale University Press.
- Shah, Jay and Bhargav Adhvaryu (2016). "Public Transport Accessibility Levels for Ahmedabad, India". In: *Journal of Public Transportation* 19, pp. 19–35.
- Shires, J. D. and G. C. de Jong (2009). "An International Meta-Analysis of Values of Travel Time Savings". In: *Evaluation and Program Planning*. Evaluating the Impact of Transport Projects: Lessons for Other Disciplines 32.4, pp. 315–325.
- Singh, Kapil (2016). *Personal Communication*.
- Small, Kenneth A. (2012). "Valuation of Travel Time". In: *Economics of Transportation* 1.1, pp. 2–14.
- Stanley, John and Didier van de Velde (2008). "Risk and Reward in Public Transport Contracting". In: *Research in Transportation Economics*. Reforms in Public Transport 22.1, pp. 20–25. (Visited on 11/04/2016).
- Stats SA (2016). *Quarterly Labour Force Survey: Quarter 1 2016*. Tech. rep. Pretoria, South Africa: Statistics South Africa.

- The World Bank (2017). *WGI 2016 Interactive*. <http://info.worldbank.org/governance/wgi/#reports>. (Visited on 02/21/2017).
- Tirachini, Alejandro et al. (2016). "Valuation of Sitting and Standing in Metro Trains Using Revealed Preferences". In: *Transport Policy* 47.Supplement C, pp. 94–104.
- Tiwari, Geetam and Deepty Jain (2012). "Accessibility and Safety Indicators for All Road Users: Case Study Delhi BRT". In: *Journal of Transport Geography*. Special Section on Rail Transit Systems and High Speed Rail 22, pp. 87–95. (Visited on 01/27/2015).
- Tokman, Victor E. (1978). "An Exploration into the Nature of Informal—formal Sector Relationships". In: *World Development* 6.9–10, pp. 1065–1075. (Visited on 12/02/2015).
- TomTom (2016). *TomTom Traffic Index*. [https://www.tomtom.com/en\\_gb/trafficindex/](https://www.tomtom.com/en_gb/trafficindex/). (Visited on 08/18/2016).
- Transport for Cape Town (2015). *MyCiTi Business Plan Update: Phase 1 and N2 Express*. Tech. rep. City of Cape Town.
- Turner, John F.C. and Robert Fichter, eds. (1972). *Freedom to Build: Dweller Control of the Housing Process*. Macmillan.
- UNODC (2013). *Global Study on Homicide*. Tech. rep. Vienna: United Nations Office on Drugs and Crime.
- Valenzuela Jr., Abel, Lisa Schweitzer, and Adrielle Robles (2005). "Camionetas: Informal Travel among Immigrants". In: *Transportation Research Part A: Policy and Practice* 39.10, pp. 895–911. (Visited on 10/11/2016).
- van Ryneveld, Philip (1989). "An Analysis of How Combi Taxis Compete with Bus Services in South Africa". Masters thesis. The Hague: Institute of Social Studies.
- (2016). *Personal Communication*.
- van Wee, Bert (2016). "Accessible Accessibility Research Challenges". In: *Journal of Transport Geography* 51, pp. 9–16. (Visited on 11/23/2016).
- Vasconcellos, Eduardo Alcantara (2001). *Urban Transport Environment and Equity: The Case for Developing Countries*. en. New York: Earthscan.
- Vaz, Eunice and Christoffel Venter (2012). "The Effectiveness of Bus Rapid Transit as Part of a Poverty-Reduction Strategy: Some Early Impacts in Johannesburg". In:
- Venter, Christoffel (2013). "The Lurch towards Formalisation: Lessons from the Implementation of BRT in Johannesburg, South Africa". In: *Research in Transportation Economics*. THREDBO 12: Recent developments in the reform of land passenger transport 39.1, pp. 114–120. (Visited on 05/05/2015).
- (2016). "Assessing the Potential of Bus Rapid Transit-Led Network Restructuring for Enhancing Affordable Access to Employment – The Case of Johannesburg's Corridors of Freedom". In: *Research in Transportation Economics*. Competition and Ownership in Land Passenger Transport (selected papers from the Thredbo 14 conference) 59.Supplement C, pp. 441–449.
- Venter, Christoffel et al. (2017). "The Equity Impacts of Bus Rapid Transit: A Review of the Evidence and Implications for Sustainable Transport". In: *International Journal of Sustainable Transportation*, pp. 1–13.

