Title
Accounting for Relationships in Land and Markets: Three Essays in Development Economics

Author
Meinzen-Dick, Laura Anjali

Publication Date
2021

Peer reviewed|Thesis/dissertation

Accounting for Relationships in Land and Markets:
Three Essays in Development Economics

By

LAURA ANJALI MEINZEN-DICK
DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Agricultural and Resource Economics

in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA

DAVIS

Approved:

Michael Carter, Co-Chair

Arman Rezaee, Co-Chair

Steve Boucher

Diana Moreira

Committee in Charge

2021

Contents

Dissertation Abstract

This dissertation is comprised of three essays in development economics in Burkina Faso and Uganda. The first two chapters explore implications of land rights and customary tenure systems, particularly the ramifications of rights to a single piece of land being held by multiple people. In the first essay, I look at political responses to a decentralization reform that will consolidate and redistribute land rights. In the second, I explore in what contexts multiple rightsholders create tenure insecurity, and how agricultural investment is affected. Finally, the third essay presents descriptive analysis on links between local markets and early childhood nutrition.

Decentralization of Land Governance and Elections in Burkina Faso

In the first chapter, I study politicians' responses to the decentralization of land governance in Burkina Faso. To what extent are politicians motivated by private rents versus concerns about constituent welfare? I develop a theoretical model and test its implications using municipal elections data during the experimental pilot phase of a land governance decentralization reform. I find that 0.8 additional political parties contest elections in municipalities randomly slated to receive pilot-phase local land offices, although voter turnout is lower than expected and elections do not become meaningfully more competitive. After implementation and documentation of land rights, both parties and voters behave similarly to control municipality counterparts. From this pattern, and by examining heterogeneity in political responses according to different tensions emerging from customary land rights systems, I argue that politicians are not only driven by their own private rents, but also demonstrate a policy-centric focus on constituent welfare. This speaks to a trade-off inherent in decentralization: despite potential efficiency gains and increased accountability to local citizens, more localized government could be more vulnerable to elite capture, and therefore the motivations of those elites are important.

Customary Tenure and Agricultural Investment in Uganda

The second chapter also stems from the fact that in customary tenure systems in Sub-Saharan Africa, multiple actors hold different rights over a given piece of land. These rightsholders interact strategically, so the distribution of rights influences the (perceived) security of tenure: anticipating another's actions can be a source of insecurity. I incorporate this strategic interaction in a model of agricultural investment to make detailed predictions about how farmers under different tenure regimes invest in short- and long-term inputs in different land value environments. I explicitly consider how rising land values, driven by sales options to outsiders, may lead local elites to assert their historic right to sell land to outsiders. The farmer, anticipating

this, may actually make fewer long-term investments on customary land as land values rise, in contrast to the freehold case. I empirically test the implications of this model using survey data from four regions of Uganda. I find that long-term investments significantly diverge between freehold and customary parcels as land pressures in an area rise. Unlike many previous papers which have conceptually modeled the impacts of tenure security but then used tenure type as a (poor) proxy, I consider tenure type and the incentives it creates throughout my model, therefore linking more closely to my empirical tests.

Markets and Child Nutrition in Rural Burkina Faso

The third chapter shifts focus to the relationships between local markets and early childhood nutritional status in Burkina Faso. By pairing unique data on rural village markets with biometric measurements of children served by those markets, we are able to examine whether and how consumer market access maters for well-being. We find a weak positive correlation between the sophistication of a market and the nutritional outcomes of the children it serves, with patterns generally following our conceptual pathway. We use dimension reduction techniques to characterize multiple features of markets, and find that market breadth (the variety of products available) as well as the size and dynamism of markets are most strongly related to nutritional outcomes. We conclude by presenting suggestive evidence that these documented mean effects may not hold in the left tail of nutritional outcomes, implying that targeted public health interventions are a necessary complement to market-driven growth. This third chapter begins to document the importance of rural markets for consumer welfare in Africa, and particularly for early childhood nutrition which is crucial for long-term outcomes.

Acknowledgements

This dissertation is the product of so many social relationships that I could never begin to capture in a model, and words will only begin to express my gratitude.

The ARE Department at UC Davis has become the intellectual home I had dreamed of finding for years. My deepest appreciation to Michael Carter, for all of his advice and support, and for always making my ideas better. Many thanks to Arman Rezaee for his guidance and thoughtfulness, particularly through the job market process. Steve Boucher taught me how to love teaching, and for that I will be forever grateful. Thanks also to Diana Moreira for holding my work to high standards and showing me how to meet them. I was particularly lucky to be in such a supportive department; Steve Vosti especially nurtured me through my early years in the program and is a model of interdisciplinary work. I became an economist under the tutelage of Pierre Mérel, Dalia Ghanem, Travis Lybbert, Ashish Shenoy, Jim Wilen, Kevin Novan, Rich Sexton, Aaron Smith, Rachael Goodhue, Kristin Kiesel, Monica Singhal, Marianne Bitler, Colin Cameron, Marianne Page, and many other excellent faculty. I am grateful also for financial support during the program from a Marjorie and Charles Elliot Fellowship, two Henry A. Jastro research awards, as well as funding from the World Bank's DIME team and the BASIS MRR Innovation Lab.

My heart overflows in thinking about all of the dear friends I have made in Davis. I have had the best office family: Joanna Mathias, Tor Tolhurst, Ashley Spalding, Scott Somerville, and Tengda Gong. Joanna, from the first days of the program it has been like magic. I am continually amazed by your grace and insight, both academic and personal. Tor, you taught me everything I know about wine and so much more besides. Spending time with each of you has the deep fulfilment of joy, and you know how much you mean to me. Ashley, I'm amazed at how spending days working with you is simultaneously so much fun and so productive, and I have missed that deeply during the pandemic. And Scott, thank you for your good humor about what a crazy place the office is, and for making my ravioli dreams come true.

To Daniel Putman, my partner in all things, thank you for your unending support. Your delight in learning about the world fills every day with joy, and you never fail to push me to be my best self, intellectually and personally. Thanks also for being my rock during the job market (and watching so many mysteries). "And what do all the great words come to in the end, but that? I love you – I am at rest with you – I have come home." All of my love also to Zora, who loves unconditionally.

I feel eternally grateful to Jess Rudder for her intentional support and friendship. Thanks also to Caitlin Kieran and Shotaro Nakamura, for so much thoughtful feedback during our meetings. Erin Winters, thank you for the zoom work sessions, as well as the constant conversations about the mundane and the important.

Sam Bird, I'm grateful to you for tricking me into ACDP – even if it was a doomed project, I learned so

much from you and it. Thank you also to the Ministry of Agriculture, Animal Industry and Fisheries team in Uganda, particularly Emmanuel Mukama and Amelia Atukunda, who have been incredible collaborators and friends. I am grateful also to John Ilukor, the only person I have come to expect miracles from. Thanks also to Janda Consult for their expertise on survey design and implementation, and to the whole team of dedicated enumerators for our baseline survey.

And thank you, from the bottom of my heart, to all of the friends who have made my time here such a delight: Aleks Michuda, Amanda Bird, Arian Seifoddini, Cynthia van der Werf, Elinor Benami, Ethan Krohn, Isaac Ahimbisibwe, Joakim Weill, Kajal Gulati, Karen Ortiz Becerra, Maureen Page, Minahil Asim, Mo Alloush, Oscar Barriga-Cabanillas, Pierce Donovan, and Sophie Xu. Thank you to Charlotte Ambrozek for being such a beautiful soul. Max and Jack Mathias, thank you for letting me be part of your family. Tomoé Bourdier, I'm constantly in awe of how you manage to be amazing at everything, including being so nice. Annie O'Connor, thank you for being so great to live with, and for loving my cat as your own. Maxime Depalle, thank you for reminding me about all the things that matter in life, especially baking and ballet (and good books). I'm grateful to Ed Whitney for countless conversations over a glass of wine. And thank you to Komal Choudhary-Hart and Jarrett Hart, the panoramic pod, for keeping me sane this past year. I also am grateful to my theology reading group, Will Benware, Jana Tuton, Brelle Albert, Walter Stone, Ann Cassidy Stone, Ross Thompson, Janet Thompson, and Kristin McMillan.

There have been so many others who have helped me on this path. From fantastic teachers in high school who encouraged me to explore, to friends like Shawn Brands, Laura Hamrick, and Taylor Goldammer who pushed me to be the best in any way I can. I am so grateful for the fantastic education I got at the University of Mary Washington, and particularly for the guidance of Laura Mentore and Shawn Humphrey. Dr. H, La Ceiba was magical, and forged who I am today - thank you. At UMW, I also met some of my best friends: Emily Sherman, Zach Feinstein, and Nicole Cochran, all of whom have filled my life with so much laughter. And most especially, Patti Thibodeau, my platonic life partner and cat co-parent for so many years. You have been such a blessing in my life.

I owe my passion, drive, and whole world to my parents, Ruth Meinzen-Dick and Carroll Dick. From my childhood, they have demonstrated and encouraged me to explore the world, to ask questions and find ways to answer them, and to seek to do so in a way that makes others' lives better. I'm sorry I 'went to the dark side' with economics, but I'm so grateful for your ever-present support, whether that's editing my papers, discussing an early idea, or affirming my whole being.

I love you all, with my whole heart. Thank you.

Introduction

> I entirely agree that a historian ought to be precise in detail; but unless you take all the characters and circumstances into account, you are reckoning without the facts. The proportions and relations of things are just as much facts as the things themselves.
>
> Gaudy Night
>
> Dorothy Sayers

Not only historians should heed Dorothy Sayers' advice: in economics as well, the relationships between people and things matter. In particular, we must seek to understand economic questions as they are situated in people's lives. In this dissertation, I seek to explore the relationships between things, and what can be gained by an explicit attention to them in understanding economic behavior. This takes two forms in this dissertation. In the first two essays, I focus on the social nature of land rights. Customary tenure systems in much of Sub-Saharan Africa distribute rights to a single piece of land among multiple people, so their interactions are crucial to understanding their rights. In the first chapter I focus on how social relationships over land are also pursued in the political domain. In the second, I delve into how the relationships between multiple rights-holders are shaped by external pressures and how, in turn, these relationships influence tenure security. In the third and final paper, I explore the relations between nutrition and markets: how well do rural markets serve their local consumers, and how do children access nutritious foods in the real world?

The three chapters of this dissertation are also linked methodologically. Throughout, I link theoretical and conceptual models closely with empirics and a close reading of the context, paying particular attention to heterogeneity. This means that the models are able to make sharp predictions about when certain effects should be found (and when they may be weaker or nonexistent): understanding contextual relationships helps link formal models with real-world data. For example, in both the first and second chapters I focus on new tensions in customary tenure that emerge as urban areas encroach, where individuals may seek to exploit

the uncertainty of outsiders who find it difficult to parse overlapping land rights. This co-construction of models and empirics allows me to not only make predictions about heterogeneity, but also to interpret it: what does the relative strength of effects in different contexts imply about the underlying incentives people face? In this way, I seek to not only incorporate the particular contexts and relationships but learn from them about broader human behavior.

The first two chapters of this dissertation are closely linked, despite the distinct country contexts and questions asked. Both stem from a fundamental feature of customary land rights in the Sub-Saharan African context: rights to a given piece of land are often held by multiple individuals, who interact over the land and in other social domains. As a stylized depiction, consider a parcel farmed by a smallholder, who holds use and management rights over his or her farm. These rights may be quite secure even if undocumented, and may even be inheritable. However, transfer rights (and particularly the right to transfer land to non-community members) are generally held by others – a lineage elder, or local elite. Other secondary rights may be held by yet others in the community, such as seasonal access or gleaning rights. Although this distribution of rights has been quite effective at governing land use for generations, there is the potential for conflict between multiple rights-holders to a given piece of land. These conflicts become more likely or salient in certain contexts. Rural areas near growing urban centers, for instance, often see an influx of outsiders seeking to buy land; it may be unclear to the urbanite who has the right to sell to them. Local elites may seek to exploit this ambiguity, expropriating smallholders' land in order to sell. In the first two chapters of this dissertation, I explore the ramifications of potential conflicts between rights-holders.

In the first chapter, "Decentralization of Land Governance and Elections in Burkina Faso," I focus on how these potential conflicts affect local politics. Despite the many potential benefits of providing public services in a more local manner, there remain concerns about elite capture and rent-seeking by politicians. In this first chapter, I combine a theoretical model of political behavior with data from local elections during the experimental pilot phase of a decentralization of land offices. Throughout, I explore to what extent observed behavior is consistent with politicians being motivated by their own private rents as opposed to a concern with constituent welfare. Newly-created land offices in a municipality will document existing rights; this documentation process inherently consolidates multiple rights and allocates them to a single rights-holder. This means that local political control will have distributional power over crucial land rights.

The experimental pilot phase of the decentralization reform in question, with random assignment to receive a land office during the time frame in question, allows me to causally attribute differences between treated and control municipalities to the decentralization. Fortuitously, the timing of elections in conjunction with the pilot allows me to disentangle anticipation effects (when politicians know a land office is coming, but have yet to see any implementation) from treatment effects once the land offices are operating. In anticipating

coming land offices, politicians expect that these offices will bring revenues into local government (which increase the potential for private rents), as well as shape land rights for constituents (thereby affecting welfare). Politicians do respond to these dual incentives: an additional 0.8 political parties contest elections in treatment municipalities. In the following election, revenues continue to flow from the land offices, but the land policy has largely been set during a first-stage documentation process that was completed. Treatment municipalities return to similar levels of party competition to the control group, which suggests that private rents are not the only motivation for politicians. I additionally explore heterogeneity in responses: effects are stronger in rural areas near urban centers, where land office revenues are higher and the clear documentation of rights is more salient for welfare, given potential buyers from the city. Finally, I explore voter behavior and attitudes, which seems to respond more to party actions than the underlying incentives of the land offices. Turnout is lower in treatment municipalities, and in Afrobarometer surveys, voters perceive more corruption among local politicians in these areas. This first chapter contributes to a broad literature on land rights, with an explicit attention to their social nature and the distribution of rights among actors who may extend interactions over land to the political realm. The chapter also documents political capture of local government, but optimistically suggests that this may be due to concern with constituents and therefore less costly than generally assumed in the literature on elite capture.

In the second chapter, "Customary Tenure and Agricultural Investment in Uganda," I consider how the distribution of rights among multiple individuals can shape tenure security and investment incentives. Secure property rights are crucial to unlocking agricultural investment; traditionally, customary land rights are modeled as less secure, in part because they are undocumented and in part due to the overlapping claims to a single piece of land. In practice, however, this may not always be the case: farmers often do not perceive customary land as less secure, and they may invest equally on all parcels. Qualitative work has explored the ways in which overlapping rights can influence perceptions of tenure security: when are conflicts between rights-holders likely to emerge? I incorporate this question into a model of agricultural investment with a binding liquidity constraint. This model allows me to explore how farmers may respond to changing land pressures under different tenure regimes.

In the model, I capture how rising land pressures and land values will relax the binding liquidity constraint, thereby allowing more investment on the land. At the same time, these land pressures give local elites more incentive to expropriate land from smallholders if they can claim legitimate transfer rights to customary land. Therefore, as land pressures rise, we should see farmers under-invest in long-term investments on customary parcels, because the land pressures make expropriation more likely and thus smallholder tenure less secure. I test the implications of this model using data from a survey I conducted of over 2,000 farmers in Uganda. I pair this data with a geospatial measure of the probability of urbanization, and use farmer-group

fixed effects to control for unobserved heterogeneity in farming skill and resources in looking at investment decisions between customary and freehold land. I empirically document divergent responses in long-term agricultural inputs to rising land pressures on freehold and customary land. That is, farmers invest more on freehold land as land pressures and values rise; this effect is attenuated on customary parcels due to the increased insecurity from land pressures. This paper importantly does not conflate incompleteness of rights with their (in)security, instead closely examining how multiple rights-holders interact in different contexts. It also addresses how the potential for elite capture can affect individual farmers: the inherent rarity of elite capture makes it difficult to document, but worries about it are more widespread and can have significant impacts on investment in some contexts.

Finally, I shift focus in the third chapter, "Markets and Child Nutrition in Rural Burkina Faso." Good nutrition early in life is crucial for later human capital and labor market outcomes, but improving it at scale has troubled policymakers. In this chapter, we consider carefully the context for nutrition in people's lives: people buy food in their local markets. In remote rural areas, markets have traditionally been studied in the context of supply chains and with an attention to rural agricultural producers, although a growing focus on food systems analysis is beginning to prioritize rural consumer-facing markets. This third chapter contributes to this growing literature with its focus on the empirical relationships between local markets and the nutritional status of the young children they serve in rural Burkina Faso.

This chapter works with a rich dataset collected for the purpose in 34 village markets in Dande district of Burkina Faso. This data contains a complete census of all vendors (in shops and open-air weekly markets) in the village, product listings for a sample of retailers, and biometric measures of 9-month old children in the area. We lay out a conceptual pathway of linkages between markets and nutrition, which highlights the complexity of the relationships and multitude of other factors involved in our measured outcomes, suggesting that any measured relationship should be weak. Turning to the data, we construct a variety of measures at the market level of the breadth of products available, the depth of the market, and market concentration. Using principle components analysis, we construct an index of market sophistication which is positively correlated with children's nutritional outcomes. Despite the low measured correlation consistent with the conceptual pathway, the relationship is stronger for shorter-term measures of nutritional status which should be more impacted by foods available and consumed. We then devote some attention to which particular features of the market are most important. Interestingly, the breadth of the market (the availability of many different products) appears to be particularly relevant. We also use a Lasso to isolate individual features. We do find, however, that many of the documented correlations are stronger for the average child than for the very smallest children in the far left tail of the distribution: these children seem equally-deprived in all markets, suggesting the need for complementary public health interventions to market-led growth.

This chapter is highly policy-relevant. Among the potential impacts of market-enhancing policies should be counted nutritional well-being, particularly for those interventions that improve the availability of healthy foods. Nevertheless, these key policies may not help everyone in the community, underscoring the importance of the distribution of effects in the population.

Throughout the three chapters of this dissertation, I focus on what we can learn from the spaces between. This includes the relationships between people, such as multiple rights-holders to land, as well as the relationships between realms, such as the market and the body. In doing so, I draw on the work of scholars outside of economics, such as anthropologists, political scientists, and nutritionists. In my work, I aim to not only translate into economics, but learn from the synthesis of disciplines and methods. This approach to development economics prioritizes the complex lived experiences of the poor: their investments and assets exist in a rich web of relationships to other people and the world around them.

Although this dissertation seeks to understand human behavior, an attention to policy underlies the questions I ask. Anticipating responses to policy changes crucially depends on the context, as I show in the first chapter. More importantly, what this illuminates about human behavior can help us craft better policy, to improve the lives of so many people who deserve better from their, and our, institutions.

Chapter 1

Decentralization of Land Governance and Elections in Burkina Faso

1.1 Introduction

Over the past three decades, developing countries have increasingly decentralized public services, moving government functions from capital cities and major urban centers to rural areas (Eaton et al., 2011). Providing these services closer to the site of use should allow for efficiency gains in local public goods provision (Casey, 2018; Oates, 1972), increasing providers' information about user needs (Kosec and Mogues, 2020) as well as decreasing users' transaction costs, even if governments are less able to solve local externalities or redistribute resources across space (Lipscomb and Mobarak, 2017).[1] Furthermore, local governments should be more accountable and responsive to citizen concerns (Casey, 2015). At the same time, however, there has been substantial concern and some evidence that politics at a local scale could suffer from capacity constraints and be more vulnerable to elite capture (Bardhan and Mookherjee, 2000; Bardhan, 2002; Faguet, 2014; Lago-Peñas et al., 2011; Ponce-Rodríguez et al., 2018; Brollo et al., 2013).[2] At a more local level, rent-seeking politicians are less constrained by opposing factions, which is particularly problematic in clientelistic systems where traditional institutions can pervade the bureaucracy (de Sardan, 2008). If, however, politicians are not only motivated by private rents (Besley, 2007; Dal Bo et al., 2013; Hanna and Wang,

[1] These trade-offs are not only important in the developing world, as decentralization is also a significant force in US and Western European governance. Oates (1972)' seminal work does not focus on the developing world.

[2] The impacts of local government capacity constraints, in terms of bureaucratic experience, ability to tax, and bargaining power for resources from the central government, have been shown to be detrimental to nighttime light density in Burkina Faso (Billing, 2019).

2013) but instead value constituent welfare,[3] then decentralization and attendant local political control could actually be beneficial, particularly in contexts where electoral pressures can be brought to bear on elites.[4]

In this paper, I theoretically and empirically examine local political responses to the decentralization of land governance in Burkina Faso. Beyond documenting these responses, I explore the extent to which politicians are motivated by private rents versus a concern with constituent welfare. Land offices consolidate land rights which, under customary tenure, were distributed among multiple individuals (Cotula et al., 2007), and instead allocate them to one person. The allocation of these unified rights can create conflicts: over land, certainly, but in the political realm as well. The experimental pilot phase of this land governance decentralization allows me to causally identify its political effects by comparing changes in matched treatment and control (randomly-assigned) municipalities over three elections.[5] Fortuitously, the timing of the pilot (relative to elections) allows me to distinguish political behavior in anticipation of the decentralization from the effects of implementation itself (which involved the creation of local land offices, registration of existing rights, and allocation of formal documents).[6]

I develop a theoretical model of local political parties and voters which distinguishes between incentives stemming from private rents to politicians and those emerging from a concern for constituent welfare. This model predicts that, in the absence of a decentralization reform, local elections see few parties contesting; more choose to enter in anticipation of land offices being created (the result of the announcement of treatment locations), as the coming land offices will provide additional government revenues, an opportunity for patronage, and, importantly, the ability to shape land rights for citizens. After implementation, when land offices have been created and policy (determining to whom newly-unified land rights will be allocated) has been set, the stream of revenues to the municipal government persists. Therefore, the model predicts that if private rents are the primary driver, party competition will continue, but if policy-setting is important, fewer parties will contest.

This model also predicts heterogeneous responses to the decentralization reform based on existing tensions in (customary) land rights in different regions, consistent with qualitative evidence. Specifically, there are two main types of land conflicts that can emerge in the consolidation of land rights: in rural areas near urban centers, and in areas with pastoralists. In near-urban rural areas, there is substantial demand from urbanites to buy documented land and an inability to distinguish between multiple rights-holders. The two incentives for parties, private rents and public welfare, are both stronger in near-urban municipalities facing

[3] I am agnostic about whether this is due to altruism or whether forward-looking politicians help citizens in order to improve electoral prospects given retrospective voting; both would have similar effects.

[4] Much as in Cruz and Keefer (2015), who show that programmatic parties have more success than clientelistic ones at implementing aid-financed projects.

[5] Causal identification has been a challenge in the study of decentralization, as policies rarely allow for experimentation at administrative-unit scales (Muralidharan and Niehaus, 2017; Blais et al., 2011).

[6] These effects are conceptually distinct, as in Brollo et al. (2013), but are often difficult to disentangle empirically.

external demand for documented land, and therefore there should be more party entry in these regions. By comparison, in areas with transient minorities of pastoralists, farmers desire to clarify and even exclude pastoralists' secondary access rights. Despite the importance of land policy for distributing rights in these areas, if the population of pastoralists is not electorally viable then political parties will not respond. In near-urban areas, the post-implementation period allows me to distinguish between private rents (which remain high) and constituent welfare. The model, together with an empirical examination of heterogeneity, suggests that parties do care about constituent welfare and the role of policy in shaping it.

My empirical results from the experimental pilot phase of a land governance decentralization in Burkina Faso are consistent with the model's dual conceptualization of party incentives, and they suggest that constituent welfare is a significant driver.[7] In the election following the announcement of local land office locations, I find a causal 0.8 party increase in the number of political parties contesting local elections in treatment municipalities, as politicians want a role in setting local land policy. This effect is stronger in rural municipalities that are closer to urban centers, as predicted by the model. There are more potential resources to control in these areas (from service fees), and land policy is more important to constituents facing outside pressures on their land. After implementation, elections in treatment and control municipalities have similar numbers of contestants, despite the continued stream of revenues from land offices in treatment areas.[8] These additional party entrants induced to compete do not appear to be electorally competitive, often failing to win any council seats. However, as the model demonstrates, even uncompetitive parties may play a role in determining local policy.

