Assessing the Equity of Changing Travel Behaviors

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Abstract

This research makes the radical claim that there is a social equity to travel behavior. Such equity is defined as a lack of systematic differences between the travel patterns of disadvantaged and non-disadvantaged groups. This research then proposes and applies an innovative methodology to help planners assess the social equity of policy interventions that result in changing travel behaviors. This methodology distinguishes between outcome equity and impact equity, proffers non-parametric and parametric statistical tests for identifying the existence (or absence) of both types of equity, and presents a theoretical framework of ranked scenarios, which integrate the findings from the statistical tests. This research applies this methodology to survey data collected after a disruption in retail land use patterns in post-soviet Prague to both identify specific findings and explore the general utility of the proposed equity model.

Introduction

The profession of city planning expressly values social equity. *The American Institute of Certified Planners (AICP) Code of Ethics and Professional Conduct* (2005) states that planners "shall seek social justice by working to expand choice and opportunity for all persons, recognizing a special responsibility to plan for the needs of the disadvantaged." The AICP code does not, however, explicitly define either the realms in which such equity should be considered or the manner in which equity should be assessed.

This research takes the somewhat radical position that an appropriate realm of equity consideration is travel behavior. This approach admittedly is a break from traditional thinking that has viewed travel behavior as a personal choice rather than evidence of systematic bias. However, if, as prevailing theory holds, people travel to engage in activities, and if many of these activities are fundamental human needs (e.g. working to earn money, shopping to acquire food, seeking healthcare to prevent disease, etc.), then it is reasonable to consider distinctions in travel behaviors across different populations to engage in the same activities as evidence of inequity. This position is not incompatible with the idea that travel

behaviors reflect choices; rather, this position sees those choices as highly constrained and sees those constraints as varying systematically across different populations. Acceptance of this position opens up a new role of the planner—namely to assess the equity of travel behavior. Such an assessment becomes a critical step to identifying areas for intervention and then designing and evaluating actual policies.

This research proposes a framework for assessing the equity of changing travel behaviors in light of a policy intervention. Since the concept of equity is rarely applied directly to travel behaviors, no clear or consistent approach has been established. In the United States, the relevant federal guidance is bifurcated in its assessment criteria between outcomes and impacts. The primary legislation, President Clinton's (1994) *Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, mandates an outcome-oriented approach that federal agencies "identify differential patterns of consumption of natural resources among minority populations and low income populations." By contrast, the 1997 US Department of Transportation guidance for implementing Executive Order 12898 injunctions an impact-oriented approach that agencies restrict "programs that may disparately impact racial and ethnic groups" (Deakin 2007).

This research attempts to harmonize the tension between equity outcomes and impacts while proffering an intuitive and easy-to-apply analytical framework. Specifically, this research argues that the goal of social justice in planning is to achieve equitable outcomes; therefore, in assessing changing equity, the fairness of impact is subordinate to the fairness of outcome. This approach is grounded in Rawls's (1971) assertion that disparate impacts are just if they are aimed at improving the state of the socially disadvantaged in comparison with the rest of society and evident in the planning profession with Davidoff's (1965) advocacy planning and Krumholz's (1982) equity planning formulations.

Literature Review

The current research examines the changing equity of the travel made for shopping purposes in light of the introduction of the first suburban shopping malls in Prague. These malls were particularly disruptive to travel behavior because they were preceded by very limited retail infrastructure and, unlike malls in North America, were anchored by the region's first supermarkets, which shifted food purchasing from small local stores.

While the term "shopping" connotes a certain frivolity in the popular imagination, the activity of selecting and purchasing goods not made at home (including groceries, clothing, household goods, building supplies, etc.) is a critical human need in the modern world. Surveys demonstrate

that between a sixth and quarter of all trips are made for shopping purposes, which is on par or greater than the portion of trips made for commuting purposes (DETR 2000; Scottish Executive 2002-2005; TPDC 2006).