- Vijayakumar, S. (1986). "Optimal Vehicle Size for Road-based Urban Public Transport in Developing Countries". In: *Transport Reviews* 6.2, pp. 193–212. (Visited on 11/11/2016).
- Walters, A. A. (1979). "The Benefits of Minibuses: The Case of Kuala Lumpur". In: *Journal of Transport Economics and Policy* 13.3, pp. 320–334. (Visited on 02/17/2015).
- Walters, Jackie (2013). "Overview of Public Transport Policy Developments in South Africa". In: *Research in Transportation Economics*. THREDBO 12: Recent developments in the reform of land passenger transport 39.1, pp. 34–45. (Visited on 10/03/2015).
- Walters, Jackie and Jan Owen Jansson (2008). "Risk and Reward in Public Transportation Contracting". In: *Research in Transportation Economics*. Reforms in Public Transport 22.1, pp. 26–30. (Visited on 05/06/2015).
- Wardman, Mark, Phani Chintakayala, et al. (2012). *European Wide Meta-Analysis of Values of Travel Time*. Tech. rep. European Investment Bank.
- Wardman, Mark and Gerard Whelan (2011). "Twenty Years of Rail Crowding Valuation Studies: Evidence and Lessons from British Experience". In: *Transport Reviews* 31.3, pp. 379–398.
- White, Peter (1995). "Deregulation of Local Bus Services in Great Britain: An Introductory Review". In: *Transport Reviews* 15.2, pp. 185–209. (Visited on 05/06/2016).
- White, Peter R. (1997). "What Conclusions Can Be Drawn about Bus Deregulation in Britain?" In: *Transport Reviews* 17.1, pp. 1–16. (Visited on 05/06/2015).
- White, Peter R. and A. A. Walters (1981). "The Benefits of Minibuses (Comment and Rejoinder)". In: *Journal of Transport Economics and Policy* 15.1, pp. 77–80. (Visited on 02/17/2015).
- Wilkinson, Peter (2010). "The Regulatory Cycle Stalled? An Assessment of Current Institutional Obstacles to Regulatory Reform in the Provision of Road-Based Public Transport in Cape Town, South Africa". In: *Research in Transportation Economics*. Reforming Public Transport throughout the World 29.1, pp. 387–394. (Visited on 05/05/2015).
- Wood, Astrid (2014a). "Learning through Policy Tourism: Circulating Bus Rapid Transit from South America to South Africa". In: *Environment and Planning A* 46.11, pp. 2654–2669. (Visited on 02/18/2015).
- (2014b). "Moving Policy: Global and Local Characters Circulating Bus Rapid Transit through South African Cities". In: *Urban Geography* 35.8, pp. 1238–1254. (Visited on 02/18/2015).
- (2015a). "Competing for Knowledge: Leaders and Laggards of Bus Rapid Transit in South Africa". en. In: *Urban Forum*, pp. 1–19. (Visited on 02/18/2015).
- (2015b). "Multiple Temporalities of Policy Circulation: Gradual, Repetitive and Delayed Processes of BRT Adoption in South African Cities". en. In: *International Journal of Urban and Regional Research* 39.3, pp. 568–580. (Visited on 08/01/2016).
- Woolf, S. E. and J. W. Joubert (2013). "A People-Centred View on Paratransit in South Africa". In: *Cities* 35, pp. 284–293. (Visited on 05/27/2016).
- World Bank (2016). *GDP per Capita, PPP (Current International \$)*. <http://data.world-bank.org/indicator/NY.GDP.PCAP.PP.CD?view=chart>, (visited on 07/17/2017).



- Wright, Lloyd and Walter Hook (2007). "Bus Rapid Transit Planning Guide". In: *Institute for Transportation and Development Policy, New York*.
- yellowwood (2014). *MyCiTi Customer Insights Programme Summary Presentation*. Tech. rep. Cape Town.
- (2015). *MyCiTi Card Recipient Qualitative Research*.
- Yiftachel, Oren (2009). "Theoretical Notes On 'Gray Cities': The Coming of Urban Apartheid?" In: *Planning Theory* 8.1, pp. 88–100.