Voters seem to respond more to the observed responses of political parties than to the underlying decentralization reform itself. This could be due to less information about planned policy changes, in addition to an observed pessimism in interpreting politician behavior. Surprisingly, despite the increased importance of local governments that will carry out land administration, voters are less likely to cast ballots in treatment municipalities in 2012 (in anticipation of treatment).[9] I suggest several potential explanations for this puzzle. Using Afrobarometer survey data, I find that voters actually perceive higher levels of corruption in local levels of government during this election campaign. This suggests that economists may not be the only ones who interpret politician behavior as rent-seeking.[10]

[7] These results are consistent with those of Cruz et al. (2018b), where more political competition is seen in regions with more social fragmentation, which could improve public good provision. However, this work highlights that the social cleavages in question need to be politically viable (unlike pastoralists, as I explore in this paper), and politicians must be able to provide relevant public goods to different groups. Additionally, political contestation must be impactful: more fragmented areas do not behave differently before meaningful decentralization, unlike a world in which political patronage and access to the state was the only driver of behavior by parties.

[8] This is again particularly true for near-urban municipalities: rents will continue to be higher after implementation, suggesting that private rents are not the only driver.

[9] This is in contrast to Blais et al. (2011), who find increased turnout in sub-national elections as their relative importance increases.

[10] Cruz et al. (2018a) argues that although voters do care about the policy positions of parties, they may not be informed

This paper contributes to three literatures within political and development economics. Although this paper does not directly measure the provision of public goods or welfare, the randomized control allows for precise causal identification of the effects of decentralization of government services, and I am able to empirically distinguish anticipation from treatment effects on political behavior (Brollo et al., 2013).

It also speaks to a literature on political motivations and concerns with elite capture, which has been of particular concern in the context of customary institutions in Sub-Saharan Africa (Hagberg, 2004; Adotey, 2019; Benjaminsen and Ba, 2009; de Sardan, 2008). Although my results are not entirely reassuring, they do suggest that electoral pressures can (somewhat) counteract local elites.[11]

Finally, this paper draws upon and expands the rich literature on land rights, particularly that on customary institutions in Sub-Saharan Africa and the interface between customary and state land institutions.[12] Although qualitative work has stressed the social nature of these land rights (and therefore their importance to many aspects of life) (Cotula et al., 2007; Alden Wily, 2011; Van Leeuwen, 2014), economists have primarily examined implications for agricultural investment (Brasselle et al., 2002; Place, 2009; Fenske, 2011; Goldstein and Udry, 2008). I shift the focus to the political realm, exploring how the distribution of land rights and tensions between rights-holders can influence governance.

In documenting political responses to the experimental decentralization of land offices and disentangling motivations for political actors, this paper has optimistic implications for policy. Despite showing that politicians behave as if they want to control local land offices, there is suggestive evidence that this is driven by a policy-centric focus on constituent welfare in addition to a desire for private rents. Therefore, political control of local governments might not be as concerning, and elite capture may not negate the benefits of efficiency and local accountability. This seems particularly true in cases where electoral incentives do not favor the elite, such as in near-urban areas where smallholder farmers worried about elite expropriation are numerous enough to counteract the political pressures of powerful elites. As Burkina Faso and other countries in the region continue to decentralize land governance and other public services, these findings will be relevant in designing safeguards on local elite capture.

of these even if they drive candidate behavior. Lierl and Holmlund (2019), on the other hand, find that municipal voters in Burkina Faso do not respond to information about incumbent performance.

[11] This implication is related to work by Eifert et al. (2013), who document ethnic mobilization in competitive elections.

[12] Customary land rights are not the only customary institutions which the state attempts to document, as Joireman (2014) shows; importantly, she argues that this ascertainment does not necessarily make the application of customary law any less flexible.

1.2 Context

1.2.1 Land Rights in Burkina Faso

The reform studied in this paper is not only an abstract decentralization of government services, but also a land reform that aims to document and formalize customary land rights. The existing shape of customary land rights in Burkina Faso is key to understanding the value of these local land offices. Most fundamentally, rights to a given piece of land are distributed among multiple individuals in a community (Cotula et al., 2007). This makes land rights inherently social; to fully grasp them involves considering the relationships between the people involved (and their interactions in multiple realms, including the political). However, only holding partial rights does not itself make those rights less secure (Brasselle et al., 2002).[13]

Ensminger, an anthropologist, states that "A common characteristic in almost all African customary systems is for use rights to be assigned at the household level, whereas transfer rights are assigned at a higher level such as the lineage, clan, or chiefdom" (Ensminger, 1997, p. 169). This is true in Burkina Faso, as primary use rights are held by many smallholder farmers, while transfer rights are generally held by local elites (including chiefs or lineage heads).[14] Additionally, in some regions of the country, pastoralists traditionally hold access rights to land,[15] allowing them to graze their herds on crop residues after harvest and access water points in exchange for manure (Hagberg, 1998). These transient pastoralists are often both physically and socially marginalized, pushed to 'livestock corridors,' and constitute a very small share of local populations,[16] especially as chemical fertilizers are increasingly adopted.[17]

These broad patterns of distributed rights lead to two main dimensions of land conflicts. First, the ambiguity about whether use rights-holders or transfer rights-holders are the 'owners' of land can be exploited in rural areas near urban centers[18] which face a growing demand for land by outsiders[19] who do not understand the local complexities of land rights. Essentially, who has the right to sell land to an outsider? Local elites,

[13] One implication of this security is that farmers are willing to invest in their customary land: "sufficient investment incentives tend to be provided by basic rights of use that, under normal circumstances, are guaranteed to many villagers (including migrants) by the local informal order" (Brasselle et al., 2002, p. 402).

[14] Despite these elites being few in number, they are relatively powerful and/or wealthy, which can give them an outsize political importance. Their holding transfer rights was traditionally a way to resolve distributive land pressures; for instance, when newcomers came to an area, local elites could allocate them land.

[15] A secondary form of use rights, although for clarity I will exclusively call these access rights.

[16] And perhaps a smaller yet share of local voters in the areas they pass through.

[17] In Sahelian regions of Burkina Faso, pastoralists dominate the population and land use systems, which may result in very different land rights and political dynamics. However, none of the pilot-phase municipalities considered in this paper are pastoralist-dominated, and I therefore do not explore these regions in detail.

[18] I will refer to these rural areas that are reasonably close to (rapidly growing) cities as 'near-urban' for concision, but it is important to note that they are predominantly rural in themselves. That is, local constituents are engaged in primarily rural ways of life. However, urban residents increasingly seek to purchase rural land near their city homes as a source of food, insurance, connection to the countryside, or for use as a vacation home. These urban residents may have extended family in other regions of the country, but seek a closer rural retreat. This also implies that urban buyers likely have little or no connection with the inhabitants of the nearby rural municipalities in which they seek to buy land.

[19] Well documented in Burkinabé media: the mayor of Loumbila, a municipality near Ouagadougou, complains "The whole world is coming to Loumbila to buy land," detailing plans to charge different fees to outsiders (201, 2016).

who may feel they have a legitimate claim given their traditional transfer rights, often also have greater access to these outsiders due to their education or other advantages and so may exploit this ambiguity. "There is a fine line between chiefs as (often self-declared) owners of all land in customary laws, and chiefs as trustee administrators" (Alden Wily, 2011, p. 6). A report by IIED and FAO sounds the alarm about this power imbalance when (as seen in near-urban areas) land values are rapidly rising: "As land values rise, farmers may be forced or tempted to sell their land. Where land is still under customary chiefs, these may be tempted to sell off lands for housing and other developments, regardless of the views of those actually farming this land" (Cotula et al., 2004, cited in Cotula et al. (2007, p. 21)). Despite abundant stories of how "local elites have been able to use their position and the ambiguities of customary law to appropriate land to further their own economic and political interests" (Ubink, 2008, p. 18), especially in near-urban areas (Ubink and Quan, 2008), this particular facet of how customary tenure adapts to external pressures has been underexamined by economists.[20] The second dimension occurs in regions where pastoralists hold access rights. Herds can cause damage to crops, for which herd owners are expected to (but may not always) pay compensation (Hagberg, 1998). These seasonal access rights are continually being renegotiated, but farmers may seek to exclude pastoralists altogether as rights are consolidated. I will explore how these two tensions created by customary tenure systems mediate political responses to the land office decentralization.

Customary tenure arrangements continue to be significant in Burkina Faso despite previous legal regimes failing to recognize them, as national laws were largely ignored locally. However, in conjunction with the Millenium Challenge Corporation's (MCC) Rural Land Governance project, the regime led by Blaise Compaoré passed two laws pertaining to rural land rights in 2009[21] and 2012.[22] These recognized customary rights as legitimate, laid out plans for municipality-level land offices (known as *Services Fonciers Ruraux*, or SFRs) that would be supported by MCC in the pilot phase, and described documents (called *Attestation de Possession Foncière Rurales* or APFRs) that would fall between full title and defined use rights. These documents did provide some flexibility in documenting secondary customary rights, but by providing a singular document to a land 'owner' they inherently unified distributed rights over a given piece of land. This documentation process therefore not only affects the security of tenure (and therefore investment), but also the distribution of rights. In this paper, I explore whether local administration can appropriately handle this distribution.

[20] There is a similar dynamic at play in China, where lineage group leaders who become village officials often expropriate land, particularly in the near-urban hinterland (Mattingly, 2016).

[21] Law 34/2009 "On Rural Land Tenure"

[22] Law 34/2012 "On Agrarian and Land Reform in Burkina Faso"

1.2.2 Politics in Burkina Faso

The decentralization of land offices in Burkina Faso occurred in a context of one-party domination and nationwide decentralization. In contrast to the land offices, most decentralized service provision was under national direction rather than local control. Additionally, despite the multitude of political parties in elections, for much of the country's history, one party, the Congrès pour la Démocratie et le Progrès (CDP) (headed by Blaise Compaoré) has been preeminent.

Blaise Compaoré and the CDP took power in 1992 in a coup that overthrew the previous long-serving president, Thomas Sankara. The new government passed the first decentralization laws in 1993, but it was not until 2004 that authority over public goods provision and finances were transferred to local governments, and many rural 'communes' (municipalities) were created to fill these governance roles. Each municipality would be governed by a council made up of two elected representatives from each village in the municipality, along with a mayor elected by the council. The first municipal elections were held in 2006, in which the CDP won 72% of council seats; allied political parties came in second, while the opposition only won a few seats. Participation nationally was around 49%, relatively high for local elections on the continent.

In November 2010, Compaoré was easily elected for a fourth term as president. However, by the 2012 joint legislative and municipal elections, a viable opposition party (the Union pour le Progrès et le Changement, UPC) had emerged. The UPC was mobilized by concerns that the CDP would amend the constitution to allow Compaoré to be reelected. Turnout was 76% nationally, "attributable to the perception that the newly established UPC would present a credible challenge to the CDP at the polls, whereas a CDP victory was viewed as a certainty in the 2007 pre-election period" (Pryce and Nascimento, 2014, p. 340). Nevertheless, the CDP won 70 of 127 legislative seats. The opposition's fears turned out to be well-founded, as in October 2014, Compaoré did attempt to amend the constitution to extend his rule, which prompted a popular uprising. The political upheaval lasted for 18 months, although in November 2014 a transitional government (backed by the military) was installed until elections could be held. The transitional government suspended municipal councils and sent 'special delegations' to fill administrative roles until new elections could be held (Lierl, 2015), although local bureaucracies, including SFRs, remained in place. November 2015 saw presidential and legislative elections, which barred allies of Compaoré from running; turnout was around 60% nationally, and former Prime Minister Roch Marc Christian Kaboré was elected president. The transitional period was finally brought to a close with municipal elections in May 2016.

There are a few features of the broader political environment also worth noting. First, in order to contest elections at a municipal level, candidates must belong to a political party, and ballots list parties rather than

individual politicians. However, these party affiliations are unstable,[23] and party alliances are determined in each locality and may not reflect national alliances between parties. There is a constitutional ban on ethnic affiliations for political parties, although some have noted that at a local level, ethnic divisions or tensions often play a role in understandings of parties (Hagberg, 1998).

The municipal councils that are the focus of this analysis are also worth highlighting briefly. Decentralization efforts were ongoing nationally, giving municipal governments at least partial responsibility for primary schools, health centers, water point maintenance, and administrative services such as civil registries (Lierl and Holmlund, 2019). However, this was primarily a de-concentration of functionality, rather than a delegation of decision-making power to local levels; staff and decisions were sent from the central level to merely implement locally. Additionally, the experimental setup of the Rural Land Governance (RLG) pilot phase should guarantee that the transfer of these other responsibilities was orthogonal to treatment status, and thus should not drive the observed results.

1.2.3 MCC Rural Land Governance Project & Impact Evaluation

Finally, it is important to have a clear sense of the 'treatment' under consideration (a full timeline is presented in figure 1.2). The Millennium Challenge Corporation (MCC) signed a 5-year, $480.9 million, compact with the government of Burkina Faso in 2009. One component of this compact was a Rural Land Governance Project, aimed to increase investment in land and rural productivity by improving land tenure security and land management. This process was designed to be locally-controlled in order to take advantage of local knowledge of land rights. However, this also implies that the consolidation of land rights for an individual would be subject to local government influence.[24]

During the first (non-experimental) phase of the project (2009-2012), MCC supported the government in drafting the two land laws described above, as well as piloted land offices in 17 municipalities. These 17 locations were chosen as priorities (although the exact criteria are unclear), and are not balanced at baseline when compared with their phase I comparison municipalities nor with the rest of the country. This period also saw national-level legal changes, so the first phase is less useful in causal identification of impacts.

In mid-2012, plans were made for the second pilot phase of the project, when an additional 30 municipalities would be brought in. These locations were chosen in 30 matched pairs, of which one would randomly be selected to receive the land office (SFR) during the pilot phase in order to conduct a rigorous impact

[23] A "leader builds up power and popularity through a network of alliances and relationships rather than through a program or an ideology; this is why party affiliation can change overnight" (Hagberg et al., 2018, p. 74). Gottlieb and Kosec (2019) document party switching in Mali as being driven by political incentives.

[24] Despite the emphasis on local control in *ex ante* messaging, MCC may have exerted control over the process in pilot municipalities. This could diminish the role of policy in practice, which in turn could shape the observed election response in 2016.

evaluation.[25] The announcement of treatment locations was made prior to the 2012 municipal elections, almost certainly for reasons of political expediency.[26] It seems reasonable to therefore consider that in the 2012 elections, local elites in treatment municipalities at least had been made aware that they would in the future receive local land offices, and any responses are due to the anticipation effects of this announcement.[27]

Between the 2012 and 2016 elections, the Rural Land Governance project proceeded with implementation. This began with creating and staffing rural land offices (SFRs).[28] Then, each village in the municipality created a participatory land use map, which brought the community together to demarcate overlapping rights and claims to land.[29] After mapping, landowners could request formal documentation of their rights in the form of APFRs, paying a locally-set fee for this document. Although 13,447 applications for APFRs were received by mid-2014, only 2,167 had been approved by local governments, and only 403 documents had actually been distributed.[30]

The national political unrest put the delivery of documents largely on hold from 2014 until new municipal councils were elected in 2016. However, the land maps created in 2013-2014 fixed the identity of the land 'owner' who was eligible to receive an APFR; in the model I outline below, this prescribes the policy of land reform. The municipal council elected in 2016 could nevertheless expect an additional stream of revenue in treated municipalities from processing documentation, paid by residents who wanted 'second-stage' documentation beyond the registration of their rights on a land map.

[25]This impact evaluation is ongoing, and focuses on impacts on tenure security and investment at a micro-level. Unlike in Briggs (2012) in Ghana, I find no strong baseline differences between treatment and control areas (nor between study areas and the rest of the country, for that matter) in political outcomes, suggesting locations were not chosen to politically benefit the incumbent party.

[26]It is difficult to pinpoint the precise public announcement of Phase II treatment locations, but they are listed in the baseline evaluation report submitted in August 2012 and are highlighted on a public map dated November 2012 (figure 1.1).

[27]I have been unable to locate local news announcements of these coming land offices prior to the 2012 election, however, so it seems unlikely that a majority of voters were fully aware. Therefore, I interpret responses by political elites (including parties) as stemming from the announcement, but responses by voters (including turnout and vote choices) as being proximally caused by the behavior of political elites.

[28]Two agents were hired to staff each SFR: a mapmaker (skilled, often recruited from the city) and a communications agent (recruited locally, and generally suggested by the mayor or council members in practice). Several people involved in the process noted that the mapmakers often abandoned what was seen as boring, low-paid work in rural areas, so communications agents were trained to take over map-making responsibilities. Additionally, although all positions should have been filled competitively, local politicians had significant influence in agent selection.

[29]During this period, over 60,000 stakeholders were trained on conflict resolution and land management. This mapping exercise was intended to document all existing rights (including those held by multiple people), but in reality presented an opportunity for officeholders to reallocate rights with real distributional consequences. By inviting some rights-holders and not others, for instance, the rights documented could be limited. In MCC's report as they closed out the compact in July 2014, they noted that 47 communal land use maps had been created (in 17 phase I and 30 phase II municipalities), 78 land administration offices had been established or upgraded, and 47 municipal buildings (holding SFRs) had been constructed (Millenium Challenge Corporation, 2014). These buildings were purposely located near other administrative offices to facilitate a 'one-stop shop' for all necessary documentation.

[30]"The National Municipal Association of Burkina Faso (AMBF) blames the slow implementation of new, decentralized land services on the lack of autonomy allowed to local governments to use funds transferred from the central government as they see fit, and on the reluctance of deconcentrated technical services to support local empowerment (Kaboré et al 2014)" (USAID, 2013, p. 22). In particular, the final approval of APFRs initially required action by the central ministry responsible for lands, which delayed delivery of documents.

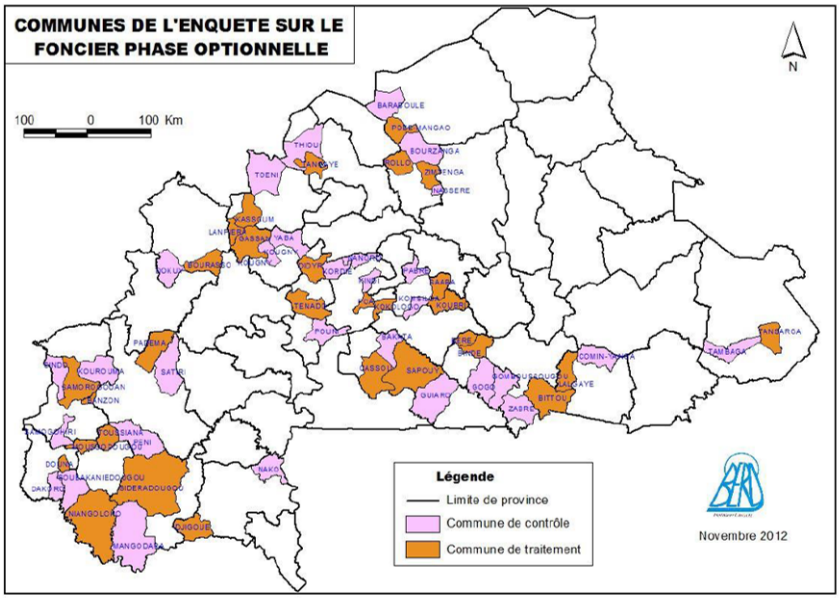


Figure 1.1: Map of RLG Impact Evaluation Municipalities

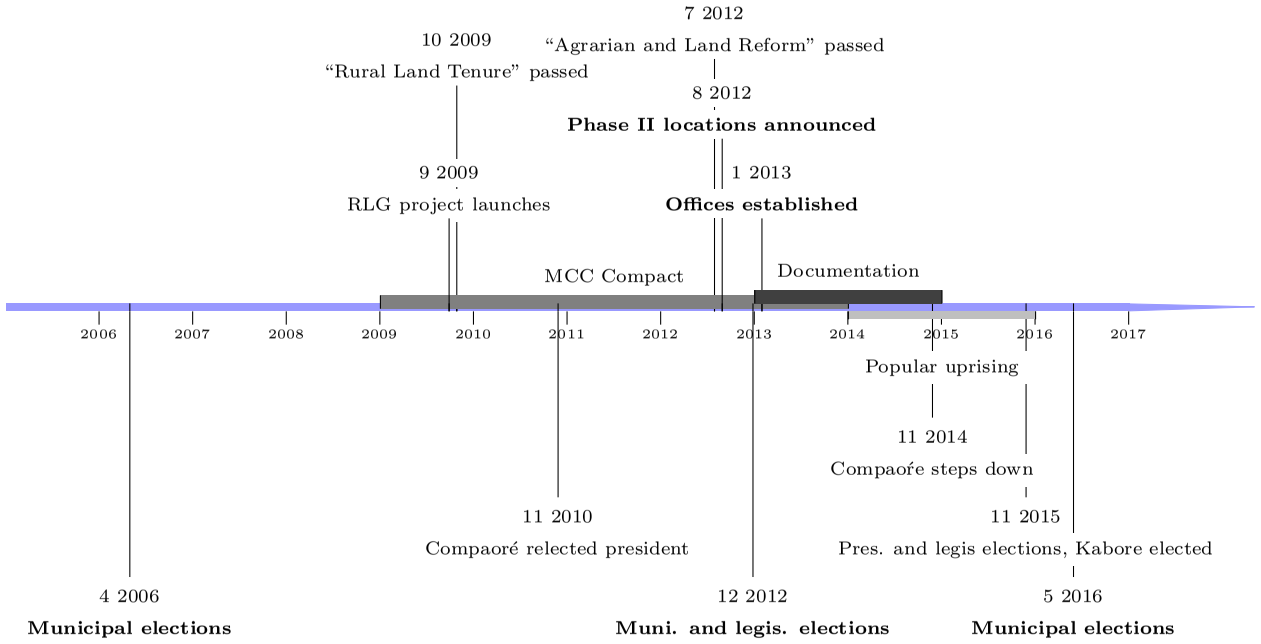


Figure 1.2: Politics, Land Rights, and Impact Evaluation Timeline in Burkina Faso. Observed data and treatments in bold.

1.3 Model

In this stylized model, I explore party entry decisions[31] in the context of a party competition model (drawing from Bardhan and Mookherjee (2010) and Bardhan and Mookherjee (2000)[32]). This model will help make sense of the political responses to the decentralization of land administration. Although there are several potential models which could capture some of the observed behavior,[33] this model incorporates the tensions inherent in land administration in Burkina Faso and thereby accounts for meaningful heterogeneity in how different areas shape political competition. More details, and a formal solution, can be found in the appendix. This model also allows for more than two potential parties, although I will focus on the entrance of a second party against an historically-dominant incumbent for clarity of intuition.

1.3.1 Environment

Consider a stylized village composed of several potential groups of people, with groups denoted by g (in population shares α_g) and parties denoted p. There is an incumbent political party which has historically dominated local politics and therefore faces extremely low costs of contesting elections. These costs are low enough that for any non-zero probability of winning the election, this party (denoted d) always contests the election. A potential challenger can choose to create a political party c and contest local elections, although this is costly (with party-specific costs of running for office C_p).

Political Incentives

The benefits of holding elected office are twofold: first, there are private rents that accrue to the officeholder, E_p, which could be non-monetary, such as prestige or the ability to appoint bureaucrats in a patronage system, but are increasing in the resources controlled by the local government.

Second, parties have intrinsic preferences over the interests of the classes they represent, which are important regardless of which party is in power. Whether these preferences stem from altruism or other political considerations, the model takes them as given.[34] I represent these preferences with welfare weights w_g^p on the utility $U_g(\theta\pi)$ of each group g. This utility is determined by the policy π of the officeholder in power, which in this case can be thought of as shifting the allocation of newly-unified land rights to one

[31] à la Tavits (2006).

[32] Who, in turn, draw from a Grossman and Helpman (1996)-style model.

[33] For instance, a model of naive party entry with parties learning that they are uncompetitive would explain the reduction in party entry between 2012 and 2016, but there are still a substantial number of parties contesting the 2016 elections which win no council seats. Alternately, there could be more uninformed voters (choosing only on their individual loyalty rather than expected utility under proposed policies) in more remote areas, which leads to less party entry in those areas. However, rent-seeking parties should still try to win office in response to decentralization.

[34] A purely altruistic politician might weight all citizens equally, with $w_g^p = 1, \forall g$, but they can also have preferences for different groups.

group or another,[35] and is assumed to be a credible commitment[36]. Utility is also determined by a parameter θ which represents the correlation between *de jure* and *de facto* rights: that is, the ability to turn the policy position π_p of a candidate for office into reality, where it is this reality that matters for constituent welfare. This captures an important distributive tension in the formalization of customary land rights in Burkina Faso. Voters' utility improves if π shifts the allocation of land rights towards them, but only insofar as that policy is enacted by θ. Therefore, if a party p wins office, their benefits of holding office are given by $E_p + \sum_g \alpha_g w_g^p U_g(\theta\pi_p)$ and if they lose office to party q, their payoff is $\sum_g \alpha_g w_g^p U_g(\theta\pi_q)$.