Studies of shopping travel have tended to be cross-sectional and therefore less relevant to a study of changes over time; however, there is a small body of research that examines changes in shopping travel behaviors between two time periods. Of these studies, several have expressly noted the positive equity outcomes of these changes between women and men. Levinson and Kumar (1995) compare travel surveys taken twenty years apart for the greater Washington, DC area. They find that, while in both the 1968 and 1988 surveys women reported greater shopping trip frequencies and longer shopping activity durations than men, these rates were converging. Yee and Niemeier (2000) compare travel surveys taken over a four-year period in the greater Seattle area. They find that, while the differences between female and male shopping durations were significant in the first survey, by the second survey women had shortened and men had lengthened their activity durations to the point of statistical equivalence. The UK Department for Transport (2003) compares nationwide travel surveys taken a decade apart. While women were found to drive to shops less than men in both surveys, in the 1999/2001 survey the differences between these rates "have narrowed slightly since 1989/1991."

These considerations of equity between the genders represent a limited, but important start. More work is necessary to expand the understanding of equity between other pairings of disadvantaged and non-disadvantaged population groups, such as ethnic groups, income groups, age groups, and vehicle ownership groups.

The current study is interested in the effect of a single land use change on shopping travel behavior. Few studies directly address changes in shopping (or any type of) travel behaviors as a result of land use changes. Owens (1996), in a volume on sustainable transport in Central and Eastern Europe, argues, "It is not possible at this stage to isolate the effects of urban land use policies on travel and its associated environmental impacts… [E]ffects are mainly long term, because the physical fabric of urban areas changes relatively slowly." By contrast, Meurs and Haaijer (2001) suggest that it may be possible, through highly detailed data sets, to control for many of the non-land use factors that change over time and affect travel behaviors. Another alternative is to examine situations when land use changes occur very rapidly. Donaghy, Rudinger, and Poppelreuter (2004) cite the earlier work of Medda and Boarnet (2003) to note, "The speed of adjustment of behavior to urban form may be instantaneous." Therefore, if a single land-use change were to occur in the absence of other changes, it would be possible to isolate the impacts on travel behavior. Several studies use narrow time frames to help isolate the shopping travel changes that are

impacted by the creation of new shopping malls as a disruptive land use. Marjanen (1995) and Lee and Yong (1998) examine changes in metropolitan shopping behaviors with the introduction of major out-of-center shopping areas in Turku, Finland and Tampines New Town, Singapore, respectively. Shiftan and Newmark (2002) examine travel behavior adaptations that accompany the introduction of a new infill mall in Haifa, Israel. These studies are able to identify distinct shopping travel changes attributable to the new land use but make no comment on their equity.

Data Collection

This study follows those noted above that examined shopping travel behavior adaptations to the introduction of shopping malls. Such malls are a burgeoning new land use in Central and Eastern Europe. This development is due in large part to the new interest of international retailers in post-socialist transitional economies. These retailers are attracted to such economies that exhibit high growth rates, expanding middle-class populations, and weak existing local retailers (Goldman 2001). These traits are true of Prague where the 1989 Velvet Revolution ushered in a new era of economic liberalism. This era is characterized by a transition to a market economy and the entry of foreign capital (Sykora 1999). The immediate result of this transition was a sharp reduction in housing starts and a sharp increase in vehicle purchases as the government ceased both to subsidize residential development and to restrict imports on automobiles. The growth in motorization rates stabilized in the mid-1990s, but at the time of this study's data collection in fall 2001 there had yet to occur a renewed expansion of housing stock as few Czechs, despite rising purchasing power, had the capital to pay for new construction.

The increased access to motor vehicles and increased purchasing power attracted foreign retail investment. By 1997, foreign retailers had begun opening major shopping malls on the fringes of the city, and, by 2001, these new malls had become a prominent mode of retailing (Incoma Research 2003). The *Prague Post* noted the anecdotal influence of the new shopping centers on shopping travel behaviors. "Already, hundreds of thousands of Czechs have traded in their afternoon walks to the store for weekly drives to the mall" (Jasek 1999).

This significant and quick impact on shopping travel behaviors of a relatively limited, but disruptive retail land-use change during a period of otherwise little real estate development provided a unique survey opportunity. Respondents could be reasonably expected to report not only current behaviors, but also their shopping travel patterns prior to the introduction of the malls (as these had been stable for years). Furthermore, with the leveling off of motorization rates and the lack of real estate

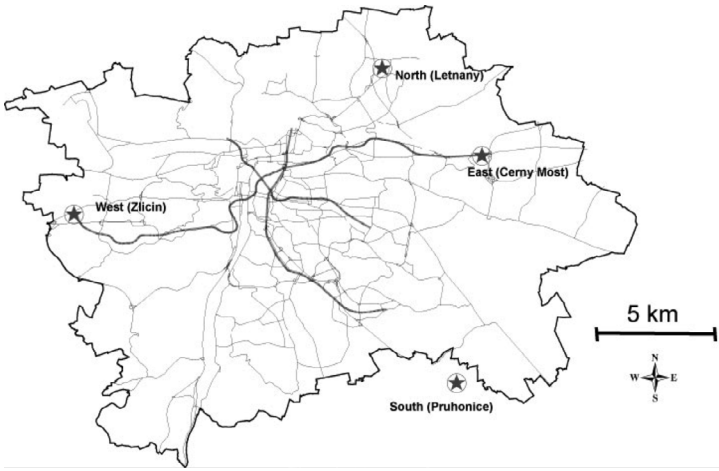

Figure 1: Prague's Four Major Suburban Retail Locations

development in other sectors, there were no clear confounding factors. In autumn 2001, the author led a surveying effort of shoppers at the four main new retailing sites at the compass points of the Prague periphery shown in Figure 1.

The survey respondents provided socioeconomic information and recalled habitual shopping travel behavior information on monthly shopping trip frequency, shopping activity duration, and shopping access mode choice, both prior to and after the introduction of the suburban shopping malls. Extensive descriptions of the survey instrument, as well as the retail locations themselves, can be found in Newmark and Plaut (2005) and Newmark, Plaut, and Garb (2004). A total of 1,649 surveys were collected. Of these, 1,303 responses or 79.0 percent of the total sample were from people age twenty or older who reported shopping as their purpose for making the trip to the mall. These responses constitute the current study sample.

This research examined the socio-demographic data reported by shoppers to identify pairings of disadvantaged / non-disadvantaged populations based on gender, income, age, and car ownership status. Since Prague has a very low rate of ethnic minorities, such status is not incorporated into the disadvantaged / non-disadvantaged groupings. The specific pairings include, with the disadvantaged population noted first, women/men, below average income/average income or above, senior citizen (age fifty-five or older) / middle aged (age twenty to fifty-four), and car-free households / car owning households. Income status is based on self identification.

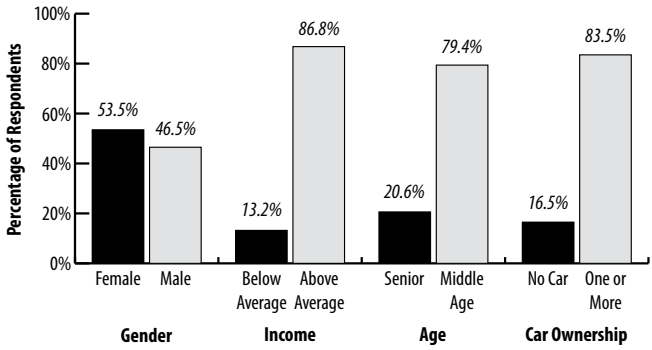

Figure 2: Shares of Disadvantaged / Non-disadvantaged Population Groups among Shoppers over Age 20

Figure 2 demonstrates the sample shares for each of the four disadvantaged/non-disadvantaged population group pairs. While most of the disadvantaged social groups comprise less than one-fifth of the study sample, the disadvantaged gender group, women, represents a majority of respondents.

Assessment Framework

This paper provides a statistical framework to test whether the reported travel behaviors are statistically distinct for the disadvantaged and non-disadvantaged social groups.