Politically-informed voters choose who to vote for based on their expected utilities under each party's governance and their (randomly distributed) loyalty towards the incumbent party, v_g, which may be negative.[37] Therefore, voters of group g vote for party c over the incumbent d if $U_g(\theta\pi_c) \geq U_g(\theta\pi_d) + v_g$, where π_p is the policy choice of party p.[38]

Solution Concept

I solve for party entry and policy choice using backwards induction: parties consider how their entry and policies will affect voter choice, and maximize their own payoffs with this in mind. Therefore, I begin with voter choices before modeling the party decisions. The order of party decisions is as follows: first, the challenger decides both whether to contest the election and what their policy, π_c, will be. Then, the incumbent party (which always contests) announces their own policy, π_d.

1.3.2 Pre-Reform Solutions

Before the announcement of the land administration decentralization, local governments are largely constrained to follow central government policy directives. In the model, this can be represented as $\theta = 0$: local governments are unable to put their policies into action, so policy platforms are irrelevant. Informed voters of group g, then, vote for the challenger over the incumbent if $0 \geq v_g$.

Noting once again that policy choices are irrelevant, the challenger will choose to contest the election only if the expected benefits of winning (private rents) are greater than the costs of contesting. Note that if the net average loyalty to the incumbent is positive ($\sum_g \alpha_g \overline{v_g} \geq 0$), the probability of winning office is relatively

[35] For instance, between the individuals who hold use and transfer rights.

[36] In future work, I will relax this assumption and consider the ways that politicians can choose costly (and therefore credible) signals. However, models which incorporate credible policy commitments consider policies that are costly for politicians to implement, incentivizing reneging after being elected. By contrast, local politicians anticipating the documentation of land rights funded by the central government do not face different costs of implementing their policy platforms, so it seems reasonable that their announced policies are more credible.

[37] The literature on voter responses to campaign promises is mixed. Cruz et al. (2018a) find that voters do judge candidates based on their campaign promises and past performance, while Lierl and Holmlund (2019) find that municipal voters in Burkina Faso do not change their votes in response to positive or negative information about incumbent performance.

[38] This model could also capture ethnic voting dynamics, where the ethnicity of voters and politicians affects the importance of loyalty.

low. Therefore in many cases, the challenger will not contest the election, resulting in the uncompetitive electoral environment observed before the introduction of the land reform.

1.3.3 Reform Announcement Solutions

When a municipality learns that it will receive a land office in the next electoral term, the policies implemented by the next election's winner become meaningful to both voters and politicians. Land offices in Burkina Faso were designed to be locally controlled, unlike the de-concentrated municipal services which operated under direction from the central government. The decisions made during the land documentation process could matter substantially to constituent well-being. Newly-unified land rights will be given to one individual (likely from the multiple rights-holders under customary tenure), which is inherently redistributive.

If different political parties have different welfare weights for population groups, they will have different 'ideal' policies for the land reform. These diverging policy preferences will drive parties to contest elections more often in two ways, as shown formally in the appendix. First, parties would like to win office and enact their preferred policies, directly improving welfare for the constituents they care most about. Second, even if they are not elected, by announcing policies that favor an electorally-viable group they can induce the incumbent party to shift their own (credible) policy platform.[39] Essentially, in order to win votes from multiple groups, the incumbent will respond to the policy proposal of the challenger by moderating their own policy stance.

Heterogeneity: Near-Urban Areas

This model also captures the dynamics of the primary land tensions and documentation in Burkina Faso and predicts heterogeneity in different regions.

Near-urban areas face high demand for clearly-documented land from outsiders.[40] This allows local governments to set higher fees for documents (and expect more documents to be requested),[41] increasing the municipal revenue available to local officials as private rents.[42] Formally, this is represented by E_p increasing

[39]This could also function through contestants earning 'a seat at the table' in later negotiations about documenting land rights, which moderate implemented policies.

[40]Rural residents are embedded in the same social environment as their customary land rights; the individual who holds secondary (access, transfer, etc.) rights to your farm plot is your neighbor, uncle, or friend. As documented in a substantial body of qualitative evidence, this also means that bundles of rights being distributed across multiple individuals does not in itself make those rights less secure. However, an outsider to this social system will struggle to parse its property rights. The value of clearly documented rights, backed by the legal framework of the state (as opposed to the social environment), is therefore higher for outsiders to the community, particularly those seeking land for part-time use who may never become part of the community. Alternately, local residents may want documentation of their land in order to sell it to outsiders who will not buy or will pay less for undocumented land.

[41]Even if outsiders are unable to request documentation themselves, local rights-holders are willing to pay more with the expectation of passing these costs on to wealthy outside buyers.

[42]Lierl (2017) and Lierl and Holmlund (2019) are motivated in large part by embezzlement among municipal governments in Burkina Faso; Hagberg (2004) describes an expectation that "the leader will 'eat' part of the money."

more in near-urban municipalities in response to the announcement of treatment, leading to more party entry in these areas. This is a relatively straightforward story of political rents increasing and a corresponding political response.

However, the model also demonstrates another mechanism by which the introduction of land offices in near-urban areas leads to a greater response by political parties: constituent welfare. Constituents may care more about land documentation policy in near-urban areas precisely because they face land pressures *from outsiders*. In an isolated rural environment, if the documents created by land offices are granted to an individual who previously did not hold primary use rights (or exclude secondary rights-holders), there are relatively few consequences: the socially-recognized land rights do not change. This can be modeled as a low θ: *de jure* rights as documented do not get translated into *de facto* reality. However, in near-urban municipalities, the risks of the documentation process become larger. Imagine that documents are granted to a secondary rights-holder who is not the primary user of the land. They then sell this land to an urbanite, who accepts the document at face value as indicating the document-holder is the appropriate person to sell the land. The urbanite is able to enforce their legal rights through better access to the formal (state) justice system. This dynamic is captured in the model as higher θ: the land documentation process has larger effects in near-urban areas than in more remote ones where implementation of a policy may be blunted by the strong social relations in which land rights continue to be embedded. This also implies that local elites who hold secondary transfer rights have more incentive to control the documentation process because if they receive land documents in their name they can sell it on to outsiders (while in rural areas there is less external demand, and elites cannot use expropriated land efficiently themselves). The higher θ in near-urban areas implies a greater weight to policy positions in determining constituent welfare, which will cause more political parties to contest elections.

I have shown, then, two mechanisms by which potential candidates in municipalities close to urban areas will respond more strongly to the creation of land offices than their counterparts further away. Both of these mechanisms stem from urban outsiders' demand for land and their inability to navigate the nuanced social complexities of customary tenure. Despite having the same net effect, the two mechanisms are theoretically distinct; the latter goes beyond private rents to account for politicians valuing their constituent welfare. I suggest ways to disentangle these mechanisms in the results section of this paper.

Heterogeneity: Pastoralists

This model could also be used to consider areas where pastoralists with secondary rights represent an important concern for land offices to resolve. Primary rights-holders may desire policy platforms that will clarify or exclude pastoralists from accessing their land as herds can cause crop damage. Pastoralists, on the

other hand, may wish to see their secondary access rights enshrined in formal documents including land use plans. This again makes constituents weight policy platforms more strongly, and, in turn, should (all else held equal) increase the number of parties contesting the election.

There is one important difference between municipalities facing near-urban land pressures and those facing pressures from pastoralists: the population shares of relevant constituent groups. In near-urban areas, party challengers who value smallholder farmers (as opposed to elites with secondary transfer rights) can make large electoral gains simply by proposing a more favorable policy allocation to the numerous farmers.[43] Appealing to pastoralists at the expense of farmers is not electorally viable, as pastoralists make up no more than 10% of the local population in these regions[44] and may not be registered to vote locally. Knowing that winning office is nearly impossible, not only are potential parties less able to put their own policies into action, but the incumbent is also less likely to shift their own policy in response (as there are few voters to 'poach' and becoming more favorable to pastoralists opens them up to challengers on the other side). Therefore, despite the important land conflicts in areas where pastoralists coexist with farmers, the model would predict relatively smaller response by political parties, as the costs of contesting are too high relative to an unlikely realization of benefits. If there was more variation in the population shares of pastoralist groups in experimental municipalities, the threshold imposed by these costs might be surpassed, in which case parties would enter more in response to this type of land conflict.

1.3.4 Post-Reform Solutions

I also observe elections that occur after the creation of land offices, so it is instructive to see what the model predicts. Local political actors responded to the promise of local control during the decentralization reform, which was most clearly seen in the first stage of the process: creating participatory land use maps which documented existing rights (including secondary rights). After this, all that remained was to give out formal documents as requested according to the consolidated map.[45] This means that by the 2016 elections, the policy options about land were curtailed (θ decreases), although rents from controlling the land offices (including fees from processing APFRs) remained. Therefore, the number of parties contesting elections should return close to the pre-reform case.

In near-urban areas, note that outsider demand for APFRs would maintain large private rents from holding office. Therefore, if private rents were the primary driving force for politician behavior, the model would predict persistently higher political competition in treatment areas near urban centers. If, however,

[43] As is seen globally, elites, although few in number, have financial resources that may make them attractive to court for the incumbent.

[44] This is true when pastoralists are identified either by ethnicity or language.

[45] Few APFR documents had been given out by 2016.

near-urban areas also see a drop in the number of parties contesting, that is suggestive that parties are primarily concerned with constituent welfare.[46]

1.4 Data

In this paper, I use several data sources to empirically examine political responses to the decentralization of land reform, matching them at the municipality-level with MCC's pilot-phase treatment status.

1.4.1 CENI Electoral Returns

There have been three municipal elections since decentralization reforms created municipalities as an administrative unit with a democratically-elected council. These occurred in 2006, 2012, and 2016. The *Commission Electorale Nationale Indépendante* (Independent National Electoral Commission, French acronym CENI) publicly reports certified results of all elections, including these municipal elections. These electoral returns specify, at the municipality-level, the number of registered voters, the number of votes cast, as well as the performance of each party contesting the election (both in the number of votes and seats won). They do not include the party affiliation of the mayor indirectly elected by the council, nor any information on candidates or winners from party lists (nor the policy platforms of the contesting parties).

CENI currently reports online the electoral results from the 2015 presidential election, 2015 legislative elections (reports at the province level), and 2016 municipal elections (reports at the municipality and village levels) (Commission Electorale Nationale Independente du Burkina Faso, 2016). However, the Internet Archive contains municipality-level results for both the 2006 and 2012 municipal elections (Commission Electorale Nationale Independente du Burkina Faso, 2006).[47]

1.4.2 Afrobarometer Surveys

In order to examine the attitudes and perceptions of voters that may be driving my results, I also use data from the subnationally geo-coded Afrobarometer survey (Benyishay et al., 2017). The Afrobarometer surveys use nationally representative samples of 1,200 citizens geo-coded to the municipality of residence. There have been three rounds of this survey in Burkina Faso to date (2008, 2012, and 2015) which neatly parallels the timing of municipal elections and the MCC intervention. Each wave of this repeated cross-section asks many of the same questions on political attitudes, including beliefs about and preferences for

[46] It is not conclusive, as new political entrants could also be learning about their electoral viability; if they are driven by private rents, but learn they are unlikely to win office and be able to access these rents, politicians may be better off joining the ruling party rather than contesting independently.

[47] I accessed 2012 results directly from the CENI website, but these results have since been removed (Commission Electorale Nationale Independente du Burkina Faso, 2012).

democratic functioning, perceptions of corruption, political identity, and voting intentions.

Despite being representative of the country as a whole, Afrobarometer does not survey citizens in every municipality. This restricts the sample in pilot-phase municipalities considerably, particularly as pilot municipalities were specifically chosen as priority areas in land conflicts (and are thus not necessarily representative of the country as a whole). The distribution of respondents in pilot-phase municipalities in each wave is given in table 1.1.[48]

Year	Treatment	Control
2008	5 Municipalities	2 Municipalities
	80 Respondents	40 respondents
2012	11 Municipalities	10 Municipalities
	88 Respondents	80 Respondents
2015	7 Municipalities	4 Municipalities
	96 Respondents	64 Respondents

Table 1.1: Distribution of Afrobarometer survey respondents in pilot-phase municipalities

1.4.3 Other Data

I use several other data sources to construct covariates and secondary outcomes, including measures of heterogeneity in existing land rights. Geo-referenced data were accessed through the William and Mary AidData database, including mean travel time to urban centers, population estimates,[49] conflict events, and land use (Goodman et al., 2019).

In order to measure where pastoralists (and their land rights) are significant local forces, I construct several variables of the share of pastoralist ethnic groups in each locality.[50,51] First, I use the Spatially Interpolated Data on Ethnicity, which draws on DHS surveys, along with population rasters, to compute the share of each municipality's population belonging to either the Fulani/Peul or Touareg/Bella ethnic groups, the main pastoralist groups in Burkina Faso (Müller-Crepon and Hunziker, 2018). I also use the primary language spoken by respondents in the 2006 census to compute the share of respondents speaking Fulfuldé in each region, the language of the Fulani/Peul people (Minnesota Population Center, 2019; Kevane, 2020).[52]

[48]Power calculations suggest that the sample in experimental municipalities is sufficient to detect reasonable changes in outcomes of interest, even in cross-sectional inference.

[49]Note that these are for the entire population, not only adults; I use this to compute the percentage of people who are registered to vote, which differs slightly from the standard voter registration rate (the percentage of eligible voters who are registered).

[50]It is also possible to use FAO livestock systems data to look at the number and share of cattle in each region kept under pastoral or agro-pastoral (as opposed to intensive sedentary) systems (FAO, 2018). However, this primarily distinguishes areas which are dominated by pastoralist land use, rather than transitory pastoralist access to farms. The experimental pilot phase funded by MCC did not create any land offices in pastoralist-dominated areas, so the more granular ethnicity-based measures are more suited for distinguishing where pastoralists are significant at this more micro-level.

[51]Classifying ethnicity is tricky, particularly on a local level where intermarriage may be common and in contexts where ethnicity and livelihoods are mutually defined, hence the use of multiple measures for robustness (Müller-Crepon and Hunziker, 2018).

[52]The smallest geographic unit consistently identified in the Integrated Public Use Microdata Series (IPUMS) is the region;

1.4.4 Balance at Baseline

Although the experimental setup of the pilot phase should guarantee (in expectation) balance between treatment and control municipalities, it is important to examine outcomes of interest at baseline. I additionally compare pilot-phase municipalities to the country as a whole to get a sense of how generalizable the findings may be (despite the purposeful selection of study locations). Table 1.2 shows that on most electoral measures, treatment and control municipalities look statistically similar to each other as well as to areas not included in the study. The second panel, which reports outcomes from the Afrobarometer survey, does show broadly lower perceptions of corruption in treatment municipalities. Because the pattern also holds for national leaders like the president's office, this is unlikely to be driven by more effective or honest local leadership in these municipalities.

1.5 Empirical Strategy

Because municipal elections in Burkina Faso occurred in conjunction with the pilot phase of the Rural Land Governance Compact, I can use an empirical strategy that stems from the intuition of a difference in differences, although the randomized assignment of treatment allows for causal identification. By comparing changes in treatment municipalities to changes in control municipalities over the same period of time, any differences can be attributed to the randomly-assigned treatment. Any time-invariant, municipality-specific differences will be differenced out over the time dimension,[53] and any shocks common to all municipalities will be controlled for.[54]

This empirical strategy relies on the assumption of parallel trends: in the absence of treatment, treated units would follow the same trend in outcomes as untreated units. Although I cannot directly test this assumption, it seems highly plausible in a randomized context (where in expectation treatment and control groups are identical). As additional support, I can check whether variables that should not be influenced by the creation of land offices have parallel trends over the period in question. For example, I test if the number of council seats available for election, determined by a formula,[55] seems to follow a common trend, as it appears to in figure 1.3. A variety of other placebo measures are discussed in the appendix, and the results do not give cause for concern about differential trends in the municipalities under consideration.[56]

small communes are collapsed for anonymity. One-tenth of the 2006 Census is publicly available through IPUMS.

[53] Although in expectation, treatment and control groups should be identical at baseline, in small samples there may be some differences.

[54] ANCOVA can improve power over difference-in-differences in cases with low autocorrelation in outcomes (McKenzie, 2012); however, the autocorrelation in the number of parties contesting in non-experimental municipalities is 0.73, so this is less of a concern.

[55] Two seats per village in the municipality, supplemented proportionally by village population if there are fewer than 10 villages.

[56] Note that as local elections only began in 2006, I cannot test for pre-trends on electoral outcomes.

Variable	(1) Phase 2 treat Mean/SE	(2) Phase 2 control Mean/SE	(3) Not in study Mean/SE	Difference (1)-(2)	(1)-(3)	(2)-(3)
A: Municipality-Level Variables						
Seats Available	44.633	48.103	49.410	-3.470	-4.776	-1.306
	(4.008)	(5.194)	(1.992)			
Registered Voters	8658.100	8225.655	10950.218	432.445	-2292.118	-2724.563
	(750.101)	(706.072)	(863.770)			
Voter turnout rate	0.496	0.482	0.503	0.014	-0.007	-0.021
	(0.019)	(0.018)	(0.006)			
Parties Contesting	4.200	3.586	4.857	0.614	-0.657	-1.271
	(0.357)	(0.279)	(0.318)			
Effective # Parties (votes)	2.163	2.158	2.407	0.004	-0.244	-0.248
	(0.108)	(0.102)	(0.087)			
Time to major cities (min)	227.887	240.011	260.105	-12.124	-32.219	-20.094
	(17.448)	(21.190)	(7.979)			
Pastoral Ethnicity share	0.054	0.053	0.111	0.001	-0.057	-0.058
	(0.009)	(0.014)	(0.012)			
N	30	29	266			
B: Afrobarometer Survey	Mean/CI	Mean/CI	Mean/CI			
All/most corrupt: president	0.17	0.33	0.21	-0.15**	-0.03	0.06**
	(0.01 - 0.32)	(-0.47 - 0.93)	(0.11 - 0.31)			
All/most corrupt: local gov	0.11	0.30	0.24	-0.19*	-0.13**	0.03
	(-0.00 - 0.24)	(-1.17 - 0.83)	(0.16 - 0.32)			
All/most corrupt: gov officials	0.14	0.40	0.24	-0.26*	-0.11	0.08
	(-0.01 - 0.37)	(-1.72 - -1.36)	(0.17 - 0.32)			
Trust somewhat/a lot: local gov	0.63	0.68	0.63	-0.05	0.000	0.03
	(0.44 - 0.87)	(0.18 - 2.36)	(0.50 - 0.76)			
Leaders should not favor own group	0.40	0.25	0.35	0.15	0.05	-0.05
	(0.14 - 0.52)	(-0.38 - 0.70)	(0.29 - 0.41)			
Trust CDP	0.57	0.53	0.51	0.05	0.06	0.01
	(0.43 - 0.75)	(-0.55 - -0.41)	(0.39 - 0.62)			
N	80	40	944			
Clusters	5	3	12			

Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. For CENI Data, standard errors are clustered at the experimental-pair level, with all non-experimental municipalities in one cluster. Afrobarometer data includes regional fixed effects and wild cluster bootstrapped confidence intervals clustered at the regional level.

Table 1.2: Balance at Baseline

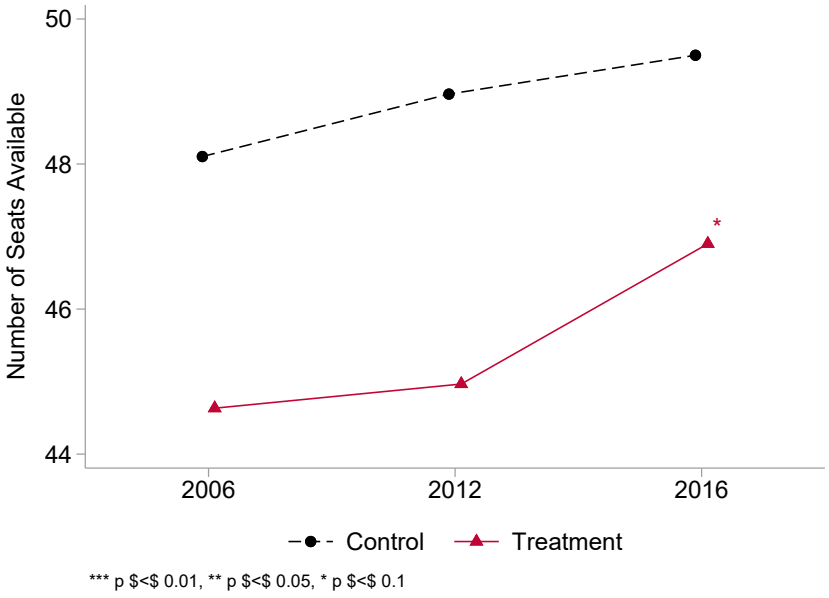


Figure 1.3: Parallel trends between treatment and control in seats available

Although I observe municipalities voting in 3 elections, all treated units receive 'treatments' at the same time: first, the announcement that land offices will be created in these municipalities, immediately before the 2012 election, and second, the actual creation of land offices and associated activities from 2012-2014, prior to the 2016 elections. The main coefficients of interest in regression tables will be on the interaction of a municipality's treatment status with 2012 and/or 2016 year dummies. Equation (1) is the estimating equation. It is important to note that observations from 2016 keep the 2012 dummy 'turned on', so coefficients should be interpreted additively. That is, β_3 represents the anticipation effect of the announcement of treatment, while β_5 represents the additional impacts of implementation.[57] This intuitively matches the treatment: the effects seen in 2016 are of the marginal effect of implementation, above and beyond the announcement and anticipation of treatment.

$$y_{mpt} = \alpha_p + \beta_1 * Treat_m + \beta_2 * 2012_t + \beta_3 * Treat_m * 2012_t + \beta_4 * 2016_t + \beta_5 * Treat_m * 2016_t + \epsilon_{mpt} \tag{1.1}$$

For most outcomes, I report three main specifications. All restrict the sample to Phase II municipalities (30 treatment and 29 control),[58] with the second and third clustering standard errors at the municipality-pair

[57] If political responses strengthened after implementation, when revenue began to flow into municipalities, then β_5 would be positive; if they weakened due to the diminished role of policy after implementation, then β_5 would be negative.

[58] One control municipality is paired with two treatment municipalities in the original impact evaluation design.

level. This level of clustering is shown by de Chaisemartin and Ramirez-Cuellar (2019) to be the appropriate one in matched-pair experimental settings such as this one. In the third specification, I also include pair fixed effects, which control for regional heterogeneity or other pair-specific factors.

For outcomes from the Afrobarometer survey data, I also use an empirical strategy that accounts for the spatially-clustered and unevenly distributed observations between treatment and control municipalities and across survey rounds. My preferred specification includes region (rather than experimental pair) fixed effects, which is the minimum geographic unit that consistently includes both treatment and control municipalities in a given survey round.[59] As I only have few clulsters and limited variation in treatment, I follow Cameron and Miller (2015) and use the Wild Cluster Bootstrap to estimate p-values (clustering at the region level).[60] I separately bootstrapped each coefficient of interest, so the interpretation of results post-treatment is as above: the additional impacts of implementation over and above those of the announcement, rather than their joint significance.

The Afrobarometer survey asks many questions about perceptions of corruption in different levels and branches of government. These questions are generally asked in the form "How many government officials [of X group] are corrupt? None of them, Some of them, Most of them, All of them, Don't know." I then re-code responses into a binary indicator equal to zero for 'none of them'/'some of them', and equal to one for 'most' or 'all of them'. Although most outcomes I consider from the Afrobarometer data are binary, I use a linear fixed effects model rather than a binary outcomes model such as a logit, as the logit cannot be Wild Cluster Bootstrapped.[61] In the appendix, I show that the results are robust to a variety of specifications, including a logit model with region fixed effects.

1.6 Results

Turning to the results of my analysis, I first consider responses by politically sophisticated actors who have the potential to control local governments. I then turn to voters, who may be responding more to the behavior of political parties rather than the underlying decentralization. For each outcome, I begin by showing the main experimental result of the difference-in-difference specification. I follow by exploring heterogeneity

[59] Although I want to control for unobserved factors that link respondents who live in a region together, I am unable to include experimental-pair fixed effects. This is because of data limitations, as there are only three pairs of treatment and control municipalities surveyed within the same year (2012). Therefore, I need to include a higher level of fixed effect to ensure the estimation does not only capture noise.

[60] As Cameron and Miller (2015) suggest, the preferred specification reported uses the Webb 6-point distribution rather than the default Rademacher 2-point distribution, as the former performs better with 12 or fewer clusters. However, the results are robust to the choice of distribution as well as to omitting fixed effects and clustering at municipality or province levels (which are less conservative). I also consider survey weighting using Afrobarometer's computed weights; however, these are calculated to achieve national representativeness rather than representativeness of pilot municipalities.

[61] The Wild Cluster Bootstrap requires additively separable errors; even the Score Wild Bootstrap which was developed for nonlinear models may give inconsistent estimates of coefficients (Cameron and Miller, 2015). Furthermore, Gomila (2020) argues that in a causal framework, linear regression is preferred for binary outcomes.

along informative dimensions, including near-urban areas and areas with pastoralists.

1.6.1 Party Responses

The primary observable outcome of the model is the number of political parties that contest the election in a given municipality. As the model predicted, figure 1.4 and table 1.3 show a substantial (and statistically significant at the 10% level) increase in the number of parties contesting the 2012 election in treatment municipalities. 2012 was an historically competitive election nationwide with more parties contesting everywhere; nevertheless, there is an even larger increase (an additional ~ 0.8 parties) in treatment municipalities. This result is consistent with political actors observing the announcement of land office locations which would be subject to local political control. As shown in the model, the potential to improve constituent welfare through land policy in addition to private rents for politicians makes it worthwhile for more parties to contest these local elections.

However, by the 2016 elections, the number of parties contesting had fallen everywhere in comparison with 2012, with a greater decrease in treatment municipalities bringing their numbers back into line with control areas. This is an important result, as land registration was ongoing in the municipal offices in 2016. It seems reasonable that holding office would continue to be valuable, particularly in terms of local revenue from creating documents. However, the first stage of the decentralization (creation of a participatory land use map) attempted to resolve the actual rights that would be documented, unifying multiple bundles for the individual socially recognized as holding primary use rights. This means that party platforms for policies that would tilt the unification of rights toward one group or another were already implemented and somewhat fixed by the 2016 elections.

Heterogeneity

As explored in the theoretical model, the heterogeneity of responses to the land reform in regions with different land rights contexts is informative. Municipalities near urban centers should see a larger increase in the number of parties contesting the 2012 elections. This could be due to both higher private rents for officeholders (from the higher willingness to pay for APFR documents by outsiders) and the additional impact of land policy choices on constituent welfare.[62] Indeed, in figure 1.5, near-urban treatment municipalities see a spike of party entrants in 2012 when compared with their more remote counterparts.

Interestingly, the model predicted that if private rents were the primary driver of party behavior, then near-urban treated municipalities should remain valuable electoral prizes in the 2016 election, as winners

[62]Recall that political parties contest the election in order to implement their own policies and shift the policy platforms of their opponents, although I do not observe the actual platforms announced by parties.

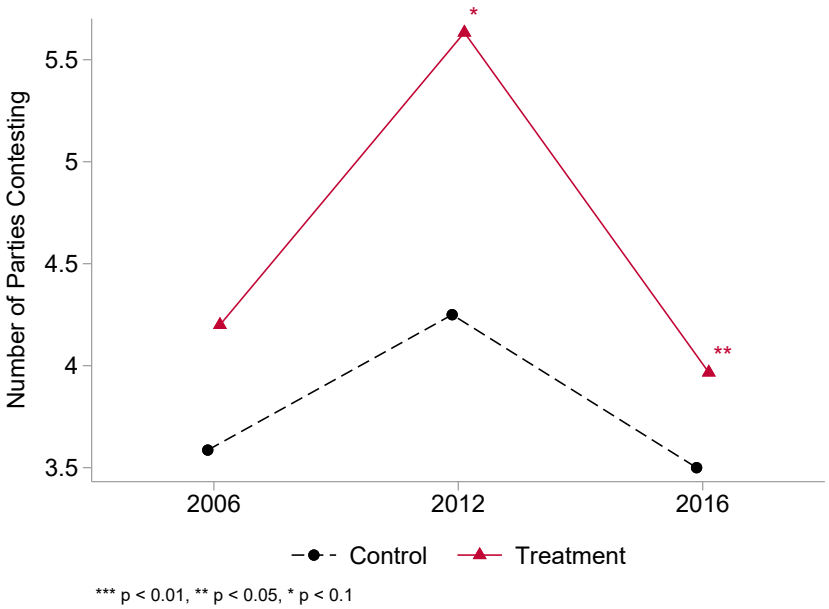


Figure 1.4: Parties enter when treatment is announced in 2012

VARIABLES	(1) Parties Contesting	(2) Parties Contesting	(3) Parties Contesting
Treatment	0.614	0.633*	0.636*
	(0.441)	(0.337)	(0.337)
2012	0.664	0.635*	0.629*
	(0.448)	(0.347)	(0.347)
Treatment*2012	0.770	0.798*	0.805*
	(0.626)	(0.441)	(0.440)
2016	-0.750*	-0.737***	-0.734***
	(0.452)	(0.247)	(0.246)
Treatment*2016	-0.917	-0.930**	-0.933**
	(0.629)	(0.371)	(0.369)
Constant	3.586***	3.586***	3.583***
	(0.314)	(0.283)	(0.219)
Observations	175	175	175
R-squared	0.154		0.281
Pair FE	No	No	Yes
Cluster SE	None	Pair	Pair
Number of comp		29	29

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns

Table 1.3: Political parties contest municipal elections when treatment is announced

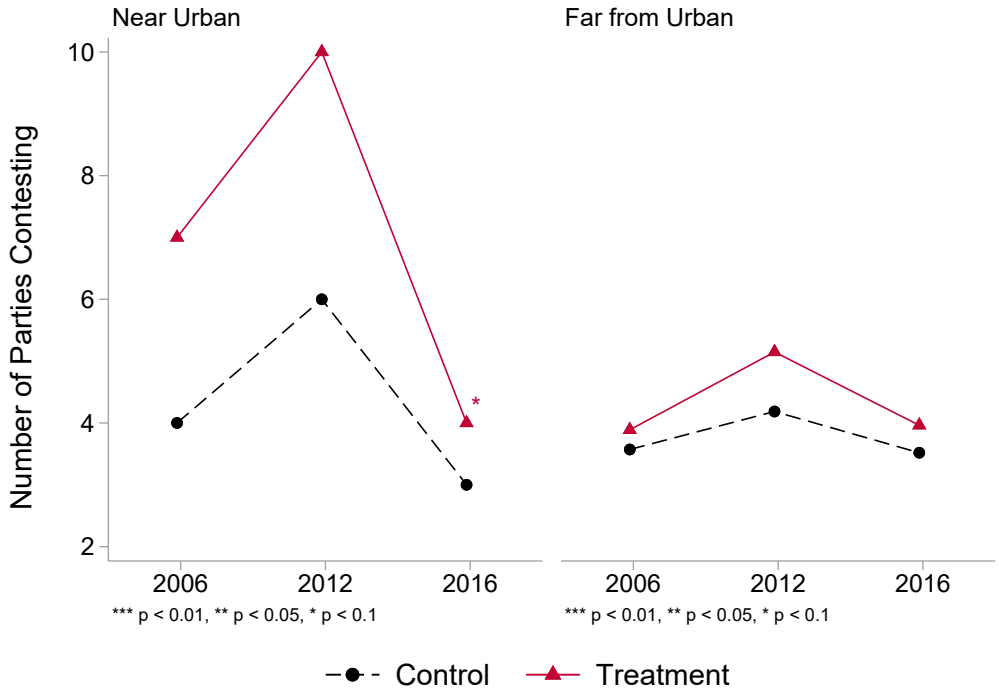


Figure 1.5: Responses are much stronger in municipalities near urban areas

could expect a continued stream of revenue from ongoing APFR fees. Conversely, the role of policy positions in shaping constituent welfare would be muted after the initial land mapping has occurred. I explore this heterogeneity empirically by interacting treatment effects over time with a dummy for municipalities fewer than 2 hours travel from urban areas.[63] Figure 1.5 and table 1.4 show that near-urban treatment municipalities have a large (2.5 fewer parties than in the 2012 election) and statistically significant (at the 1% level) decrease in the number of parties contesting between 2012 and 2016. This brings the number of parties close to their near-urban control counterparts (as well as to levels seen in more remote areas). Although not conclusive, this provides suggestive evidence that parties are indeed concerned with constituent welfare. This is encouraging: despite land offices being under local political control, local politicians may not be primarily concerned with their own private gains.[64]

Despite important land conflicts in areas with pastoralists making land policy extremely important to constituents, the model predicts that there may not be electoral responses in these regions. Because of the small population share of pastoralists in regions where they hold secondary access rights, a political party

[63]This represents a rough estimate of how far into the rural surroundings land speculators and urban residents are willing to travel regularly, although results are robust to various distances.

[64]It could be concerning that, in the absence of treatment, urban areas face different secular pressures that change the political environment totally apart from the land office decentralization. However, appendix figure 1.12 shows that in municipalities not involved in the experimental pilot phase, the trends over time are remarkably similar despite more parties contesting in near-urban areas.

VARIABLES	(1) Parties Contesting	(2) Parties Contesting	(3) Parties Contesting
Treatment	0.317	0.404	0.431
	(0.418)	(0.348)	(0.348)
Near-Urban	0.429	0.783*	0.671
	(1.576)	(0.471)	(0.512)
Treatment*Near Urban	2.683	1.737**	1.569**
	(1.836)	(0.690)	(0.587)
2012	0.614	0.588	0.581
	(0.418)	(0.363)	(0.362)
Treatment*2012	0.646	0.671	0.678
	(0.593)	(0.437)	(0.435)
2012*Near Urban	1.386	1.412***	1.419***
	(2.229)	(0.363)	(0.362)
Treatment*2012*Near-Urban	0.354	0.329	0.322
	(2.597)	(1.020)	(1.020)
2016	-0.667	-0.653***	-0.649**
	(0.421)	(0.245)	(0.244)
Treatment*2016	-0.519	-0.532	-0.536
	(0.596)	(0.370)	(0.368)
2016*Near Urban	-2.333	-2.347***	-2.351***
	(2.230)	(0.245)	(0.244)
Treatment*2016*Near Urban	-2.481	-2.468***	-2.464***
	(2.598)	(0.564)	(0.563)
Constant	3.571***	3.559***	3.561***
	(0.293)	(0.297)	(0.243)
Observations	175	175	175
R-squared	0.330		0.370
Pair FE	No	No	Yes
Cluster SE	None	Pair	Pair
Number of comp		29	29

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns & AidData

Table 1.4: Weaker responses in municipalities far from urban areas

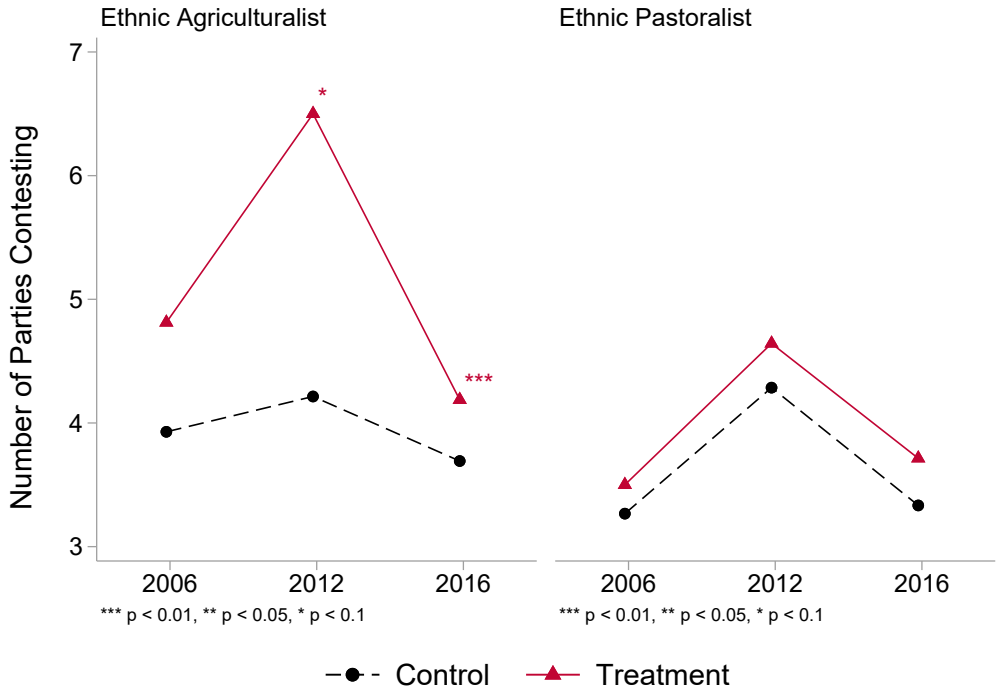


Figure 1.6: Areas with some pastoralists do not show strong electoral responses to treatment

that prioritizes their rights in land policy is not electorally viable – either to win or to influence opposition policy – as their preferred policy redistributes away from the majority of voters. In figure 1.6, it is clear that municipalities with more than 4% of the population identified as pastoralist[65] do not respond to the announcement of treatment status with more parties contesting local elections. Table 1.5 confirms this; note that the statistically significant decrease in parties contesting in treatment municipalities in 2016 is almost precisely offset in those with some pastoralists. This lack of response by parties in areas with pastoralist conflicts is not due to the unimportance of land issues in these regions, but rather due to electoral viability.[66]

[65]Data comes from the Spatially Interpolated Data on Ethnicity (SIDE), although the pattern is the same when using IPUMS Census data on language spoken. The 4% threshold was chosen as the median share of pastoralists in a municipality in order to maximize power (having two similarly-sized sub-samples), although results are robust to a variety of thresholds. Only three experimental-phase municipalities have more than 10% pastoralists, and none have a share close to 50% that would be considered electorally viable. This also means that these regions are not substantively different than other farming areas, except in that pastoralists move through them; their land quality and remoteness are similar to areas without a pastoralist minority presence.

[66]It would be extremely interesting to examine political responses in areas with electorally viable shares of pastoralists. However, the structure of pastoralist land use makes this difficult: in regions suitable for crop-growing, pastoralists will always be marginal and often transitory, while in areas that are unsuitable for agriculturalists, pastoralists dominate but do not face the same conflicts over secondary land access rights. In these pastoralist-dominated areas, other dimensions of land conflicts may become politically important, although such conflicts are not part of the experimental sample.

VARIABLES	(1) Parties Contesting	(2) Parties Contesting	(3) Parties Contesting
Treatment	0.884	1.229**	1.341**
	(0.601)	(0.495)	(0.501)
Some Pastoralists	-0.662	0.462	1.534*
	(0.610)	(0.680)	(0.755)
Treatment*Some Pastoralists	-0.651	-1.205**	-1.328**
	(0.857)	(0.550)	(0.566)
2012	0.286	0.286	0.286
	(0.621)	(0.546)	(0.546)
Treatment*2012	1.402	1.402*	1.402*
	(0.850)	(0.728)	(0.728)
2012*Some Pastoralists	0.733	0.720	0.708
	(0.870)	(0.703)	(0.703)
Treatment*2012*Some Pastoralists	-1.278	-1.265	-1.252
	(1.217)	(0.891)	(0.889)
2016	-0.522	-0.601	-0.614
	(0.633)	(0.394)	(0.395)
Treatment*2016	-1.791**	-1.712***	-1.698***
	(0.859)	(0.570)	(0.570)
2016*Some Pastoralists	-0.430	-0.339	-0.312
	(0.879)	(0.511)	(0.509)
Treatment*2016*Some Pastoralists	1.814	1.723**	1.696**
	(1.223)	(0.748)	(0.745)
Constant	3.929***	3.347***	2.786***
	(0.439)	(0.483)	(0.482)
Observations	175	175	175
R-squared	0.231		0.410
Pair FE	No	No	Yes
Cluster SE	None	Pair	Pair
Number of comp		29	29

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data sources: CENI Electoral Returns & SIDE

Table 1.5: Areas with Pastoralists do not see larger increases in parties contesting in response to treatment

Electoral Competitiveness

The previous results show that additional parties contest elections in response to the announcement of treatment. Are these parties electorally competitive? In a system like Burkina Faso's, historically dominated by one-party rule, it is important to understand if a decentralization reform presents voters with a greater choice of viable parties. However, Tavits (2008) argues that the entry of even uncompetitive parties can shape the political environment. In my model, this can be concretely seen: even parties that do not win office themselves are able to shift the policy platforms of other (more viable) parties, and thereby affect welfare. Across multiple measures of electoral competitiveness suggested by the literature, I find no evidence that treatment municipalities become more politically competitive, as shown in table 1.6.

The first measure commonly used is the effective number of parties (Kelly, 2020; Golosov, 2016; Tavits, 2008; Kuenzi and Lambright, 2007; Shaukat, 2019).[67] The effective number of parties can be computed either using the number of votes or seats won, each of which has slightly different interpretations. The former measures how competitive parties are in winning voters, while the latter combines this with structural factors that determine how votes are translated into seats. I use Golosov (2010)'s variation on this class of measures which performs better in highly fragmented or highly concentrated party systems.[68] Results for the Golosov effective number of parties are presented in columns (1) (computed using vote shares) and (2) (computed using seat shares) of table 1.6. Other measures are also presented in appendix table 1.17. Regardless of the measure used, there are not significant differences between treatment and control municipalities, and the magnitudes are also relatively small. Therefore, although more parties compete in treatment municipalities in 2012, they do not seem to make the elections meaningfully more competitive.

There are other potential ways to look at electoral competiveness; importantly, the model incorporates the expected probability that any potential party entrant wins. One way to estimate this is by the number of parties that fail to win any council seats (possible in multi-seat elections such as these), as shown in column (3) of table 1.6. Another is to take advantage of a constitutional clause on the funding of political campaigns requiring all parties pay a deposit to be included on the ballot, which entitles them to some public campaign funding. If they receive 10% of votes in the election, then they are reimbursed their deposit. Although this deposit is not large for municipal elections, it may be economically substantial in rural areas. Therefore, we can consider the number of parties that fail to reach this 10% threshold as being electorally uncompetitive, with results reported in column (4).

[67] This is constructed in a similar manner to measures of market competition such as Herfindahl-Hirschman indices. The classic measure of the effective number of parties was proposed by Laakso & Taagepera in 1979, and is equivalent to an inverse Simpson index of diversity.

[68] Defined as $N = \sum_{i=1}^{n} \frac{p_i}{p_i + p_1^2 - p_i^2}$, where n is the number of parties with at least one vote, p_i is a given party's proportion of all votes (seats) won, and p_1 is the largest party's vote (seat) share.

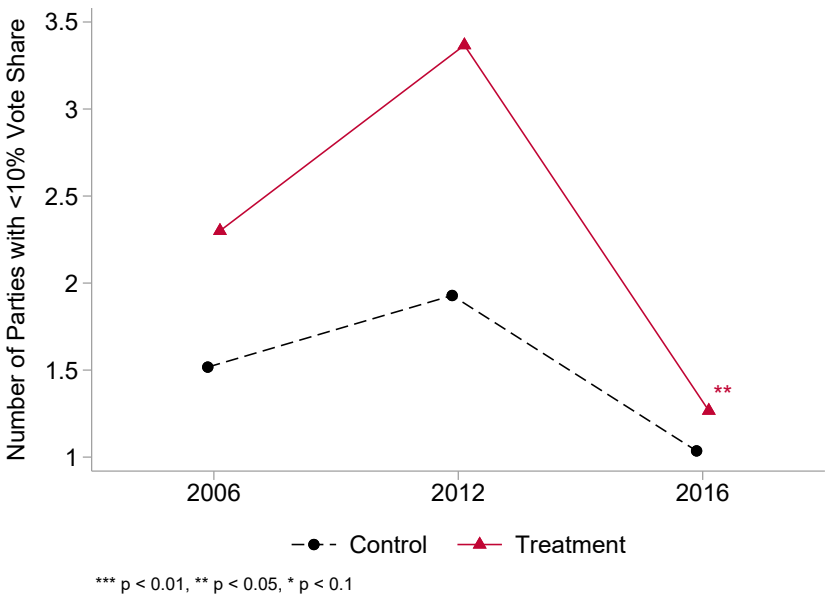


Figure 1.7: Parties entering in response to treatment in 2012 fail to reach the 10% vote share for reimbursement

When looking at either of these measures, although there is no statistical significance for the positive difference between treatment and control in 2012, there is a larger decrease in 2016 for treatment municipalities. A graphical examination of these results in figure 1.7 shows a similar pattern to that seen in the number of parties, where treatment municipalities have more parties that fail to reach the 10% vote share threshold in the 2012 election. Therefore, although more parties compete in elections, it seems clear that they largely do not present a serious challenge to the dominant parties.

How should this spike in non-viable parties be interpreted? Although it is possible that political entrepreneurs are learning about their electoral potential over time, it is unclear why this would happen differentially in treatment and control areas. The model also shows that the strategic policy responses of (dominant) incumbents may be driving these results. First, a party that proposes an electorally-viable policy (such as one advocating for shifting unified land rights to many individuals instead of a few elites) may see the incumbent shift their own policy enough to attract the majority of voters. Therefore, a somewhat naive party could be 'scooped' by the incumbent's platform response. However, more sophisticated challengers could contest the election precisely to induce this policy shift, with little expectation of actually winning office (and the attendant private rents) themselves.

VARIABLES	(1) Effective # Parties (Votes)	(2) Effective # Parties (Seats)	(3) Parties Winning No Seats	(4) Parties with $\leq$ 10% Vote Share
Treatment	-0.00222	-0.0631	0.468	0.803**
	(0.106)	(0.0931)	(0.333)	(0.333)
2012	0.282***	0.133	0.248	0.386
	(0.0979)	(0.0892)	(0.316)	(0.351)
Treatment*2012	0.152	-0.0103	0.318	0.680
	(0.117)	(0.0915)	(0.423)	(0.478)
2016	0.00726	0.104	-0.906***	-0.892***
	(0.111)	(0.109)	(0.237)	(0.266)
Treatment*2016	0.124	0.235	-0.727**	-1.208**
	(0.153)	(0.143)	(0.329)	(0.442)
Constant	1.623***	1.408***	1.208***	1.515***
	(0.0645)	(0.0605)	(0.207)	(0.219)
Observations	175	175	175	175
R-squared	0.221	0.169	0.245	0.342
Number of comp	29	29	29	29
Pair FE	Yes	Yes	Yes	Yes
Cluster SE	Pair	Pair	Pair	Pair

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns

Table 1.6: Electoral competitiveness does not seem to increase in treatment municipalities

Rent-seeking behavior

Despite some suggestive evidence that concern for constituent welfare is driving political party behavior, it is instructive to examine private rent-seeking behavior in more detail.[69] I have argued that the actions of electorally non-viable parties are unlikely to be driven by private rents which can only be realized if the party wins office. There is one party, however, that I (and local politicians) can identify as electorally viable: the CDP. This nationally dominant party, aligned with the president, had access to a deep reserve of political resources that made contesting local elections relatively easy. This was true to such an extent in the 2006 and 2012 elections that I modeled the 'incumbent' party on the CDP: they contested in every single municipality nationwide in these elections, and won a majority of seats (and therefore the mayoralty) in 87% of these first two elections. After the national political turnover between 2014-2015, however, the CDP was no longer as

[69] I am currently collecting additional data in order to more directly test the importance of private rents for political behavior, with support from a Henry A. Jastro research grant. First, I will use annual municipal budgets over the period of 2006 - 2018, which are largely set by the central government and unpredictable (Mahieu; Dafflon and Madies, 2013). This will allow me to measure the resources controlled by each municipal council, and estimate the correlation between this budget and the number of parties contesting. Although this work will not be causal, it will allow me to estimate the magnitude of the relationship. There are potential instrumental variables stemming from central government allocation formulae that could help in isolating the effect of generalized private resources controlled by officeholders. Second, I will collect data on the number of APFRs given out in each municipality and the (locally-set) fees for these documents. This will allow me to estimate the revenues raised by land offices as well as the general demand for documentation in each region.