This research defines two types of equity: static equity and dynamic equity. Static equity considers travel behaviors between social groups at a given point in time and is a measure of outcome equity. Dynamic equity considers the change in travel behaviors over time and is a measure of impact equity. For example, a comparison of commute times among ethnic groups addresses static equity while a comparison of the changes in commute times among ethnic groups with the introduction of a new rail line addresses dynamic equity. Figure 3 presents these two concepts graphically.

This research then applies statistical tests of difference to the disadvantaged / advantaged population pairings for travel behaviors of interest. Differences that are statistically significant at a predetermined confidence level suggest that the null hypothesis of equity can be rejected and therefore an inequity exists; otherwise, this framework assumes that the null hypothesis cannot be rejected and an equity exists. The logic of this approach is that while individual travel behaviors are expected to vary, the aggregated patterns of the individual behaviors of two separate populations are not expected to vary – unless there is a systematic inequity.

This statistical methodology has several innovative elements. First, the defining of static and dynamic components of equity provides a clear structure for considering the fairness of outcomes and impacts. Second, the application of statistical tests of difference provides a straightforward means for determining the existence (or lack) of equity. Finally, this approach is value-neutral with regard to the directionality of that variation. Any statistical disparity constitutes an inequity even if the disparity may appear to favor a disadvantaged group. This neutrality provides a rigorous and consistent method for evaluating equity.

This paper also provides a theoretical framework to integrate static and dynamic equity into a coherent assessment model for evaluating changes in travel behaviors. Table 1 presents this framework of hypothetical equity scenarios ranked from best to worst.

This model is organized primarily around outcomes and secondarily around impacts. Three equity categories are identified: positive, neutral, or negative. These categories are based on changes in static equity between an initial and subsequent time period. Positive outcomes, those ranked best, refer to a change from inequity to equity; neutral outcomes refer to the absence of change in the state of equity (or inequity) between the two time periods; and negative outcomes, those ranked worst, refer to a change from equity to inequity. Each theorized scenario is assigned to one of these three categories based on its outcomes as measured by static equity. The scenario's ranking within each category is then based on the impacts as measured by dynamic equity. Equitable impacts are preferred to inequitable impacts.

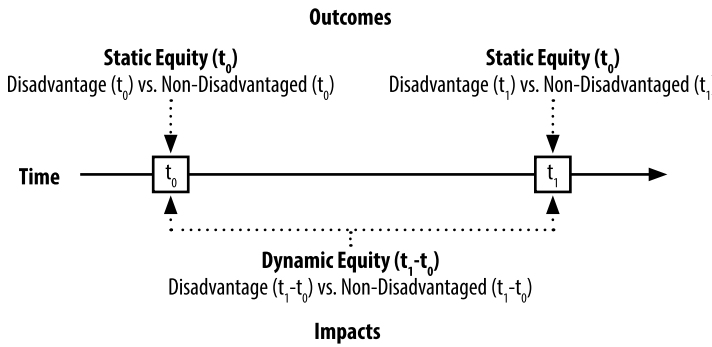

Figure 3: Model of Static (Outcome) and Dynamic (Impact) Equity

TABLE 1 Framework for Assessing Changes in Equity

Rank	Case Description	Static Equity (Outcomes)		Dynamic Equity (Impacts)
		t_0	t_1	t_1-t_0
Positive	Outcome equity achieved with equitable impact	○	●	●
	Outcome equity achieved through disparate impact	○	●	○
Neutral	Outcome equity maintained with equitable impact	●	●	●
	Outcome equity maintained with disparate impact	●	●	○
	Outcome inequity maintained with equitable impact	○	○	●
	Outcome inequity maintained with disparate impact	○	○	○
Negative	Outcome equity lost with equitable impact	●	○	●
	Outcome equity lost with disparate impact	●	○	○

In this table, the symbol "●" denotes equity, the symbol "○" denotes inequity, $\mathbf{t_0}$ refers to the initial time period, and $\mathbf{t_1}$ refers to the subsequent time period.