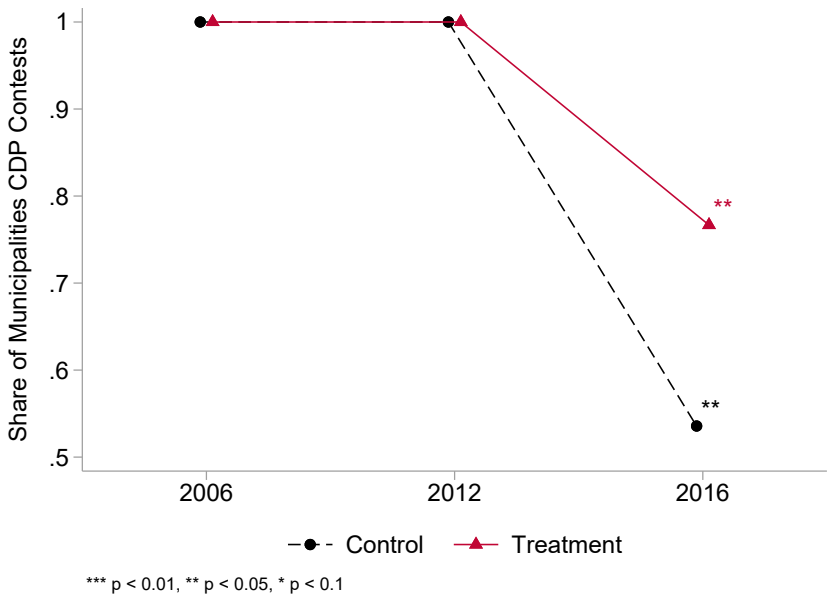


Figure 1.8: CDP is more likely to contest in treatment municipalities, post-transition

dominant, having lost its intimate access to the state. This functionally increased the costs for any local branch of the CDP to contest municipal elections in 2016. However, they did remain electorally viable, in part due to voters' knowledge about CDP performance locally while new parties represented a complete unknown (Lierl and Holmlund, 2019). Figure 1.8 shows that although the CDP ran in fewer municipalities in 2016, they were more likely to contest in municipalities that had received land offices. It seems plausible that these municipalities presented an opportunity for larger revenues (and therefore rents for the taking), making them more attractive as the costs of contesting rose. The CDP, knowing that they could potentially win office, was motivated by these rents while smaller parties may not have been.

Experimental Spillovers and Learning

It is also worth exploring whether political actors may be learning from other jurisdictions given the experimental setup of the decentralization. That is, politicians may observe another municipality implementing the land office, and its potential political rents, and change their behavior accordingly, rather than in direct response to the incentives. This type of mechanism could potentially explain the lack of significant differences between treatment and control areas in 2016:[70] if control municipalities anticipate that they will be next to receive a land office, they may be presently anticipating future treatment and thus behaving similar to treated municipalities. As a result, the lack of difference I find would represent a change on the part of

[70]Note that although the coefficient on Treatment*2016 is significant in my preferred specifications, this is because the dummy for 2012 stays 'on.' This coefficient therefore indicates a return in treatment municipalities to control-group levels from their peak in 2012.

the 'control' group, rather than deteriorating effects in treatment municipalities.' This could indicate that private rents, which politicians can expect to continue after 2016, do remain important in party decisions.

I explore whether municipalities learn from each other in two ways. First, in column (1) of table 1.7, I interact year and treatment dummies with a dummy for municipalities in the same province as a land office location from Phase I of the MCC rollout.[71] It may be that local actors in other municipalities observed this earlier implementation, allowing them to (for example) foresee the political benefits of controlling land offices and therefore decide to run for office. This learning would likely be stronger in municipalities near Phase I municipalities. I do not find statistically significant differences in responses by political parties, although I begin to lose power when splitting the sample this way.

More important, however, is to consider whether the fact that treatment and control municipalities are statistically indistinguishable in 2016 (on most measures) is due not to treatment effects dissipating, but rather that control municipalities are beginning to anticipate their own treatment, and thus behaving more like treated areas. One way to test this is to compare the behavior in control municipalities with that in municipalities outside of the study over time. In columns (2) and (3) of table 1.7, I regress the number of parties contesting a given municipal election on treatment status (phase II treatment, phase II control, or non-study) and year, clustering standard errors at the province level. In column (3), I also include province-fixed effects, as there are no experimental pairs for municipalities outside of the phase II study. Interestingly, this shows a positive and significant effect for control municipalities in 2016, similar to the effect seen in treatment municipalities in 2012 when they were anticipating treatment.

Together, these results indicate that control areas were beginning their own contests in anticipation of future offices (driven by both private rents and constituent welfare), so politicians in treated municipalities may not have entirely given up on ongoing rents from existing land offices. However, this response in the control group does not seem to be driven primarily by those municipalities slated to receive land offices through other donor projects in the near future, as seen in columns (4) and (5).[72]

1.6.2 Voter Responses and Welfare

I have shown that politicians respond to the decentralization of land offices and have argued that they are motivated in part by a concern with constituent welfare. These constituents, then, should also be concerned with the outcomes of these elections, as they determine policies that will have real welfare effects. However, the announcement of coming land offices was not extremely well-publicized. Voters may therefore be uninformed about the underlying decentralization reform, and respond instead to the more proximal (and

[71] Recall that there was a first pilot phase of the RLG project, which implemented land offices in 17 priority municipalities.

[72] These municipalities may have had some knowledge of future interventions, although I have not found any pre-election announcements of these locations.

VARIABLES	(1) Parties Contesting	(2) Parties Contesting	(3) Parties Contesting	(4) Parties Contesting	(5) Parties Contesting
Control		-1.459**	-2.511*	-1.582**	-2.089***
		(0.706)	(1.255)	(0.726)	(0.764)
Treatment	0.914	-0.832	-1.818*	-1.090*	-2.195*
	(0.578)	(0.553)	(1.080)	(0.647)	(1.273)
Phase I Province	-0.704				
	(1.027)				
Treatment*Phase I Prov	-0.377				
	(0.712)				
Office in 2017				-1.491**	-1.955*
				(0.643)	(1.139)
Control*Office in 2017				0.926	-1.353
				(0.717)	(1.999)
2012	0.567	0.711***	0.445	0.719***	0.403
	(0.396)	(0.264)	(0.404)	(0.275)	(0.451)
Control*2012		-0.0555	0.171	-0.0369	0.279
		(0.342)	(0.464)	(0.336)	(0.499)
Treatment*2012	0.683	0.723*	0.988*	0.715*	1.031*
	(0.643)	(0.403)	(0.516)	(0.410)	(0.556)
2012*Phase I Province	0.0997				
	(0.691)				
Treatment*2012*Phase I Prov	0.206				
	(0.919)				
2012*Office in 2017				-0.161	0.156
				(0.459)	(0.429)
Control*2012*Office in 2017				-0.0366	-0.806
				(0.903)	(0.755)
2016	-0.578	-1.267***	-1.276***	-1.323***	-1.335***
	(0.378)	(0.177)	(0.178)	(0.207)	(0.207)
Control*2016		0.515**	0.531**	0.563*	0.549*
		(0.259)	(0.246)	(0.316)	(0.309)
Treatment*2016	-0.505	-0.399	-0.390	-0.344	-0.332
	(0.545)	(0.449)	(0.449)	(0.459)	(0.458)
2016*Phase I Province	-0.289				
	(0.500)				
Treatment*2016*Phase I Prov	-0.684				
	(0.728)				
2016*Office in 2017				0.370	0.382
				(0.276)	(0.275)
Control*2016*Office in 2017				-0.237	0.230
				(0.519)	(0.604)
Constant	3.957***	4.833***	5.265***	5.073***	5.596***
	(0.614)	(0.702)	(0.406)	(0.794)	(0.574)
Observations	175	990	990	990	990
R-squared	0.309		0.079		0.120
FE	Pair	None	Province	None	Province
Cluster SE	Pair	Province	Province	Province	Province
Number of Clusters		45	45	45	45

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns

Table 1.7: Little learning from Phase I, but control areas may be anticipating treatment in 2016

observable) party behavior.

Although the model did not specifically address whether constituents vote, it could easily be extended to do so. The model would intuitively predict higher voter turnout in municipalities voting for who will control the land office, and perhaps more votes for challenger parties. These predicted responses by voters could be attenuated by the difficulty of learning about local policy platforms, particularly in a multiparty environment. Even if voters do not respond *ex ante* to the politics of land reform, there may still be *ex post* effects on their welfare.[73] An important caveat is that although treatment locations were announced prior to the 2012 election, this information may not have been broadly known among the electorate.[74] Therefore, voters may be responding more to the proximal observed behavior of political elites rather than the underlying announcement of land offices.

Voter Turnout

It is difficult to recover local parties' policy platforms to test if voters respond in accordance with the model.[75] However, if I modeled the extensive margin decision for a constituent to vote (excluded from the current model for clarity), it would likely predict that voters are more invested in local elections when they will determine land policy than in cases where local governments merely carry out central directives. Voters are concerned not only with the capacity of local politicians to provide public goods, but also distributional implications of who will receive public goods (such as documented land). Therefore, voter turnout should increase in treatment municipalities provided that voters know about coming land offices. Puzzlingly, there is actually a smaller increase in voter turnout in treatment municipalities in 2012, as seen in figure 1.9 and column (1) of table 1.8. I explore several potential explanations for this unexpected result.

First, note that the 2012 elections saw an enormous surge in voter turnout in all areas as municipal elections were concurrent with national legislative elections (which generally have higher turnout). The 2012 legislative election was genuinely competitive, with what was seen as a viable opposition to the continued dominance of Compaoré and the CDP.[76] However, this increase from approximately 48% turnout to 80% was significantly (at the 5% level) smaller (by four percentage points)[77] in treatment municipalities.

[73] I will use Prindex survey data on perceptions of tenure security to explore some of these *ex post* welfare implications. One intriguing pattern from the aggregate Prindex data is that individuals *with* formal documents in Burkina Faso report higher levels of tenure *insecurity* than those without any documentation. I will use geolocated survey data to see if this effect is driven by those in near-urban municipalities, who have preventatively gotten documents in response to ongoing land pressures.

[74] I have been unable to find local news reporting on coming land offices prior to the 2012 elections.

[75] It is also impossible to see individual vote choices in order to test if different classes of voters favor parties based on their policy affiliation.

[76] It may also be that the simultaneous municipal and legislative elections actually depressed turnout in treatment municipalities: if the 2012 election was perceived as a national election, then increasing the relative importance of local governments should reduce turnout in national elections (Blais et al., 2011). However, voter attitudes toward the national assembly do not seem systematically different between treatment and control municipalities, as seen in responses to the Afrobarometer survey. Unfortunately, legislative elections were conducted at the province level, so it is impossible to determine differences in voter turnout for these legislative elections between treatment and control municipalities.

[77] This is a meaningful difference compared to results elsewhere in the literature; get out the vote experiments in the US are

Voters may be responding primarily to the behavior of political parties, however, rather than to the underlying announcement of future land offices. Despite the announcement of treatment locations in mid-2012, this information was not circulated broadly, and it seems unlikely that the average voter in rural districts would have heard about land offices or fully processed what they would mean for voters' land rights. Instead, voters may simply observe more parties contesting the election, which (in column (2) of table 1.8) is negatively associated with voter turnout nationally. In some treatment municipalities, the 2012 election cycle saw more than 10 parties contesting local elections, which could potentially overwhelm potential voters wanting to make an informed choice.[78] In column (3), I re-run the difference-in-differences specification, controlling for the number of parties in a given election, and find that the treatment effect depressing turnout in treatment municipalities in 2012 holds, indicating that the number of parties contesting is not the only factor at play.

Another way the behavior of political parties in response to decentralized land offices may be depressing turnout is through policy responses. If the entry of new parties induced incumbents to shift their policy platforms enough to satisfy voters, informed voters may not see enough difference between the incumbent and challenging parties to justify the costs of voting. This is difficult to test empirically, as I cannot recover the policy proposals from these local elections.

Finally, in column (4) of table 1.8, I test whether the drop in voter turnout is the result of higher voter registration in treatment municipalities. Suppose that new party entrants register additional marginal voters who then do not vote come election day. This would increase the denominator of the turnout rate, depressing measured turnout even if no fewer voters are going to the polls. When I calculate the share of the total population[79] registered to vote in each municipality for each election, I find no significant differences between treatment and control municipalities over time.

Despite the theoretical importance of local land offices for constituent welfare, the political responses of voters are somewhat puzzling. Luckily, I can look at citizens' own responses to questions about political engagement using the Afrobarometer survey, explored in the next section.

Voter Attitudes and Political Perceptions

Although election results data do not allow for a close examination of voter responses to the treatment, I can make use of surveyed voter attitudes and perceptions from the geo-coded Afrobarometer survey data.

able to increase turnout by 5 percentage points (Green et al., 2013).

[78] Ballots in Burkina Faso only list party names and symbols; in control municipalities in 2012, most voters are faced with either 3, 4, or 5 parties, while in treatment municipalities, the average municipality has 5.6 parties contesting, with as many as 10 parties on the ballot. Therefore, one could imagine that the costs of learning about the parties and deciding how to vote may be much higher for citizens in treatment municipalities, leading some to stay home.

[79] Note this is not eligible voters, but the whole population, estimated by AidData.

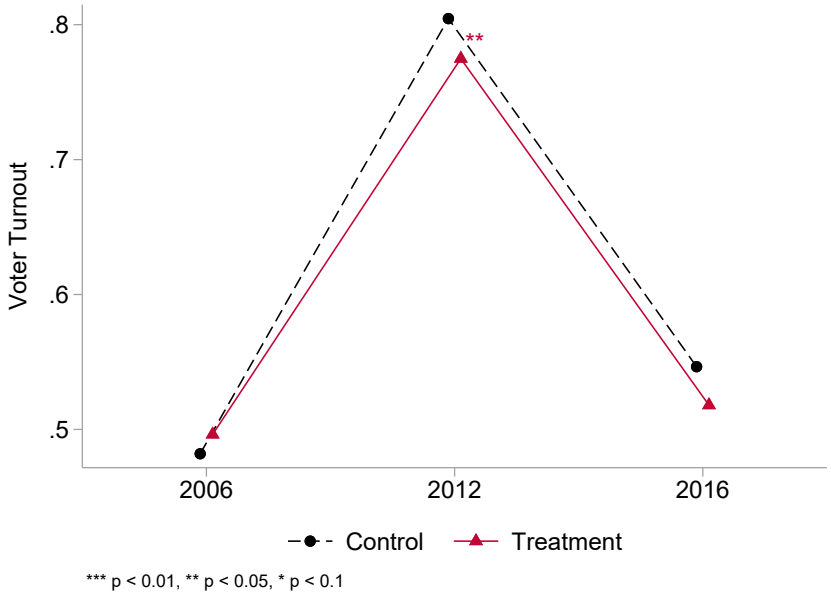


Figure 1.9: Voter turnout increases less in treatment communes

VARIABLES	(1) Voter Turnout	(2) Voter Turnout	(3) Voter Turnout	(4) Voter Registration Rate
Treatment	0.0149		0.0169	-0.00462
	(0.0231)		(0.0237)	(0.0169)
2012	0.323***	0.289***	0.325***	-0.0263**
	(0.0165)	(0.00631)	(0.0162)	(0.0121)
Treatment*2012	-0.0441**		-0.0416**	0.0156
	(0.0198)		(0.0198)	(0.0140)
2016	-0.260***	-0.258***	-0.263***	0.0300***
	(0.0152)	(0.00632)	(0.0153)	(0.00499)
Treatment*2016	0.00356		0.000675	-0.00229
	(0.0175)		(0.0163)	(0.00535)
Number Parties		-0.00685***	-0.00309	
		(0.000673)	(0.00425)	
Constant	0.482***	0.534***	0.493***	0.277***
	(0.0129)	(0.00548)	(0.0184)	(0.0126)
Observations	175	1,089	175	175
R-squared	0.817	0.701	0.818	0.057
Number of comp	29		29	29
Pair FE	Yes	No	Yes	Yes
Cluster SE	Pair	Pair	Pair	Pair

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns

Table 1.8: Voter turnout decreases with more parties and in response to the announcement of treatment

Despite suggestive evidence that politicians are driven by more than private rents, voters may perceive politicians' motives as corrupt. Each survey round of this survey is nationally representative but does not survey respondents in every municipality (and therefore, there is not a balanced panel from the study municipalities). However, the timing of these surveys neatly parallels the timeline of the study: one wave was in 2008, prior to the signing of the compact with MCC (and thus should be unaffected by treatment status which was assigned later); the second occurred immediately prior to the 2012 municipal election (so should capture voter's perceptions after treatment status was announced but prior to implementation); and the third wave was in 2015 (after land offices had been created and were functioning). Therefore, I can use a similar difference-in-differences framework to those used above.

In column (1) of table 1.9, I look at perceptions of corruption in the office of the president as a placebo check. Given that treatment occurred at a local level, perceptions of the national government should not change substantially. Indeed, I find no significant differences between treatment and control municipalities in any year. In column (2), the question instead asks about corruption among government officials, a category which would include the functionaries working in newly-created land offices. Interestingly, although there is a statistically significant difference between treatment and control municipalities at baseline, there appears to be a statistically significant increase in the perception of corruption among government officials in treatment municipalities in 2012 (while the more heavily contested election campaigns are ongoing), falling back to similar levels as control municipalities in 2015 (after implementation). There is a similar pattern when looking at perceived corruption among local government (municipality) council members (column (3)), although these results are not statistically significant (bootstrapped p-value = .15). This pattern parallels the results for the number of parties contesting, which supports the interpretation of observed party behavior as rent-seeking. The observed decrease in perceptions of corruption in 2015 was unsurprising to those involved in the MCC project, as they felt that the Rural Land Governance project had paid particular attention to avoiding corruption, including participatory land use mappings with communities that would prevent elite capture of the land offices. The results in column (3) are perhaps encouraging that concerns about political capture raised by party responses to the announcement of treatment in 2012 can be dealt with effectively.

I also use the Afrobarometer surveys to test whether pilot land offices were targeted to areas that supported the ruling party, as well as if their presence changed opinions about the CDP or about the need for presidential term limits (the trigger of 18 months of civil unrest in 2014-2015). Table 1.16 does not support either of these theories, however, as there are no systematic differences between treatment and control municipalities.

	(1)	(2)	(3)
	Corrupt in President's Office	Corrupt in Gov Officials	Corrupt in Local Gov
Treatment	-.0698054	-.3111226**	-.2588241**
	(0.67)	(0.05)	(0.19)
2012	.0110917	-.0632625	-.0878433
	(0.88)	(0.67)	(0.57)
Treatment*2012	.0911531	.2895166*	.3102148**
	(0.38)	(0.08)	(0.15)
2015	-.0051325	-.0004007	.0708754
	(0.96)	(0.99)	(0.50)
Treatment*2015	-.1661832	-.1386811	-.2395636*
	(0.36)	(0.48)	(0.16)
Constant	.3591549	.49182***	.3888866
Observations	358	370	388
R^2	0.018	0.039	0.039
Number Clusters	12	12	12
Fixed Effect	Region	Region	Region
Standard Errors	Wild Cluster Bootstrap	Wild Cluster Bootstrap	Wild Cluster Bootstrap
Years Asked	08/12/15	08/12/15	08/12/15

Wild Cluster Bootstrapped p-values in parentheses, cluster at regional level
*** p<0.01, ** p<0.05, * p<0.1 indicating analytic p-values
Data source: Afrobarometer

Table 1.9: Perceptions of corruption at the local level increase in anticipation of treatment

1.7 Conclusion

In this paper, I have demonstrated that politicians do try to control local land offices, as more parties contest elections in response to the announcement of treatment. Using a theoretical model and a careful attention to heterogeneity in land tenure contexts, I find evidence that this political behavior is not driven only by a desire for private rents but also by a concern for constituent welfare. These results bear the important caveat that donor involvement in the pilot phase may have exerted enough control to overrule local politics. That is, if MCC was involved enough in the documentation process, electoral winners may not have been able to implement their preferred policy (and therefore been reluctant to contest again in 2016).

Nevertheless, there are important implications for policy. If, as I have suggested, constituent welfare is an important motivator for local politicians, then decentralization is not as subject to elite capture as a more pessimistic, rent-seeking view of politicians would imply. The model of political behavior I explore also suggests that decentralization is less likely to suffer from elite capture when there are electorally viable constituencies that can resolve their conflicts through the electoral realm, or where outside pressures limit elite capture. This work also opens up interesting possibilities for future research, including looking at later land offices created using quasi-experimental methods. This would provide an important test of quasi-experimental methods often used in political economy against a randomized control trial, as well as allowing

for exploration of decentralization that occurred with weaker donor control.

1.8 References

Paul Taryam Ilboudo, maire de la commune de Loumbila : « Tout le monde fonce à Loumbila pour acheter des terres... », 10 2016.

E. Adotey. Parallel or dependent? The state, chieftaincy and institutions of governance in Ghana. *African Affairs*, 433(2009):628–645, 2019.

L. Alden Wily. Customary land tenure in the modern world: Rights to resources in crisis: Reviewing the fate of customary tenure in Africa. Technical report, 2011.

P. Bardhan. Decentralization of governance and development. *Journal of Economic Perspectives*, 16(4): 185–205, 2002.

P. Bardhan and D. Mookherjee. Capture and governance at local and national levels. *American Economic Review: Papers and Proceedings*, 90(2):135–139, 2000.

P. Bardhan and D. Mookherjee. Determinants of redistributive politics: An empirical analysis of land reforms in West Bengal, India. *American Economic Review*, 100(4):1572–1600, 2010.

T. A. Benjaminsen and B. Ba. Farmer-herder conflicts, pastoral marginalisation and corruption: A case study from the inland Niger delta of Mali. *The Geographical Journal*, 175(1):71–81, 2009.

A. Benyishay, R. Rotberg, J. Wells, Z. Lv, S. Goodman, L. Kovacevic, and D. Runfola. Geocoding Afrobarometer Rounds 1-6: Methodology & Data Quality, 2017.

T. Besley. *Principled Agents? The Political Economy of Good Government.* Oxford University Press, Oxford, 2007.

T. Billing. Government fragmentation, administrative capacity, and public goods: The negative consequences of reform in Burkina Faso. *Political Research Quarterly*, 72(3):669–685, 2019.

A. Blais, E. Anduiza, and A. Gallego. Decentralization and voter turnout. *Environment and Planning C: Government and Policy*, 29(2):297–320, 2011.

A. S. Brasselle, F. Gaspart, and J.-P. Platteau. Land tenure security and investment incentives: Puzzling evidence from Burkina Faso. *Journal of Development Economics*, 67(2):373–418, 2002.

R. C. Briggs. Electrifying the base? Aid and incumbent advantage in Ghana. *Journal of Modern African Studies*, 50(4):603–624, 2012.

F. Brollo, T. Nannicini, R. Perotti, and G. Tabellini. The political resource curse. *The American Economic Review*, 103(5):1759–1796, 2013.

C. Cameron and D. Miller. A practitioner's guide to cluster-robust inference (robust covariance for OLS). *Journal of Human Resources*, 2015.

K. Casey. Crossing party lines: The effects of information on redistributive politics. *American Economic Review*, 105(8):2410–2448, 2015.

K. Casey. Radical decentralization: Does community-driven development work? *Annual Review of Economics*, 10(1):139–163, 2018.

Commission Electorale Nationale Independente du Burkina Faso. Elections municipales du 23 Avril 2006: Resultats provisoires par Commune, 2006.

Commission Electorale Nationale Independente du Burkina Faso. Elections municipales: Resultats provisoires par Commune, 2012.

Commission Electorale Nationale Independente du Burkina Faso. Resultats Municipales 2016, 2016.

L. Cotula, J.-P. Chauveau, S. Cissé, J.-P. Colin, P. Lavigne Delville, B. Neves, J. Quan, and C. Toulmin. Changes in 'customary' land tenure systems in Africa. Technical report, iied, 2007.

C. Cruz and P. Keefer. Political parties, clientelism, and bureaucratic reform. *Comparative Political Studies*, 48(14):1942–1973, 2015.

C. Cruz, P. Keefer, J. Labonne, and F. Trebbi. Making policies matter: Voter responses to campaign promises. *NBER Working Paper*, (No. 24785), 2018a.

C. Cruz, J. Labonne, and P. Querubin. Social fragmentation, electoral competition and public goods provisions. (November), 2018b.

B. Dafflon and T. Madies. The political economy of decentralization in Sub-Saharan Africa: A new implementation model in Burkina Faso, Ghana, Kenya, and Senegal. Technical report, The World Bank, 2013.

E. Dal Bo, F. Finan, and M. Rossi. Strengthening state capabilities: The role of financial incentives in the call to public service. *Quarterly Journal of Economics*, pages 1169–1218, 2013.

C. de Chaisemartin and J. Ramirez-Cuellar. At what level should one cluster standard errors in paired experiments? 2019.

J. P. O. de Sardan. State bureaucracy and governance in Francophone West Africa: An empirical diagnosis and historical perspective. In G. Blundo and P.-Y. Le Meur, editors, *The Governance of Daily Life in Africa : Ethnographic Explorations of Public and Collective Services*. 2008.

K. Eaton, K. Kaiser, and P. J. Smoke. *The political economy of decentralization reforms: implications for aid effectiveness*. The World Bank, 2011.

B. Eifert, E. Miguel, and D. N. Posner. Political competition and ethnic identification in Africa. In M. Bratton, editor, *Voting and Democratic Citizenship in Africa*, pages 61–78. Lynne Rienner Publishers, Boulder, 2013.

J. Ensminger. Changing property rights: Reconciling formal and informal rights to land in Africa. In J. N. Droback and J. V. Nye, editors, *The Frontiers of the New Institutional Economics*, chapter 8, pages 165–196. Academic Press, San Diego, 1997.

J. P. Faguet. Decentralization and governance. *World Development*, 53:2–13, 2014.

FAO. Livestock production systems spotlight: Burkina Faso cattle and poultry sectors. Technical report, 2018.

J. Fenske. Land tenure and investment incentives: Evidence from West Africa. *Journal of Development Economics*, 95(2):137–156, 2011.

M. Goldstein and C. Udry. The profits of power: Land rights and agricultural investment in Ghana. *Journal of Political Economy*, 116(6):981–1022, 2008.

G. V. Golosov. The effective number of parties: A new approach. *Party Politics*, 16(2):171–192, 2010.

G. V. Golosov. Factors of party system nationalization. *International Political Science Review*, 37(2): 246–260, 2016.

R. Gomila. Logistic or linear? Estimating causal effects of experimental treatments on binary outcomes using regression analysis. *Journal of Experimental Psychology: General*, pages 1–27, 2020.

S. Goodman, A. Benyishay, Z. Lv, and D. Runfola. GeoQuery: Integrating HPC systems and public web-based geospatial data tools. *Computers & Geosciences*, 122:103–112, 2019.

J. Gottlieb and K. Kosec. The countervailing effects of competition on public goods provision: When bargaining inefficiencies lead to bad outcomes. *American Political Science Review*, 113(1):88–107, 2019.

D. P. Green, M. C. McGrath, and P. M. Aronow. Field experiments and the study of voter turnout. *Journal of Elections, Public Opinion and Parties*, 23(1):27–48, 2013.

G. M. Grossman and E. Helpman. Electoral competition and special interest politics. *The Review of Economic Studies*, 63(2):1996, 1996.

S. Hagberg. *Between Peace and Justice: Dispute Settlement between Karaboro Agriculturalists and Fulbe Agro-pastoralists in Burkina Faso*. Acta Universitatis Upsaliensis, Uppsala, 1998.

S. Hagberg. Ethnic identification in voluntary associations: The politics of development and culture in Burkina Faso. In H. Englund and F. B. Nyamnjoh, editors, *Rights and the Politics of Recognition in Africa*, chapter 8. Zed Books, London, 2004.

S. Hagberg, L. Kibora, S. Barry, S. Gnessi, and A. Konkobo. *'Nothing will be as before!': Anthropological perspectives on political practice and democratic culture in 'a new Burkina Faso'*. Uppsala Universitet, Uppsala, 2018.

R. Hanna and S.-Y. Wang. Dishonesty and selection into public service. 2013.

S. F. Joireman. Aiming for certainty: the Kanun, blood feuds and the ascertainment of customary law. *The Journal of Legal Pluralism and Unofficial Law*, 46(2):235–248, 2014.

C. L. Kelly. *Party Proliferation and Political Contestation in Africa*. 2020.

M. Kevane. Ethnicity, public goods and elections in Burkina Faso: Insights for the insurgency of 2016-20? 2020.

K. Kosec and T. Mogues. Decentralization without democracy. *World Politics*, 72(2):165–213, 2020.

M. Kuenzi and G. M. S. Lambright. Voter turnout in Africa's multiparty regimes. *Comparative Political Studies*, 40(6):665–690, 2007.

I. Lago-Peñas, S. Lago-Peñas, and J. Martinez-Vazquez. Guest editorial. *Environment and Planning C: Government and Policy*, 29(2):197–203, 2011.

M. Lierl. The effect of local elections on embezzlement in Burkina Faso. Technical report, IPA, 2015.

M. Lierl. Elections and Embezzlement: Experimental Evidence from Burkina Faso. 2017.

M. Lierl and M. Holmlund. Performance information and voting behavior in Burkina Faso's municipal elections: Separating the effects of information content and information delivery. In T. Dunning, G. Grossman, M. Humphreys, S. Hyde, and C. McIntosh, editors, *Information, Accountability, and Cumulative Learning : Lessons from Metaketa I*, chapter 8. Cambridge University Press, 2019.

M. Lipscomb and A. M. Mobarak. Decentralization and pollution spillovers: Evidence from the re-drawing of county borders in Brazil. *Review of Economic Studies*, 84(1):464–502, 2017.

S. Mahieu. Local governance and accountability in Africa: Insights from Guinea, Burkina Faso and Rwanda. Technical report.

D. C. Mattingly. Elite capture: How decentralization and informal institutions weaken property rights in China. *World Politics*, 68(3):383–412, 2016.

D. McKenzie. Beyond baseline and follow-up: The case for more T in experiments. *Journal of Development Economics*, 99(2):210–221, 2012.

Millenium Challenge Corporation. Measuring results of the Burkina Faso Rural Land Governance Project. Technical report, 2014.

Minnesota Population Center. Integrated Public Use Microdata Series, International: Version 7.2, 2019.

C. Müller-Crepon and P. Hunziker. New Spatial Data on Ethnicity: Introducing SIDE Introduction and motivation. *Journal of Peace Research*, 55(5):1–22, 2018.

K. Muralidharan and P. Niehaus. Experimentation at scale. *Journal of Economic Perspectives*, 31(4): 103–24, 2017.

W. E. Oates. *Fiscal Federalism*. Edward Elgar Publishing, 1972.

F. Place. Land tenure and agricultural productivity in Africa: A comparative analysis of the economics literature and recent policy strategies and reforms. *World Development*, 37(8):1326–1336, 2009.

R. A. Ponce-Rodríguez, C. R. Hankla, J. Martinez-Vazquez, and E. Heredia-Ortiz. Rethinking the political economy of decentralization: How elections and parties shape the provision of local public goods. *Publius: The Journal of Federalism*, 48(4):523–558, 2018.

P. Pryce and M. I. Nascimento. The 2012 parliamentary election in Burkina Faso. *Electoral Studies*, 34 (August 2013):338–342, 2014.

M. Shaukat. Too close to call: Electoral competition and politician behavior in India. 2019.

M. Tavits. Party system change: Testing a model of new party entry. *Party Politics*, 12(1):99–119, 2006.

M. Tavits. Party systems in the making: The emergence and success of new parties in new democracies. *British Journal of Political Science*, 38(1):113–133, 2008.

J. M. Ubink. *In The Land of the Chiefs: Customary Law, Land Conflicts, and the Role of the State in Peri-Urban Ghana*. 2008.

J. M. Ubink and J. Quan. How to combine tradition and modernity? Regulating customary land management in Ghana. *Land Use Policy*, 25(2):198–213, 2008.

USAID. USAID Country Profile: Property Rights and Resource Governance Burkina Faso. Technical report, 2013.

M. Van Leeuwen. Renegotiating customary tenure reform - Land governance reform and tenure security in Uganda. *Land Use Policy*, 39:292–300, 2014.

Model & Solutions

In this model, I start from a traditional model of party competition (I draw from Bardhan and Mookherjee (2010) and Bardhan and Mookherjee (2000), who draw from a Grossman and Helpman (1996)-style model which is relatively common). However, I add two features to this style of model: first, I allow for party entry rather than assuming 2 parties (modeling party entry with a standard model as in work by Tavits (2006), and secondly, allowing for more than 2 potential parties. There are other minor modifications which I will discuss as they emerge.

To illustrate the intuition, however, I consider the entry decision of a second political party in a context where one party has historically dominated (and always contests the election). The model can easily be extended to allow for multiple challengers to this incumbent.

Setup

Consider a stylized village which has several potential groups of people, with groups denoted by g. Within each village, each class g exists in a share α_g ($\sum_g \alpha_g = 1$, $\alpha_g \geq 0$).

There is an incumbent political party which has historically dominated local politics and therefore faces extremely low costs of contesting elections. These costs are low enough that for any non-zero probability of winning the election, this party (denoted d) always contests the election. A potential challenger can choose to create a political party c and contest local elections, although this is costly (with party-specific costs of running for office C_p).

The benefits of holding elected office are twofold: first, there are private rents that accrue to the office-holder, E_p (which could be nonmonetary, such as prestige, but are increasing in the resources controlled by the local government).

Secondly, parties have intrinsic preferences over the interests of the classes they represent, represented by welfare weights w_g^p on each group g. These enter into the politician's payoff as $\sum_g \alpha_g w_g^p U_g(\theta\pi)$. That is, constituent welfare is important to political entrepreneurs, independent of their private rents from holding office. The parameter θ represents the correlation between *de jure* and *de facto* rights: that is, to turn the policy position π_p of a candidate for office into reality (and this reality is what matters for constituent welfare).

Therefore, if a party p wins office, their benefits of holding office are given by $E_p + \sum_g \alpha_g w_g^p U_g(\theta\pi_p)$ and if they lose office to party q, their payoff is $\sum_g \alpha_g w_g^p U_g(\theta\pi_q)$. Therefore, the challenger c will choose to

contest the election against the incumbent d if:

$$\psi_c \left[E_c + \sum_g \alpha_g w_g^c U_g(\theta \pi_c) \right] + (1 - \psi_c) \left[\sum_g \alpha_g w_g^c U_g(\theta \pi_d) \right] - C_c \geq \sum_g \alpha_g w_g^c U_g(\theta \pi_d) \tag{1.2}$$

Where ψ_c is the probability of party c winning the election, as in a standard Tavits-style model of party entry. ψ_c is an increasing, continuously-differentiable function of V_c, the vote share won by that party. However, parties have some uncertainty about ψ_c, so (for instance) a party which expects to win 49% of votes may, in some circumstances, still contest the election.

Politically-informed voters choose who to vote for based on their expected utilities if governed by each party and their (randomly distributed) loyalty towards the incumbent party, v_g. This loyalty has a group-specific distribution [note: either assume normal or uniform]. Therefore, voters of group g vote for party c over the incumbent d if $U_g(\theta \pi_c) \geq U_g(\theta \pi_d) + v_g$, where π_p is the policy choice of party p.

I solve for party entry and policy choice using backwards induction: parties consider how their entry and policies will affect voter choice, and maximize their own payoffs with this in mind. Therefore, I begin with voter choices before modeling the party decisions. The order of party decisions is as follows: first, the challenger decides both whether or not to contest the election and what their policy, π_c, will be. Then, the incumbent party (which always contests) announces their own policy, π_d.

Pre-Reform Solutions

Before the announcement of the land administration decentralization, assume that local governments are constrained to follow central government policy directives. Therefore, π_p is the same regardless of the election result.

Informed voters of group g, then, vote for the challenger over the incumbent if $0 \geq v_g$. This gives a vote share to the challenger of:

$$V_c = \sum_g \alpha_g \int_{-\infty}^{0} v_g dv_g$$

Noting once again that policy choices are irrelevant, the challenger will choose to contest the election if:

$$\psi_c \left(\sum_g \alpha_g \int_{-\infty}^{0} v_g dv_g \right) [E_c] - C_c \geq 0$$

An intuitive result: they will only contest the election if the expected benefits of winning are greater than the costs of contesting. Note that if the average loyalty to the incumbent is positive ($\overline{v_g} \geq 0$), the

probability of winning office is relatively low. Therefore in many cases, the challenger will not contest the election, resulting in the uncompetitive electoral environment observed before the introduction of the land reform.

Reform Announcement Solutions

When a municipality learns that it will receive a land office in the next electoral term, however, the policies implemented by the next election's winner become meaningful to both voters and politicians. Land offices in Burkina Faso were designed to be locally controlled, unlike the deconcentrated municipal services which operated under direction from the central government. The decisions made during the land documentation process could matter substantially to constituent well-being: fair documentation of rights should improve tenure security (with well-explored theoretical and empirical implications for agricultural investment as well as improved access to rental and credit markets), but an unscrupulous actor could take the opportunity to claim documents for land they do not have (primary use) rights to.

In this case, then, voters will choose the challenger if:

$$U_g(\theta\pi_c) \geq U_g(\theta\pi_d) + v_g$$

Which gives a vote share for the challenger of:

$$V_c = \sum_g \alpha_g \int_{-\infty}^{U_g(\theta\pi_c)-U_g(\theta\pi_d)} v_g dv_g$$

Which, if voters are made better off under π_c than under π_d, is higher than in the pre-reform case. More accurately, party c can attract more voters of group g by campaigning on a platform that favors them in the land reform; if this platform is redistributional and makes voters of group h off, then they will lose voters of group h.

Moving backwards, the incumbent then sets their policy π_d (conditional on the entry and policy choices of the challenger). There are two relevant cases for the incumbent to consider.

First, if the challenger is not contesting the election, then the incumbent seeks to maximize:

$$\max_{\pi_d} \left[E_d + \sum_g \alpha_g w_g^d U_g(\theta\pi_d) \right] - C_d$$

As they are guaranteed to win office. Denote the solution to this problem π_{0d}^*.

If, however, the challenger has announced that they will contest the election with a platform of π_c^* (optimally solved below), then the incumbent will maximize:

$$\max_{\pi_d}(1-\psi_c(V_c(\pi_c^*,\pi_d)))\left[E_d+\sum_g \alpha_g w_g^d U_g(\theta\pi_d)\right]+\psi_c(V_c(\pi_c^*,\pi_d))\left[\sum_g \alpha_g w_g^d U_g(\theta\pi_c^*)\right]-C_d$$

Denote this solution as $\pi_{1d}^*(\pi_c^*)$.

Turning to the challenger, if they decide to contest the election, they anticipate the response function $\pi_{1d}^*(\pi_c)$ and maximize:

$$\max_{pi_c}\psi_c(V_c(\pi_c,\pi_{1d}^*(\pi_c)))\left[E_c+\sum_g \alpha_g w_g^c U_g(\theta\pi_c)\right]+(1-\psi_c(V_c(\pi_c,\pi_{1d}^*(\pi_c)))\left[\sum_g \alpha_g w_g^c U_g(\theta\pi_{1d}^*(\pi_c))\right]-C_c$$

Which is optimally solved by π_c^*.

The challenger will then compare their expected payoff if they enter and set π_c^* with their payoff if they choose not to contest:

$$\sum_g \alpha_g w_g^c U_g(\theta\pi_{0d}^*)$$

And choose the entry decision that gives them a higher payoff.

Simplified Two-Group Case

For simplicity, imagine that there are only two groups in the population. One group, f, are ordinary farmers who cultivate an individual plot of land and would prefer that the land office merely document their existing rights to the land. The second group, e, are local elites who under customary tenure arrangements have some secondary rights over farms cultivated by the f type (for instance, e types hold transfer rights while f types hold use rights over the same piece of land). There are more farmers than elites: $\alpha_f > \alpha_e$. These elites would prefer that the land office document their rights instead of those held by the farmers. If I represent the policy choice π_p as denoting the extent to which the documentation process favors the elites, with $\pi = 1$ only documenting all rights as belonging to the elites and $\pi = 0$ documenting all rights as belonging to farmers, $U_e'(\pi) > 0$ and $U_f'(\pi) < 0$.

Therefore, the vote share for the challenger (if they contest) is:

$$V_c = \alpha_f \int_{-\infty}^{U_f(\theta\pi_c)-U_f(\theta\pi_d)} v_f dv_f + (1-\alpha_f)\int_{-\infty}^{U_e(\theta\pi_c)-U_e(\theta\pi_d)} v_e dv_e$$

Note that because the utilities of each group are opposed, for any given policy set by the challenger π_c,

if the incumbent sets $\pi_d > \pi_c$, more elite voters will choose the incumbent (and vice-versa).

Assume further that the elites and the incumbent party are naturally affiliated ($w_e^d > w_f^d$), and the challengers value the welfare of the farmers more ($w_e^c < w_f^c$).

If the challenger does not contest the election, the incumbent will solve:

$$\max_{\pi_d} \left[E_d + \alpha_f w_f^d U_f(\theta\pi_d) + (1-\alpha_f) w_e^d U_e(\theta\pi_d)\right] - C_d$$

π_{0d}^*, then, solves the first order condition:

$$\alpha_f w_f^d \theta \frac{\partial U_f}{\partial \pi_d} + (1-\alpha_f) w_e^d \theta \frac{\partial U_e}{\partial \pi_d} = 0$$

If the challenger does contest the election and announces π_c^*, the incumbent will solve:

$$\max_{\pi_d} (1-\psi_c(V_c)) \left[E_d + \sum_g \alpha_g w_g^d U_g(\theta\pi_d)\right] + \psi_c(V_c) \left[\sum_g \alpha_g w_g^d U_g(\theta\pi_c^*)\right] - C_d$$

When I take the first order condition to solve for π_{1d}^*, I find:

$$\begin{aligned} 0 =& \alpha_f w_f^d \theta \frac{\partial U_f}{\partial \pi_d} + (1-\alpha_f) w_e^d \theta \frac{\partial U_e}{\partial \pi_d} - \frac{\partial \psi_c}{\partial V_c}\frac{\partial V_c}{\partial \pi_d}\left[E_d + \alpha_f w_f^d U_f(\theta\pi_d) + (1-\alpha_f) w_e^d U_e(\theta\pi_d)\right] \\ & - \psi_c(V_c)\left[\alpha_f w_f^d \theta \frac{\partial U_f}{\partial \pi_d} + (1-\alpha_f) w_e^d \theta \frac{\partial U_e}{\partial \pi_d}\right] + \frac{\partial \psi_c}{\partial V_c}\frac{\partial V_c}{\partial \pi_d}\left[\alpha_f w_f^d U_f(\theta\pi_c) + (1-\alpha_f) w_e^d U_e(\theta\pi_c)\right] \end{aligned}$$

Which can be rewritten as:

$$\begin{aligned} 0 =& (1-\psi_c(V_c))\left[\alpha_f w_f^d \theta \frac{\partial U_f}{\partial \pi_d} + (1-\alpha_f) w_e^d \theta \frac{\partial U_e}{\partial \pi_d}\right] \\ & - \frac{\partial \psi_c}{\partial V_c}\frac{\partial V_c}{\partial \pi_d}\left[E_d + \alpha_f w_f^d [U_f(\theta\pi_d) - U_f(\theta\pi_c)] + (1-\alpha_f) w_e^d [U_e(\theta\pi_d) - U_e(\theta\pi_c)]\right] \end{aligned}$$

Note that the term inside the brackets on the first line of this condition is exactly the first order condition from the uncompetitive case. I can use this to show that if $\pi_c < \pi_{0d}^*$ (that is, the challenger proposes a policy more favorable to farmers than the uncompetitive policy chosen by the incumbent), that the incumbent will shift their own optimal policy: $\pi_{0d}^* > \pi_{1d}^*(\pi_c)$.

Intuitively, in order to win some votes from farmers and therefore be competitive, the incumbents will respond to the policy proposal of the challenger by moderating their own policy stance.

Heterogeneity: Municipalities Near Cities

The simple two-group case discussed above previews some of the tensions inherent in the land documentation process, which become increasingly important in municipalities close to cities.

I will refer to these rural areas that are reasonably close to (rapidly growing) cities as 'near-urban' for concision, but it is important to note that they are predominantly rural in themselves. That is, local constituents are engaged in a primarily rural way of life. However, urban residents are increasingly seeking to purchase rural land near their city homes, as a source of insurance, connection to the countryside, or vacation home. These urban residents may have extended family in other regions of the country, but seek a closer rural retreat. This also implies that they likely have little or no connection with the inhabitants of the nearby rural municipalities they seek to buy land in. Two important implications stem from this fact: first, they can be ignored as constituents in either voting behavior or politicians' preferences, and second, they have a relatively higher demand for clearly-documented land.

This latter point is crucial. Rural residents are embedded in the same social environment as their customary land rights: the individual who holds secondary (access, transfer, etc) rights to your farm plot is your neighbor, uncle, or friend. As documented in a substantial body of qualitative evidence, this also means that bundles of rights being distributed across multiple individuals does not in itself make those rights less secure. However, an outsider to this social system will struggle to parse its property rights. Therefore, the value of clearly documented rights, backed by the legal framework of the state (as opposed to the social environment), is higher for outsiders to the community, particularly those seeking land for part-time use who may never become part of the community.

Urbanites seeking land in nearby rural areas have a higher relative demand for documentation, then. They are willing to pay higher fees to cover the cost of documents. The decentralized SFR offices, then, can set higher fees for APFR documents if they are near urban areas, to tap this higher willingness to pay. These fees become part of the municipal budget, which local elected officials can take advantage of. In the context of the model, this can be represented as a larger increase in E_p in near-urban areas when the land offices are introduced. The entry condition for the challenger, given by

$$\psi_c(V_c)\left[E_c + \sum_g \alpha_g w_g^c U_g(\theta\pi_c)\right] + (1-\psi_c(V_c)\left[\sum_g \alpha_g U_g(\theta\pi_{1d}^*)\right] - C_c \geq \sum_g \alpha_g w_g^c U_g(\theta\pi_{0d}^*)$$

Is more likely to be satisfied as E_c increases. The model therefore predicts more party entry in response to the announcement of treatment in near-urban municipalities. This is a relatively straightforward story of

political rents: the rents of holding office increase more in near-urban areas due to higher willingness to pay for documentation by outsiders, and so there is a political response.

This model also demonstrates another mechanism by which the introduction of land offices in near-urban areas leads to a greater response by political parties choosing to contest the election. Parties also care about the welfare of their constituents, as captured by the payoff term $\sum_g \alpha_g w_g^p U_g(\theta\pi)$ (and not only their own private rents, E_p). If constituents' utility responds more to policy in near-urban areas, then the value of contesting the election is higher in near-urban areas set to receive a land office.

To understand why constituents may care more about land documentation policy in near-urban areas, consider the role of policy in a general sense. In an isolated rural environment, if the documents created by SFRs exclude secondary rightsholders, or is granted to an individual without primary use rights, there are relatively few consequences. Without a strong permeation of the state's legal system and enforcement (that is, a low θ), the individual who holds socially-sanctioned customary rights will continue to exercise them, regardless of what documents say. However, in near-urban municipalities, the risks of the documentation process become larger. Imagine that documents are granted to a secondary rightsholder who is not the primary user of the land. They then sell this land to an urbanite, who accepts the document at face value as indicating they are the appropriate person to sell the land. The urbanite is able to enforce their legal rights, through better access to the formal (state) justice system. This dynamic is captured in the model as an increase in θ, the efficacy of the policy: the land documentation process has larger effects in near-urban areas than in more remote ones where a policy may be blunted. Returning to the two-group simplified case detailed above, elites would have more incentive to control the documentation process and have land documented in their name, as they can sell it on to outsiders.

Formally, an increase in *theta* will also cause relatively more political entrants to contest elections in municipalities near urban areas in response to the reform. This is not only due to the higher weight on the constituent-welfare component of the politicians' payoffs: the strategic interactions of policy choices explored above also become more important.

I have shown two mechanisms by which potential candidates in municipalities close to urban areas will respond more strongly to the creation of land offices than their counterparts further away. Both of these mechanisms stem from urban outsiders' demand for land and their inability to navigate the nuanced social complexities of customary tenure. Despite having the same net effect, the two mechanisms are theoretically distinct: the latter goes beyond private rents to account for politicians valuing their constituent welfare.