Table 1: Framework for Assessing Changes in Equity

Applying the Framework

This section applies the proposed equity assessment framework to the shopping travel data collected in Prague regarding monthly shopping trip frequency, shopping activity duration, and shopping access mode choice. These three data points were collected in interval, ordinal, and nominal levels of measurement, respectively, which affects the choice of appropriate statistical tests of difference. To provide more analytical options, the nominal mode share data were also recoded as dummy variables for each of the three modal options: car, transit, and pedestrian.

Static Equity

Static equity is assessed by identifying the cross-sectional existence of travel behavior variation between disadvantaged and non-disadvantaged population groups for each of the two time periods. The equity findings for the two time periods can then be compared to identify, first, if the change in land use has resulted in a change in the equity of travel behavior and, second, if that change in the equity of travel behavior represents a shift towards or away from fairness.

Two statistical tests are used to best align with the levels of measurement of the survey data. A parametric t test assesses the interval data on shopping trip frequency. The same test is also applied to the recoded mode share dummy variables. A non-parametric Chi-squared test assesses the ordinal data on activity duration and the nominal data on mode shares. These tests are shown in Tables 2 and 3.

The static equity analysis shows that the monthly shopping trip frequency became equitable among gender, income, and car ownership pairings following the introduction of the malls in Prague – all positive equity outcomes. Unfortunately, shopping activity duration, which had been equitable between men and women, became inequitable. This finding suggests that women continue to spend more time shopping than men, but in longer blocks rather than many short trips. Shopping activity durations remained equitable for the income groups and inequitable for the age groups, but did have a positive change for the car ownership groups. Mode choice, as measured by distribution, remained inequitable in both time periods for all population pairings; however, on an individual mode basis, there was a negative change for the age pairing regarding transit use as many older adults who had previously walked for shopping needed to use transit to access the malls. Conversely, there was a positive change in static equity for the gender, income, and age pairings regarding walking. Unfortunately, this equity is due to the fact that hardly anyone walks to the malls.

TABLE 2 **Static Equity Assessment**

		Before (t_0)				After (t_1)			
***t* Test**		**n**	**$\bar{x}$**	**SD**	***t***	**n**	**$\bar{x}$**	**SD**	***t***
Monthly Trip Frequency	Female	675	5.09	2.676	3.20	690	2.74	2.440	**-0.08**
	Male	581	4.61	2.622		601	2.75	2.332	
	Below Average	163	5.25	2.674	1.83	168	2.83	2.772	**0.44**
	Average or Above	1078	4.84	2.659		1108	2.73	2.325	
	Age 55+	264	5.33	2.584	3.28	266	3.21	2.416	3.57
	Age 20 to 54	996	4.74	2.666		1029	2.62	2.365	
	No Car	204	5.55	2.596	4.10	209	2.89	2.637	**0.97**
	One Car or More	1030	4.73	2.665		1058	2.70	2.329	
χ^2 Test		**n**	**χ^2**	**df**	**Sig.**	**n**	**χ^2**	**df**	**Sig.**
Activity	Gender	1229	**1.095**	3	**0.778**	1296	33.250	3	0.000
	Income	1214	**2.853**	3	**0.415**	1280	**0.576**	3	**0.902**
	Age	1233	14.556	3	0.002	1300	10.810	3	0.013
	Car Ownership	1210	11.606	3	0.009	1272	**1.772**	3	**0.621**
Duration	Gender	1243	163.576	3	0.000	1272	385.528	2	0.000
	Income	1269	47.422	3	0.000	1300	53.105	2	0.000
	Age	1250	20.299	3	0.000	1280	22.396	2	0.000
	Car Ownership	1265	43.460	3	0.000	1296	55.936	2	0.000

Statistics not significant at the 90 percent confidence level are **boldfaced** and represent a state of equity.