Variable	(1) Non-experimental Treatment Mean/SE	(2) Experimental[1] Treatment Mean/SE	(3) Never Treated Mean/SE	T-test Difference (1)-(2)	(1)-(3)
Seats Available	54.869	44.633	47.855	10.236	7.014*
	(3.222)	(4.008)	(2.217)		
Registered Voters	10299.131	8658.100	10976.860	1641.031	-677.729
	(689.234)	(750.101)	(1018.567)		
Voter turnout rate	0.501	0.496	0.504	0.005	-0.003
	(0.008)	(0.019)	(0.007)		
Parties Contesting	3.925	4.200	5.109	-0.275	-1.183**
	(0.213)	(0.357)	(0.373)		
Effective # Parties (votes)	2.129	2.163	2.471	-0.034	-0.342**
	(0.061)	(0.108)	(0.103)		
Pastoralist	0.449	0.600	0.425	-0.151	0.023
	(0.048)	(0.091)	(0.033)		
Far from Urban	0.467	0.333	0.380	0.134	0.087
	(0.048)	(0.088)	(0.033)		
N	107	30	221		

Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.
Data source: CENI Electoral Returns
[1]: Experimental refers to only MCC Phase II treatment municipalities.

Table 1.10: Experimental treatment municipalities seem broadly similar to other municipalities which received land offices, but some differences between non-experimental treatment and never treated.

External Validity

To examine external validity, I present balance tables which compare experimental (phase II) treatment municipalities to municipalities which received treatment under a non-experimental program (either Phase I or non-MCC programs after 2015), as well as to all other municipalities which never received a land office. Table 1.10 presents balance on variables included in the election returns, and table 1.11 presesnts balance on variables included in the Afrobarometer surveys. It appears that my focus on the experimental phase also may make results more generalizable: non-experimental (phase I) municipalities appear to be larger and less electorally competitive than the rest of the country, although surveyed voter attitudes are broadly similar.

Placebo Checks

Despite the random assignment of treatment status, it is worth checking that variables that should not be affected by the announcement of and creation of land offices in municipalities do not change differentially

	Non-experimental Treatment	Experimental[1] Treatment	Never treated Never treated	T-test Difference	
	Mean/CI	Mean/CI	Mean/CI	(1)-(2)	(1)-(3)
All/most corrupt: president	0.17	0.33	0.21	0.08	-0.01
	(0.01 - 0.32)	(-0.47 - 0.93)	(0.11 - 0.31)		
All/most corrupt: local gov	0.11	0.30	0.24	0.15**	-0.02
	(-0.00 - 0.24)	(-1.17 - 0.83)	(0.16 - 0.32)		
All/most corrupt: gov officials	0.14	0.40	0.24	0.12	-0.05
	(-0.01 - 0.37)	(-1.72 - -1.36)	(0.17 - 0.32)		
Trust somewhat/a lot: local gov	0.63	0.68	0.63	0.04	0.01
	(0.44 - 0.87)	(0.18 - 2.36)	(0.50 - 0.76)		
Leaders should not favor own group	0.40	0.25	0.35	-0.09	-0.02
	(0.14 - 0.52)	(-0.38 - 0.70)	(0.29 - 0.41)		
Trust CDP	0.57	0.53	0.51	-0.02	0.04
	(0.43 - 0.75)	(-0.55 - -0.41)	(0.39 - 0.62)		

Notes: The value displayed for t-tests are the differences in the means across the groups. Wild Cluster Bootstrapped standard errors are clustered at the region level. Region fixed effects are included in all estimation regressions. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.
Data source: Afrobarometer survey
[1]: Experimental refers to only MCC Phase II treatment municipalities.

Table 1.11: Treatment groups are statistically similar on survey measures at baseline.

between treatment and control municipalities, to lend support to the causal argument. The electoral returns are relatively sparse in this regard: only the number of seats available in a given municipality, which is determined by a formula, is a good placebo. However, table 1.12 presents the same specification as throughout, with this placebo as the outcome.

In the Afrobarometer data, however, there is information on the provision of other local public goods in the municipality, perceptions of other levels of government and other functionings of government, and opinions about national political issues (including the 2014 unrest) as placebo checks. Tables 1.13, 1.14, 1.15 and 1.16 report these checks, respectively, and indeed, there are few statistically significant treatment effects on any of these outcomes.

Robustness Checks

For most results reported in the paper, I have checked robustness to a variety of specification choices. There are several interesting dimensions to explore, which I present below.

VARIABLES	(1) Seats Available	(2) Seats Available	(3) Seats Available
Treatment	-3.470	-3.470	-3.470
	(4.409)	(5.597)	(5.597)
2012	1.825	1.825	1.979
	(4.488)	(1.438)	(1.591)
Treatment*2012	-1.492	-1.492	-1.645
	(6.263)	(1.602)	(1.744)
2016	-0.955	-0.955	-1.194
	(4.535)	(1.503)	(1.642)
Treatment*2016	2.889	2.889*	3.128*
	(6.296)	(1.681)	(1.797)
Constant	48.10***	48.10***	48.02***
	(4.720)	(5.271)	(3.003)
Observations	175	175	175
R-squared			0.017
Number of pairs	29	29	29
Pair FE	No	No	Yes
Cluster SE	None	Pair	Pair

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns

Table 1.12: Placebo Check: Number of Council Seats Available

	(1) Electricity grid	(2) Piped water	(3) Sewage	(4) School	(5) Police station	(6) Health clinic
Treatment	-.1917588	-.3594043	-.0355205	-.3390796	.5180141	.2306639
	(0.67)	(0.06)	(0.40)	(0.08)	(0.10)	(0.58)
2012	-.1593666	-.1231068	-.0353802	-.0523584	.6888804	.4746795
	(0.68)	(0.73)	(0.41)	(0.55)	(0.08)	(0.35)
Treatment*2012	.3716798	.3631331	.0555865	.3912367	-.5919516	-.3163727
	(0.50)	(0.29)	(0.42)	(0.06)	(0.17)	(0.65)
2015	-.0511418	.7703703	.0251802	.0378365	-.2996438	.0695917
	(0.19)	(0.00)	(0.43)	(0.75)	(0.19)	(0.77)
Treatment*2015	.1321355	.0506836	.0662207	-.1625539	.239895	-.0463234
	(0.62)	(0.86)	(0.47)	(0.60)	(0.27)	(0.95)
Constant	.1741187	.2953581	.018679	1.027353	-.2965989	.2386938
Observations	448	448	448	448	448	448
R^2	0.131	0.763	0.090	0.211	0.206	0.105
Number of regions	12	12	12	12	12	12
Fixed Effect	Region	Region	Region	Region	Region	Region

Wild Cluster Boostrapped p-values in parentheses
Data source: Afrobarometer survey

Table 1.13: Placebo Check: Public services in Survey Enumeration Areas

	(1) Gov handling crime well	(2) Gov handling health well	(3) Gov handling education well	(4) Gov handling water well
Treatment	-.0741821	.1851171	-.0270661	-.0179442
	(0.71)	(0.32)	(0.87)	(0.93)
2012	-.0551552	.2612381	.1489857	-.1478423
	(0.73)	(0.21)	(0.38)	(0.42)
Treatment*2012	.1355472	-.1597682	-.0196819	.0705859
	(0.51)	(0.39)	(0.92)	(0.69)
2015	.0553903	-.301878	-.2471382	.0595489
	(0.67)	(0.01)	(0.01)	(0.55)
Treatment*2015	-.077262	.0366653	-.1032353	-.2610781
	(0.66)	(0.80)	(0.46)	(0.01)
Constant	.5778868	.3678669	.5515825	.3699182
Observations	407	430	429	430
R^2	0.003	0.056	0.070	0.046
Number of regions	12	12	12	12
Fixed Effects	Region	Region	Region	Region

Wild Cluster Boostrapped p-values in parentheses
Data source: Afrobarometer

Table 1.14: Placebo Checks: Perceptions of how well the government is providing other public goods

	(1) Opposition parties should cooperate with the government	(2) President should be monitored by NA	(3) Officials often/always go unpunished
Treatment	-.1216905	-.037526	-.1412026
	(0.31)	(0.85)	(0.16)
2012	-.1370136	.1417801	.0055167
	(0.32)	(0.07)	(0.94)
Treatment*2012	.1399332	.080229	.0874819
	(0.41)	(0.60)	(0.39)
2015	.2180273	.0614474	.0764117
	(0.04)	(0.70)	(0.51)
Treatment*2015	-.0476423	-.0146765	.0286156
	(0.77)	(0.92)	(0.85)
Constant	.816052	.6099668	.6981749
Observations	424	424	394
R^2	0.039	0.051	0.026
Number of regions	12	12	12
fe	Region	Region	Region

Wild Cluster Boostrapped p-values in parentheses
Data source: Afrobarometer survey

Table 1.15: Placebo checks: attitudes about national politics

	(1) Support Term Limit	(2) Trust CDP
Treatment	-.1651713	.163052
	(0.47)	(0.37)
2012	-.023049	-.010422
	(0.94)	(0.92)
Treatment*2012	.1908113	-.0635544
	(0.55)	(0.62)
2015	.1613045	
	(0.13)	
Treatment*2015	.034328	
	(0.69)	
Constant	.7313894	.5162566
Observations	421	229
R^2	0.078	0.013
N_g	12	11
Fixed Effect	Region	Region
Standard Errors	Wild Cluster Bootstrap	Wild Cluster Bootstrap

Wild Cluster Bootstrapped p-values in parentheses, cluster at regional level
Question on Trusting CDP only asked in 2008 & 2012
Data source: Afrobarometer

Table 1.16: No differential support for Compaoré or term limits

Alternate measures of Competitiveness

Although Golosov's method of computing the effective number of parties is preferable when there is a dominant party (Golosov, 2010), the more traditional Laakso & Taagepera formula shows similar results (including the lack of significant differences between treatment and control municipalities in any year) in table 1.17.

CDP Performance

Although I showed above that the previously-ruling party, the CDP, was more likely to contest elections in 2016 in those municipalities which had received land offices, despite a large drop in the share of municipalities they contest nationwide, it is interesting to see if there is any difference in voter responses to this party due to treatment. However, a simple regression with the vote share won by the CDP ignores the extensive margin: that is, the outcome is only non-zero in municipalities where the CDP chose to run. In order to examine the response of the CDP's vote share to treatment, then, I must use a method to account for the extensive margin which determines whether the outcome of interest is observed: that is, whether the CDP contests. A Heckman selection model explicitly models this extensive-margin 'selection' decision, as well as the performance on the outcome of interest. It requires, however, at least one variable to influence the

VARIABLES	(1) Effective # Parties (Votes)	(2) Effective # Parties (Seats)	(3) Effective # Parties (Votes)	(4) Effective # Parties (Seats)
Treatment	0.0122	-0.110	-0.00222	-0.0631
	(0.145)	(0.117)	(0.106)	(0.0931)
2012	0.457***	0.188*	0.282***	0.133
	(0.130)	(0.104)	(0.0979)	(0.0892)
Treatment*2012	0.251	0.0340	0.152	-0.0103
	(0.182)	(0.117)	(0.117)	(0.0915)
2016	-0.148	0.114	0.00726	0.104
	(0.132)	(0.125)	(0.111)	(0.109)
Treatment*2016	0.0521	0.281*	0.124	0.235
	(0.187)	(0.151)	(0.153)	(0.143)
Constant	2.156***	1.624***	1.623***	1.408***
	(0.0808)	(0.0752)	(0.0645)	(0.0605)
Observations	175	175	175	175
R-squared	0.229	0.204	0.221	0.169
Number of comp	29	29	29	29
Pair FE	Yes	Yes	Yes	Yes
Cluster SE	Pair	Pair	Pair	Pair
Measure	Laasko & Taagepera	Laasko & Taagepera	Golosov	Golosov

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns

Table 1.17: Two measures of effective numbers of parties

outcome but not participation, so as to separately identify the two equations. I use the CDP's incumbency as this variable: although normally incumbent parties find it easier to run again, using the levers of state for their own campaign purposes, the 'special delegations' that took over municipal governance in the aftermath of the 2014 unrest mean that the winner of the 2012 elections was not actually in power during the 2016 election campaign. However, Lierl and Holmlund (2019) demonstrate that voters do favor the incumbent party in 2016, as they have more information about their performance. Therefore, it seems reasonable that the vote share received by the CDP will depend to some extent on whether the CDP was incumbent. The results from the Heckman model are shown in columns (3) - (5) of table 1.18. However, in part because of the small sample size, these models are unstable and in some variations do not converge. The inclusion of the number of parties makes the model stable, and is therefore included.

When I use the Heckman model, I find that there are no significant differences between CDP vote share in treatment and control municipalities, before or after treatment. Therefore, although the party seems to be responding to treatment, it may be that less-informed voters are unable to attribute the land offices to a particular party (consistent with Lierl and Holmlund (2019)'s findings that voters know little about local government performance, even on regularly-used services), or that they do not see the land office as valuable enough to reward politicians for.

Alternate Dimensions of Heterogeneity

Importantly, when looking at heterogeneity in treatment effects, I created dichotomous groupings based on continuous variables (distance to urban centers, as well as ethnic or linguistic-based population shares). The results presented above are broadly robust to a variety of thresholds, although some splits involve relatively small groups which affects statistical significance. Figure 1.10 shows the mean travel time in minutes to an urban center for each municipality in the country; figure 1.11 shows the percentage of the population in each municipality identified by SIDE as belonging to a pastoralist ethnic group. Table 1.19 presents results from a variety of distances to cities defined as 'near-urban'; the significant interaction effect appears robust to these different bandwidths.

Table 1.20 looks at treatment heterogeneity with different definitions of areas containing some pastoralists. Columns (1) and (2) use the Spatially Interpolated Data on Ethnicity; column (1) uses the median value of the ethnic share of pastoralist groups, 4%, to define 'more-pastoralist' areas, while column (2) uses a more restrictive 10% share which only 5 municipalities meet. Columns (3) and (4) use the linguistic definition from IPUMS Census data, with (3) cutting at the median (5%) and (4) splitting at 10% (again, only 5 municipalities in the experimental phase meet this condition). Results are broadly consistent between the

VARIABLES	(1) CDP Contest	(2) CDP Vote Share	(3) CDP Vote Share	(4) CDP Contest	(5) /
Treatment	0.00407	0.0226	0.0370	0.0551	
	(0.00394)	(0.0465)	(0.0431)	(0.752)	
2012	0.00488	-0.0892***	-0.0826**	-0.718	
	(0.00505)	(0.0315)	(0.0394)		
Treatment*2012	-0.00488	-0.0210	-0.000751	-0.193	
	(0.00505)	(0.0444)	(0.0488)	(1.170)	
2016	-0.468***	-0.417***	-0.360***	-7.086	
	(0.0973)	(0.0325)	(0.0536)		
Treatment*2016	0.234**	0.0611	0.0282	0.649	
	(0.106)	(0.0441)	(0.0538)		
Number Parties			-0.0243**	0.885***	
			(0.0111)	(0.277)	
CDP Incumbent			0.00963		
			(0.0344)		
athrho					-0.0791
					(0.640)
lnsigma					-2.131***
					(0.0624)
Constant	0.997***	0.609***	0.749***	4.910	
	(0.0229)	(0.0237)	(0.0448)		
Observations	175	175	175	175	175
R-squared	0.354	0.740			
Number of comp	29	29			
Pair FE	Yes	Yes	Yes	Yes	Yes
Cluster SE	Pair	Pair	Pair	Pair	Pair
Model	Linear	Linear	Heckman	Heckman	Heckman

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns

Table 1.18: CDP Performance on the extensive and intensive margin

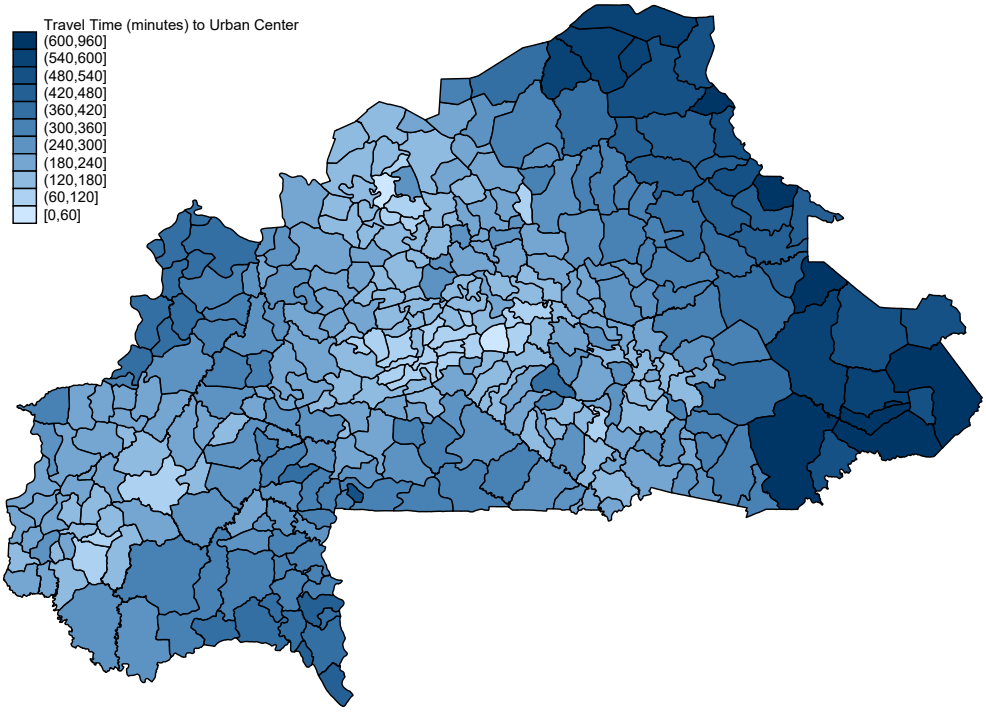


Figure 1.10: Travel time in minutes to urban centers

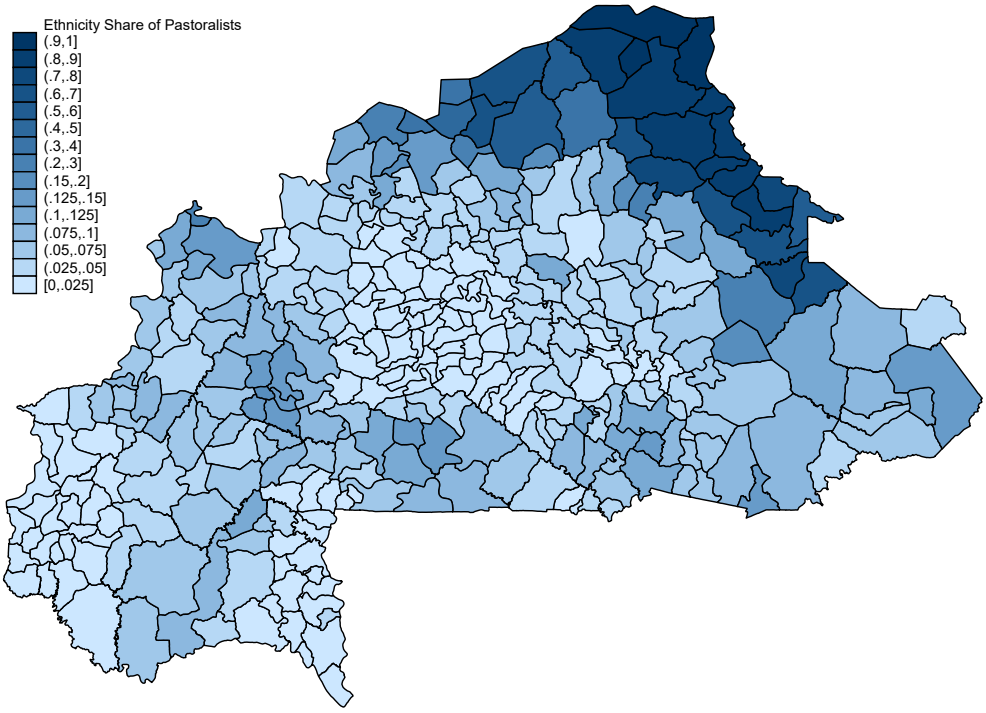


Figure 1.11: Ethnicity share of pastoralist groups

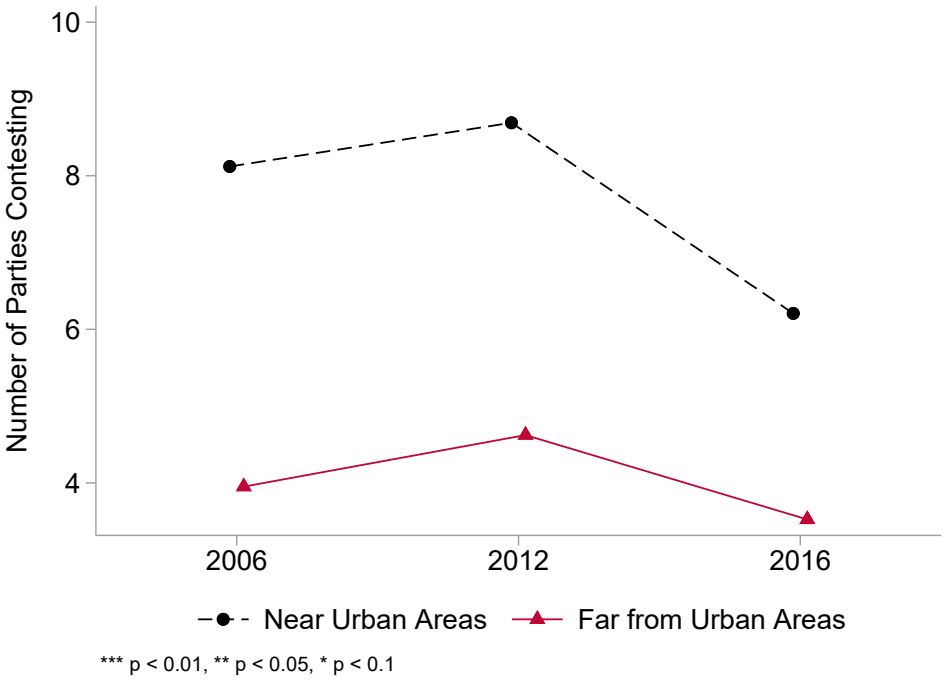


Figure 1.12: Similar Trends in Near-Urban and Rural Non-experimental Areas

two definitions of pastoralists, although treatment effects do seem stronger when using a more restrictive definition (consistent with the explanation proposed above, that appealing to small pastoralist groups in a community is not a winning electoral strategy, but more so as this group increases in size).

Additionally, there could be some concern that near-urban areas face different secular trends in the political environment that the heterogeneous treatment effects analysis is picking up, apart from the treatment in question. However, figure 1.12 shows that despite different levels in the number of parties contesting in near-urban and remote areas, they seem to have roughly similar trends.

Binary Outcomes Model for Afrobarometer Data

The preferred specification for Afrobarometer outcomes presented above uses a Wild Cluster Bootstrap (with a Webb 6-point distribution), with Region fixed effects and clusters at the region level. However, to ensure my results are robust to a variety of modeling choices, I check a variety of alternate specifications. In tables 1.21 - 1.25, I show that results are broadly similar across my preferred specification (column (1)), the same bootstrap using survey weights (column (2)), calculating cluster-robust standard errors analytically (columns (3) and (4)). I also have checked robustness to different levels of fixed effects and clustering, as well as to bootstrapping with the Rademacher 2-point distribution (not presented here), with broadly similar results.