TABLE 3 Static Equity Assessment (Dummy Mode Shares)

Variables			*t* Statistical Test							
			Before (t_0)				After (t_1)			
Mode Choice	Socio-Economic	Disadvantage Pairing	n	$\bar{x}$	SD	*t*	n	$\bar{x}$	SD	*t*
Car	Gender	Female	652	0.40	0.490	-6.35	693	0.62	0.485	-7.79
		Male	561	0.58	0.494		603	0.81	0.392	
	Income	Below Average	160	0.32	0.467	-4.61	168	0.56	0.498	-4.18
		Average or Above	1041	0.50	0.500		1112	0.73	0.445	
	Age	Age 55+	257	0.30	0.459	-7.02	267	0.53	0.500	-6.65
		Age 20 to 54	960	0.53	0.499		1033	0.75	0.431	
	Car Ownership	No Car	196	0.08	0.275	-19.04	210	0.16	0.365	-23.81
		One Car or More	996	0.56	0.497		1062	0.82	0.385	
Transit	Gender	Female	652	0.23	0.420	5.12	693	0.33	0.469	7.29
		Male	561	0.12	0.327		603	0.16	0.369	
	Income	Below Average	160	0.23	0.423	1.70	168	0.40	0.491	4.22
		Average or Above	1041	0.17	0.377		1112	0.23	0.421	
	Age	Age 55+	257	0.21	0.405	**1.22**	267	0.42	0.494	6.45
		Age 20 to 54	960	0.17	0.377		1033	0.21	0.406	
	Car Ownership	No Car	196	0.39	0.490	7.03	210	0.77	0.421	20.06
		One Car or More	996	0.14	0.342		1062	0.15	0.356	
Pedestrian	Gender	Female	652	0.37	0.483	2.58	693	0.05	0.483	**1.03**
		Male	561	0.30	0.459		603	0.03	0.161	
	Income	Below Average	160	0.45	0.499	2.96	168	0.04	0.200	**0.07**
		Average or Above	1041	0.33	0.469		1112	0.04	0.197	
	Age	Age 55+	257	0.49	0.501	5.68	267	0.05	0.216	**0.76**
		Age 20 to 54	960	0.30	0.458		1033	0.04	0.191	
	Car Ownership	No Car	196	0.53	0.501	5.73	210	0.07	0.258	2.12
		One Car or More	996	0.30	0.460		1062	0.03	0.176	

Statistics not significant at the 90 percent confidence level are **boldfaced** and represent a state of equity.

Table 3: Static Equity Assessment (Dummy Mode Shares)

Dynamic Equity

Dynamic equity emphasizes the change rather than the end states. This analysis posits that fairness is perceived in both an absolute and a relative sense, while considering the latter a preferred measure of impact equity as it accounts for initial travel patterns. Therefore, this analysis of dynamic equity considers both absolute and percent change. These calculations can only be done on interval variables for which a change in the mean value can be calculated.

The calculation of absolute change requires two steps. The first step calculates the change in behavior for each respondent and then tests whether the mean change for all those respondents is significant using a paired t comparison of means test. This step establishes what the mean change is and whether that change is statistically significant. The second step uses the mean change information to see if there is a condition of equity between the disadvantaged and non-disadvantaged social groups using a second t test.

The calculation of percentage change for monthly trip frequency is simply determined as the absolute change value between the two time periods divided by the initial value. The mean of these values for the disadvantaged groups and non-disadvantaged groups are compared with a difference of means t test. This procedure cannot be used for the mode choice dummy variables since it would yield undefined ratios for any individual for whom the initial dummy value is zero. This research employs an alternative approach that examines the percentage change in the proportion of the disadvantaged/non-disadvantaged subsample selecting the specific mode. Table 4 presents these findings while the detailed findings for the monthly shopping trip frequency are available upon request and summarized in Table 5.

The dynamic equity analysis shows that for monthly shopping trip frequency the absolute change for income and age groups were equitable and the percentage change for all groups were equitable. For the car dummy variable, the absolute change was equitable for the car ownership pairing and the percentage change was equitable for the age pairing. For the transit dummy variable, the absolute change was equitable for all groups except men and women and the percentage change was equitable for the age and car ownership groups. For the pedestrian dummy variable, the absolute change was equitable for all groups and the percentage change was equitable for no group.

Table 4: Dynamic Equity Assessments

TABLE 4 Dynamic Equity Assessments

Variables			*t* and *z* Statistical Tests									
			Absolute Change						Percentage Change			
Behavioral	**Socio-Economic**	**Disadvantage Pairing**	$\Delta_{\bar{x}}$	**SD**	**Paired *t***	**df**	**Sig.**	***t***	**n**	**%$\Delta\hat{p}$**	**SD**	***z***
Car	Gender	Female	0.23	0.500	11.916	649	0.000	0.00	652	0.554	0.006	-1.628
		Male	0.23	0.449	12.044	559	0.000		561	0.404	0.003	
	Income	Below Average	0.25	0.477	6.651	158	0.000	0.49	160	0.755	0.038	-1.536
		Average or Above	0.23	0.481	15.419	1038	0.000		1041	0.449	0.002	
	Age	Age 55+	0.23	0.455	7.962	255	0.000	0.00	257	0.775	0.027	**-2.088**
		Age 20 to 54	0.23	0.484	14.807	957	0.000		960	0.722	0.002	
	Car Ownership	No Car	0.08	0.385	2.980	194	0.003	**-5.69**	196	0.925	0.188	-1.063
		One Car or More	0.26	0.490	16.845	993	0.000		996	0.462	0.002	
Transit	Gender	Female	0.09	0.495	4.435	649	0.000	1.57	652	0.427	0.014	-0.398
		Male	0.05	0.389	2.821	559	0.005		561	0.341	0.033	
	Income	Below Average	0.16	0.534	3.712	158	0.000	**2.25**	160	0.725	0.061	-1.398
		Average or Above	0.06	0.438	4.112	1038	0.000		1041	0.346	0.012	
	Age	Age 55+	0.22	0.538	6.508	255	0.000	**5.25**	257	1.034	0.051	**-3.285**
		Age 20 to 54	0.03	0.415	2.177	957	0.030		960	0.211	0.012	
	Car Ownership	No Car	0.37	0.573	9.125	194	0.000	**8.39**	196	0.964	0.021	**-4.643**
		One Car or More	0.01	0.395	0.833*	993	0.377*		996	0.098	0.014	
Pedestrian	Gender	Female	-0.32	0.496	-16.460	649	0.000	**-1.81**	652	-0.860	0.001	-1.228
		Male	-0.27	0.463	-14.066	559	0.000		561	-0.912	0.001	
	Income	Below Average	-0.41	0.506	-10.191	158	0.000	**-2.81**	160	-0.907	0.002	0.628
		Average or Above	-0.29	0.477	-19.320	1038	0.000		1041	-0.876	0.001	
	Age	Age 55+	-0.45	0.513	-13.876	255	0.000	**-5.37**	257	-0.901	0.001	0.652
		Age 20 to 54	-0.26	0.465	-17.377	957	0.000		960	-0.873	0.001	
	Car Ownership	No Car	-0.46	0.499	-12.763	194	0.000	**-4.90**	196	-0.864	0.002	-0.622
		One Car or More	-0.27	0.472	-18.215	993	0.000		996	-0.895	0.001	

Statistics not significant at the 90 percent confidence level are **boldfaced** and represent a state of equity. The two statistics marked with an asterisk (*) are also not significant, but are not boldfaced as they do not imply any equity condition between disadvantaged and non-disadvantaged groups.

TABLE 5 Integrating Static and Dynamic Equity Relationships

		Static Equity (Outcomes)						Dynamic Equity (Impacts)	
Variables		Distributional			Mean			Absolute	Percentage
Socio-Economic	Behavioral	t_0	t_1	Δ	t_0	t_1	Δ	t_1-t_0	t_1-t_0
Gender	Trip Frequency				○	●	+	○	●
	Activity Duration	●	○	-					
	Mode Choice	○	○						
	Car Dummy				○	○		○	●
	Transit Dummy				○	○		●	●
	Pedestrian Dummy				○	●	+	○	●
Income	Trip Frequency				○	●	+	●	●
	Activity Duration	●	●						
	Mode Choice	○	○						
	Car Dummy				○	○		●	●
	Transit Dummy				○	○		○	●
	Pedestrian Dummy				○	●	+	○	●
Age	Trip Frequency				○	○		●	●
	Activity Duration	○	○						
	Mode Choice	○	○						
	Car Dummy				○	○		●	○
	Transit Dummy				●	○	-	○	○
	Pedestrian Dummy				○	●	+	○	●
Car Ownership	Trip Frequency				○	●	+	○	●
	Activity Duration	○	●	+					
	Mode Choice	○	○						
	Car Dummy				○	○		○	●
	Transit Dummy				○	○		○	○
	Pedestrian Dummy				○	○		○	●

In this table, the symbol "●" denotes equity, the symbol "○" denotes inequity. Additionally, in the consideration of static equity, any change (Δ) in equity or inequity between the two time periods is noted. A shift from inequity towards equity is considered positive and noted with a plus (+) sign. A shift from equity towards inequity is considered negative and noted with a minus (-) sign.

Integrating Static and Dynamic Equity

Table 5 combines the outputs from the statistical analysis according to the theoretical equity framework established in Table 1. This approach dispenses with numbers to simply identify where static and dynamic equities occurred in the changing shopping travel behaviors.

Positive (+) or negative (-) changes are marked with the corresponding sign. All of the positive changes for which dynamic equity could be calculated demonstrated such equity. This combination of static and dynamic equity represents the highest-ranking outcome. Notably, in each of these cases, dynamic equity was equitable in relative but not absolute terms. By contrast, the one negative change for which dynamic equity could be calculated, transit use among the age cohorts, saw no dynamic equity. This combination of static and dynamic equity represents the lowest ranking outcome.

The neutral cases for which dynamic equity could be calculated were all inequitable in both time periods. Two of these cases demonstrated dynamic equity in both relative and absolute terms, four of these cases demonstrated dynamic equity in relative terms only, and one of these cases demonstrated dynamic equity in absolute terms only. These cases all represent a higher ranking neutral outcome which at least maintains some equity of impact. One case, the use of transit among car ownership groups, remained inequitable in both time periods without any dynamic equity. This represents the lowest ranked neutral combination.

Conclusions

This research claims that there is an equity to travel behavior and provides a framework for planners and policy makers to assess that equity. The three key innovations of this framework include distinguishing outcome equity from impact equity, providing value-neutral statistical tests to identify the existence of both types of equity, and presenting a theoretical model that integrates both outcome and impact equity into a single set of ranked scenarios. This research applies this assessment framework to data collected in Prague on changes in shopping travel patterns in response to the emergence of new retail land uses. This application affirms the general utility of this assessment framework while also raising questions for future research.

One key question is the proper specification of travel behaviors. The current work's separation of trip frequency and activity duration allowed for the land use change to register as both equitable on the former, but inequitable on the latter for the gender pairing. While such nuanced presentation does

demonstrate that interventions have different impacts, there may be a need for a broader measure of travel that would allow for more conclusive binary determinations of whether a policy change simply was or was not equitable.

A second question addresses the assessment of dynamic equity. The current work considers both absolute and relative impacts as measures of dynamic equity. However, all five cases that saw positive change demonstrated dynamic equity in relative terms while only one of these also demonstrated dynamic equity in absolute terms. Of all the findings of dynamic equity, only one case was only in absolute terms and not also in relative terms. Future work might explore whether dynamic equity is best represented by percentage and not absolute change.

Policy Implications

While future research will refine the methodology, this paper establishes that there is an equity to travel behavior (which can be measured) and that changes in policy can affect this equity. Proposed interventions should therefore be assessed, in part, as to their impacts on the equity of travel behavior between disadvantaged and non-disadvantaged population groups. These assessments are facilitated by the proliferation of activity-based travel demand models, which provide for highly detailed consideration of likely travel behaviors. Incorporating such assessments into the standard practice of policy evaluation embodies the planner's ethical responsibility to promote social equity.

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