In looking at changes in voter perceptions of corruption using the Afrobarometer data above, I used a

VARIABLES	(1) Parties Contesting	(2) Parties Contesting	(3) Parties Contesting
Treatment	0.431	-0.0899	-0.250
	(0.348)	(0.290)	(0.327)
Near-Urban	0.671	-0.888	-0.690
	(0.512)	(0.567)	(0.631)
Treatment*Near-Urban	1.569**	2.025**	1.407**
	(0.587)	(0.742)	(0.602)
2012	0.581	0.664	0.207
	(0.362)	(0.411)	(0.428)
Treatment*2012	0.678	0.547	0.611
	(0.435)	(0.457)	(0.461)
2012*Near-Urban	1.419***	-0.0636	0.682
	(0.362)	(0.784)	(0.651)
Treatment*2012*Near-Urban	0.322	0.671	0.290
	(1.020)	(0.974)	(0.793)
2016	-0.649**	-0.697**	-0.281
	(0.244)	(0.274)	(0.280)
Treatment*2016	-0.536	-0.145	0.0988
	(0.368)	(0.316)	(0.369)
2016*Near-Urban	-2.351***	-0.103	-0.719
	(0.244)	(0.580)	(0.441)
Treatment*2016*Near-Urban	-2.464***	-2.145***	-1.625**
	(0.563)	(0.695)	(0.624)
Constant	3.561***	3.890***	4.014***
	(0.243)	(0.290)	(0.386)
Observations	175	175	175
R-squared	0.421	0.405	0.378
Number of comp	29	29	29
Pair FE	Yes	Yes	Yes
Cluster SE	Pair	Pair	Pair
Bandwidth	2 hours	3 hours	4 hours

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Data source: CENI Electoral Returns + AidData

Table 1.19: Stronger results near cities, although relatively robust to larger bandwidths

VARIABLES	(1) Parties Contesting	(2) Parties Contesting	(3) Parties Contesting	(4) Parties Contesting
Treatment	1.341**	0.758*	0.853	0.597
	(0.501)	(0.380)	(0.539)	(0.374)
Some Pastoralists	1.534*	-0.980**	-0.765	0.758***
	(0.755)	(0.419)	(0.978)	(0.203)
Treatment*Pastoralists	-1.328**	-0.175	-0.234	0.126
	(0.566)	(0.451)	(0.694)	(0.509)
2012	0.286	0.540	0.206	0.503
	(0.546)	(0.354)	(0.520)	(0.367)
Treatment*2012	1.402*	0.884*	1.486*	0.979**
	(0.728)	(0.476)	(0.746)	(0.473)
2012*Some Pastoralists	0.708	2.460***	0.948	1.497*
	(0.703)	(0.354)	(0.662)	(0.829)
Treatment*2012*Pastoralists	-1.252	-2.384***	-1.405	-1.979**
	(0.889)	(0.539)	(0.870)	(0.807)
2016	-0.614	-0.687**	-0.733*	-0.653**
	(0.395)	(0.254)	(0.403)	(0.266)
Treatment*2016	-1.698***	-1.121***	-1.882***	-1.125***
	(0.570)	(0.395)	(0.624)	(0.387)
2016*Some Pastoralists	-0.312	-1.313***	-0.0363	-0.847*
	(0.509)	(0.254)	(0.493)	(0.457)
Treatment*2016*Pastoralists	1.696**	2.371**	1.711**	1.958**
	(0.745)	(0.867)	(0.729)	(0.785)
Constant	2.786***	3.617***	3.931***	3.535***
	(0.482)	(0.231)	(0.555)	(0.230)
Observations	175	175	175	175
R-squared	0.410	0.310	0.342	0.299
Number of comp	29	29	29	29
Pair FE	Yes	Yes	Yes	Yes
Cluster SE	Pair	Pair	Pair	Pair
Measure	SIDE	SIDE	IPUMS	IPUMS
Threshold	4%	10%	5%	10%

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.20: Some differences in treatment heterogeneity depending on measure of pastoralism used

linear probability model. However, this does not explicitly account for the binary nature of the outcome variables (whether or not most politicians are corrupt), and therefore does not bound projected probabilities to be between zero and one. In fact, when adding the coefficients of these models, the predicted probability that most government officials are corrupt is negative when including all interactions. Therefore, it is worth considering binary outcome models as a robustness check. This effort is complicated by a desire to control for fixed effects (to account for regional heterogeneity in surveyed attitudes and responses). The nationally-representative sample in each wave of the Afrobarometer does not include respondents in both treatment and control municipalities for a given experimental pair very often, so cluster fixed effects will reduce the number of observations used for identification too much. Additionally, most clusters are observed only in one year, so there is no variation in time; in others, there is no variation between treatment and control municipalities. Therefore, I include fixed effects at the region level, which control for unobserved heterogeneity at a slightly larger level so as to include more municipalities. The results from a logit with regional fixed effects and region-clustered analytic standard errors (as the wild or score cluster bootstraps are inconsistent with the logit) are presented in column (5) of tables 1.21 - 1.25.

Although there are minor differences between the various models, the results overall present a consistent pattern: there is a significant decrease in perceptions of corruption among local government councillors in treatment municipalities in 2015. Although the magnitudes of coefficients between a linear probability and logit model cannot be directly compared, the signs and significances are roughly the same, as are the marginal effects at the mean.

	(1) Corruption in President's Office	(2) Corruption in President's Office	(3) Corruption in President's Office	(4) Corruption in President's Office	(5) Corruption in President's Office
Treatment	-.0698054	-.1435174	-.0698054	-.1435174	-.309088
	(0.67)	(0.52)	(0.61)	(0.34)	(0.68)
2012	.0110917	.0362828	.0110917	.0362828	.1445132
	(0.88)	(0.58)	(0.89)	(0.58)	(0.69)
Treatment*2012	.0911531	.1208692	.0911531	.1208692	.3354454
	(0.38)	(0.37)	(0.35)	(0.30)	(0.53)
2015	-.0051325	-.0622281	-.0051325	-.0622281	-.0989417
	(0.96)	(0.62)	(0.96)	(0.54)	(0.85)
Treatment*2015	-.1661832	-.0695833	-.1661832	-.0695833	-.7575623
	(0.36)	(0.67)	(0.29)	(0.64)	(0.36)
Constant	.3591549	.3684992	.3591549	.3684992	
			(0.00)	(0.00)	
Observations	358	358	358	358	358
R^2	0.018	0.110	0.018	0.110	
Number of Regions	12		12		
Fixed Effect	Region	Region	Region	Region	Region
Standard Errors	Wild Bootstrap	Wild Bootstrap	Analytic	Analytic	Analytic
Model	Webb 6-point	Webb 6-point	Linear	Linear	Logit
Weight	Unweighted	Survey weighted	Unweighted	Survey Weighted	Unweighted

Wild Cluster Bootstrapped or Analytic Cluster-Robust p-values in parentheses, cluster at regional level
Data source: Afrobarometer

Table 1.21: Perceptions of corruption in the President's office results robust to a variety of specifications

	(1) Corruption in Gov Officials	(2) Corruption in Gov Officials	(3) Corruption in Gov Officials	(4) Corruption in Gov Officials	(5) Corruption in Gov Officials
Treatment	-.3111226	-.3494559	-.3111226	-.3494559	-1.480553
	(0.05)	(0.05)	(0.01)	(0.00)	(0.01)
2012	-.0632625	-.0579099	-.0632625	-.0579099	-.1887773
	(0.67)	(0.64)	(0.61)	(0.61)	(0.71)
Treatment*2012	.2895166	.3469639	.2895166	.3469639	1.342956
	(0.08)	(0.04)	(0.06)	(0.01)	(0.05)
2015	-.0004007	-.0080935	-.0004007	-.0080935	-.1054177
	(0.99)	(0.90)	(1.00)	(0.90)	(0.77)
Treatment*2015	-.1386811	-.1407866	-.1386811	-.1407866	-.5054067
	(0.48)	(0.45)	(0.43)	(0.44)	(0.53)
Constant	.49182	.4829131	.49182	.4829131	
			(0.00)	(0.00)	
Observations	370	370	370	370	370
R^2	0.039	0.106	0.039	0.106	
Number of Regions	12		12		
Fixed Effect	Region	Region	Region	Region	Region
Standard Errors	Wild Bootstrap	Wild Bootstrap	Analytic	Analytic	Analytic
Model	Webb 6-point	Webb 6-point	Linear	Linear	Logit
Weight	Unweighted	Survey weighted	Unweighted	Survey Weighted	Unweighted

Wild Cluster Bootstrapped or Analytic Cluster-Robust p-values in parentheses, cluster at regional level
Data source: Afrobarometer

Table 1.22: Perceptions of corruption among government officials results robust to a variety of specifications

	(1) Corruption in Local Gov	(2) Corruption in Local Gov	(3) Corruption in Local Gov	(4) Corruption in Local Gov	(5) Corruption in Local Gov
Treatment	-.2588241	-.300364	-.2588241	-.300364	-1.372686
	(0.19)	(0.10)	(0.06)	(0.02)	(0.05)
2012	-.0878433	-.0632249	-.0878433	-.0632249	-.3338814
	(0.57)	(0.69)	(0.52)	(0.65)	(0.62)
Treatment*2012	.3102148	.3297491	.3102148	.3297491	1.567829
	(0.15)	(0.12)	(0.06)	(0.05)	(0.06)
2015	.0708754	.0706392	.0708754	.0706392	.2485434
	(0.50)	(0.39)	(0.42)	(0.32)	(0.53)
Treatment*2015	-.2395636	-.2164227	-.2395636	-.2164227	-1.055188
	(0.16)	(0.17)	(0.05)	(0.06)	(0.07)
Constant	.3888866	.3778106	.3888866	.3778106	
			(0.00)	(0.00)	
Observations	388	388	388	388	382
R^2	0.039	0.103	0.039	0.103	
Number of Regions	12		12		
Fixed Effect	Region	Region	Region	Region	Region
Standard Errors	Wild Bootstrap	Wild Bootstrap	Analytic	Analytic	Analytic
Model	Webb 6-point	Webb 6-point	Linear	Linear	Logit
Weight	Unweighted	Survey weighted	Unweighted	Survey Weighted	Unweighted

Wild Cluster Bootstrapped or Analytic Cluster-Robust p-values in parentheses, cluster at regional level
Data source: Afrobarometer

Table 1.23: Perceptions of corruption in local government results robust to a variety of specifications

	(1)	(2)	(3)	(4)	(5)
	Support term limit	Support term limit	Support term limit	Support term limit	Support term limit
Treatment	-.1651713	-.1950934	-.1651713	-.1950934	-.831091
	(0.47)	(0.40)	(0.27)	(0.25)	(0.23)
2012	-.023049	-.0325595	-.023049	-.0325595	-.1852225
	(0.94)	(0.89)	(0.89)	(0.85)	(0.81)
Treatment*2012	.1908113	.2303963	.1908113	.2303963	.9403277
	(0.55)	(0.41)	(0.31)	(0.25)	(0.28)
2015	.1613045	.2036297	.1613045	.2036297	.9497276
	(0.13)	(0.06)	(0.03)	(0.00)	(0.03)
Treatment*2015	.034328	-.0178935	.034328	-.0178935	.8543751
	(0.69)	(0.80)	(0.69)	(0.81)	(0.29)
Constant	.7313894	.7216691	.7313894	.7216691	
			(0.00)	(0.00)	
Observations	421	421	421	421	413
R^2	0.078	0.105	0.078	0.105	
Number of Regions	12		12		
fe	Region	Region	Region	Region	Region
ses	Wild Bootstrap	Wild Bootstrap	Analytic	Analytic	Analytic
Model	Webb 6-point	Webb 6-point	Linear	Linear	Logit
weight	Unweighted	Survey weighted	Unweighted	Survey Weighted	Unweighted

Wild Cluster Bootstrapped or Analytic Cluster-Robust p-values in parentheses, cluster at regional level
Data source: Afrobarometer

Table 1.24: Support for a term limit results robust to a variety of specifiations

	(1)	(2)	(3)	(4)	(5)
	Trust CDP	Trust CDP	Trust CDP	Trust CDP	Trust CDP
Treatment	.163052	.1736554	.163052	.1736554	.6694361
	(0.37)	(0.44)	(0.21)	(0.20)	(0.20)
2012	-.010422	-.0214322	-.010422	-.0214322	-.0462453
	(0.92)	(0.84)	(0.94)	(0.87)	(0.93)
Treatment*2012	-.0635544	-.0786591	-.0635544	-.0786591	-.2756045
	(0.62)	(0.56)	(0.69)	(0.62)	(0.68)
Constant	.5162566	.5443258	.5162566	.5443258	
			(0.00)	(0.00)	
Observations	229	229	229	229	226
R^2	0.013	0.089	0.013	0.089	
Number of regions	11		11		
Fixed Effect	Region	Region	Region	Region	Region
Standard Errors	Wild Bootstrap	Wild Bootstrap	Analytic	Analytic	Analytic
Model	Webb 6-point	Webb 6-point	Linear	Linear	Logit
Weight	Unweighted	Survey weighted	Unweighted	Survey Weighted	Unweighted

Wild Cluster Bootstrapped or Analytic Cluster-Robust p-values in parentheses, cluster at regional level
Data source: Afrobarometer

Table 1.25: Trust in CDP results robust to a variety of specifications

Chapter 2

Customary Tenure and Agricultural Investment in Uganda

2.1 Introduction

Secure property rights are fundamental to investment and prosperity, and land tenure in particular is critical for poor farmers to make long-term investments and improve agricultural productivity. In much of Sub-Saharan Africa, customary tenure predominates. Economists have traditionally focused on the undocumented and therefore theoretically less secure nature of customary tenure when compared with freehold land, where the owner enjoys all rights in perpetuity. Large-scale formalization policies across much of the continent have aimed to address this insecurity to allow farmers to make transformative investments in their own farms. However, empirical work has been more mixed than theory; customary land is not always less secure in farmers' own estimation (nor under-invested relative to freehold land), and formalization has not always unlocked investment. By contrast, qualitative work has emphasized the socially-constructed nature of customary tenure, where multiple individuals may hold overlapping rights over a single piece of land. The distribution of rights can therefore influence the (perceived) security of tenure. Often framed around issues of elite capture, these patterns have been difficult to document in quantitative survey data.

In this paper, I incorporate the social dynamics of land rights into a model of agricultural investment with a binding liquidity constraint. This allows for nuanced predictions about how farmers respond to changing land pressures under different tenure regimes. As land pressures increase, liquidity constraints should relax, but local elites may face more incentive to expropriate customary land for sale to outsiders. If farmers begin to worry about elite expropriation, this should impact their investment decisions. In particular, do farmers

under-invest in long-term agricultural inputs on customary parcels as land pressures rise?

In order to empirically test the implications of this model, I use data from a survey I conducted of 2,189 farmer households in Uganda. In order to capture an exogenous component of land pressures, I use an index of the probability of urbanization by 2030. As areas are more likely to urbanize, they should develop credit markets (relaxing liquidity constraints), and urban buyers will incentivize local elite expropriation. However, this measure should abstract away from other pathways by which land values could impact agricultural investment. My primary empirical specification looks at heterogeneous responses to rising land pressures between customary and freehold land for a variety of investments, controlling for farmer group fixed-effects to capture unobserved farmer quality characteristics.[1]

I propose a model which incorporates a liquidity constraint into a standard endogenous model of customary tenure and investment, where long-term investments are lower on (relatively insecure) customary land than on freehold land. In the context of traditional smallholder agriculture, this model implies that optimal investment is an (increasing) function of land values on freehold land. However, I explicitly consider a case where one household or individual may hold primary use rights, while another, such as a lineage elder, may hold rights of transfer. Additionally, when outsiders struggle to identify land 'owners' in illegible local tenure systems, elites have been able to sell land used by other members of the community for their own private benefit. Their incentives to do so are greater in contexts with rapidly increasing land values. This means that rising land values, driven by sales options to outsiders, may lead local elites to assert their historic right to sell land. The farmer, anticipating this, may actually make fewer long-term investments on customary land as land values rise, in contrast to the freehold case.

In testing this model in the Ugandan context, I find that long-term input use responds to rising land values more strongly on freehold land than on customary land. Elite incentives to expropriate rise along with land pressures, causing tenure insecurity on customary land, and this attenuates the impacts of increased liquidity. This divergence in input use between freehold and customary parcels is also present (to a lesser extent) on short-term inputs, contrary to the model's predictions. This may be driven by changing cropping patterns, as urban markets increase demand for cash crops that require more intensive input use. Nevertheless, the difference in responses is stronger for long-term inputs, which can be attributed to the tenure-security effect.

By incorporating the social nature of customary land rights to a model of agricultural investment, this paper avoids the common conflation of incompleteness of rights with insecurity. Instead, it considers how multiple rights-holders interact in different land value environments to make more nuanced predictions about investment on customary land. In addition to bringing qualitative insights to an economic framework, I use

[1] These farmer groups were part of the sampling strategy in the data collection process. They extend the intuition of household fixed-effects to control for unobserved heterogeneity as farmer groups are self-selected, but allow for sufficient identifying variation.

economic modeling to explore how farmers would strategically respond to changing incentives. This model captures how the potential for elite capture affects individual farmers. It thereby returns the focus to the welfare of smallholders, and by examining a broader population allows me to quantitatively document the effects of elite capture (which historically has been difficult due to the rarity of observed cases).

Furthermore, the detailed focus on agricultural investment in the survey allows me to use continuous measures of investment, as the binary measures used in much of the literature restrict identifying variation (Fenske, 2011). Finally, unlike many previous papers which have conceptually modeled the impacts of tenure *security* but then empirically used tenure *type* as a (poor) proxy, I consider tenure type and the incentives it creates throughout my model, therefore linking more closely to my empirical tests.

The remainder of this paper consists of a review of both the quantitative and qualitative literature on customary tenure and agricultural investment in Sub-Saharan Africa, with a particular focus on Uganda, followed by a model which captures many of the insights explored. I then discuss the context and data used, as well as an empirical strategy with several hypotheses laid out. I present results for a variety of short- and long-term inputs, and conclude by discussing their implications for the model's relevance to the Ugandan context.

2.2 A Review of the Literature

2.2.1 "Rights over land are rights over people:" Customary Tenure Arrangements in Sub-Saharan Africa

To begin, it is worth emphasizing the scale of customary tenure regimes in Sub-Saharan Africa. Across the continent, only between 2 and 10 percent of the land is formally titled, with the remainder subject to customary tenure, state ownership (including forest reserves and national parks), or other informal arrangements (Cotula et al., 2007). Indeed, "[customary] tenure represents the *major* tenure regime on the continent" (Alden Wily, 2011).

Features of Customary Tenure

There is an enormous diversity in customary systems around the region, as a hallmark of the customary is its very localized, negotiated nature. However, there are a few generalizations that tend to hold broadly and have been highlighted by qualitative researchers as key to local understandings of the customary.

The first point to stress is that tenure is not an isolated sphere of life: "customary land tenure is as much a social system as a legal code" (Alden Wily, 2011), embodying local power relations, authority, and

access to knowledge and labor (Van Leeuwen, 2014). This embedding of land tenure in social relationships means that it is open to negotiation, which both enables adaptability to changing circumstances but can also marginalize those in weaker bargaining positions (Cotula et al., 2007).

One particular way in which this social nature of customary tenure works is by having "overlapping rights over the same resources held by different users" (Cotula et al., 2007). Ensminger, an anthropologist, specifies that "A common characteristic in almost all African customary systems is for use rights to be assigned at the household level, whereas transfer rights are assigned at a higher level such as the lineage, clan, or chiefdom" (Ensminger, 1997). This means that although individuals may be quite secure in their ability to use a particular plot of land in their lifetime, adaptive reallocation within the community could occur in response to changing circumstances. Customary leaders also are able to allocate (often unused) land to migrants into an area as well as adjudicate any conflicts that may occur between members of the community. Although the particular ways these rights are divided may vary considerably across the region, this 'dis-bundling' of property rights is common and adds a strategic dimension to any decisions about land.[2]

It has been argued that "sufficient investment incentives tend to be provided by basic rights of use that, under normal circumstances, are guaranteed to many villagers (including migrants) by the local informal order:" that is, this dispersion of rights is not a cause of instability or under-investment in itself (Brasselle et al., 2002). However, the continual adaptation of customary institutions means that such systems are dynamic and see considerable changes over time. Indeed, there is a strand of the literature that posits land rights will evolve towards a concentration of bundled rights in one farmer's hands in response to increasing population pressures or the introduction of new crops and cropping systems (Boserup, 1965; Platteau, 1996). However, others have taken issue with this argument, pointing out that even market-based land transactions remain "embedded in complex systems of social relations" (Cotula et al., 2007).

Elites and Customary Tenure

It is worth focusing on the role of elites in customary tenure, both in a (somewhat idealized) 'traditional' world as well as in contemporary contexts. As discussed above, a common feature of customary systems is that elites, representing the family or lineage writ large, serve as trustees or administrators of land owned by the family group. Often, they hold transfer rights in order to (re)allocate land within the community in response to shocks (such as the death of a large landholder without heirs or an influx of new migrants to an area), as well as to prevent the alienation of a communal resource without the consent of the community.

However, beginning with colonial administrators, outsiders have attempted to fit Western notions of

[2]In this paper, I do not explicitly consider pastoralist systems, which are found throughout the region but which entail a whole host of other property rights concerns (as modeled by Goodhue and McCarthy (2008) and in the first chapter of this dissertation).

ownership based on freehold tenure onto customary tenure systems, and this institutional mismatch has created ambiguity about who the 'owners' of land actually are. This ambiguity has been at times exploited by local elites: "There is a fine line between chiefs as (often self-declared) owners of all land in customary laws, and chiefs as trustee administrators" (Alden Wily, 2011). This process is exacerbated by pressures on other features of the traditional social environment. "While customary authorities are still effective in regulating land access, the collegiate bodies that used to oversee their work are not; the result is a breakdown in accountability and a privatization of common lands" (Cotula et al., 2007). Elites are therefore able to respond as individuals rather than as guardians of the corporate group, and can thus assert their rights of ownership to outsiders unfamiliar with the complexities of local tenure arrangements.

Mattingly (2016) documents a similar process in China: when lineage elites join village political institutions, both public goods provision and the likelihood of land expropriation increase. He argues that "social institutions serve as channels of bottom-up informal accountability *and* top-down political control," depending on the incentive structure. Public goods provision has features of a repeated low-stakes game (inducing cooperation between elites and their communities), but land development is more akin to a one-shot game with higher stakes. This has important parallels with elites in Sub-Saharan Africa, as I shall show later in this paper.

Customary Tenure and Rising Land Values

The qualitative literature on customary tenure has documented the tensions and conflicts that emerge as customary systems adapt to external pressures such as rising land values. Most cases have considered land values rising due to *non-agricultural* uses, such as urban and peri-urban expansion, or the potential for natural resource extraction. Some large scale land acquisitions have been for agricultural purposes, although generally at such a scale or requiring technologies such that local smallholders are unable to participate. Therefore, this should be thought of as an increase in the *marketable* value of land rather than its value to smallholder agriculture.

In a report by the International Institute for Environment and Development and the Food and Agriculture Organization, the stress rising land values put on customary systems is discussed repeatedly: "As land values rise, farmers may be forced or tempted to sell their land. Where land is still under customary chiefs, these may be tempted to sell off lands for housing and other developments, regardless of the views of those actually farming this land" (Cotula et al., 2004, cited in Cotula et al. (2007)). In Ghana, this manifests as the same parcel of land being sold multiple times by and to different people; "many of these multiple sales are by different people in a family lineage, each contending that they have the status to sell under the customary system" (Barry and Danso, 2014). More often, however, "land scarcity may lead to a redefinition of the land

claims of different groups within the extended family... with weaker groups becoming more vulnerable to losing their land access" (Cotula et al., 2007). Despite abundant stories of how "local elites have been able to use their position and the ambiguities of customary law to appropriate land to further their own economic and political interests" (Ubink, 2008), especially in peri-urban areas but also in many rural ones (Ubink and Quan, 2008), this particular facet of how customary tenure adapts to external pressures has been little studied by economists. Economics, with its ability to explore the strategic interactions between individuals, can therefore contribute to our understanding of this important issue. In particular, economics can model how land users anticipate the changing incentives of local elites, and therefore change their own investment incentives.

2.2.2 Models of Land Tenure and Investment

It is worth briefly considering other theoretical treatments of land tenure and investment in order to situate the model presented in this paper. Broadly, land tenure has been thought to encourage investment through three possible mechanisms, going back as far as the discussion in Feder (1988, cited in Place (2009)). These have been termed the assurance, collateralizability, and realizability mechanisms: stronger land rights should provide assurance that the farmer will be able to reap any gains from investment, increase access to capital by leveraging the land as collateral, and allow the farmer to sell the land and realize gains from investment sooner (as well as transferring land to those most able or likely to invest) (Besley, 1995, cited in Fenske (2011)).

Each of these mechanisms is the subject of an extensive theoretical and empirical literature, and their relevance to customary tenure in Africa has been long debated. Credit markets have been shown to be thin, farmers may be credit rationed for other reasons, and land markets are often missing or face other restrictions. This discussion will focus on the first of these, which does not rely on the existence of functioning complementary markets. Despite the intuitive appeal of stronger tenure inducing higher investment, the complexities of land rights in Sub-Saharan Africa mean that defining 'stronger land rights' poses difficulty, and the precise way they are defined and empirically measured can have important implications.

The simplest models attempt to capture tenure as an exogenous probability of losing the land, along with any fixed investments, before the profits of those investments can be fully realized. These models often make this assumption to instead focus attention on other features of the investment context (Jacoby and Minten, 2006). For instance, Dillon and Voena (2015) focus on intra-household bargaining resulting from tenure insecurity for widows, and so model whether a widow can inherit marital property as a village-level (exogenous) determination.

However, much qualitative evidence on customary tenure regimes in Sub-Saharan Africa has stressed the endogeneity of tenure security (discussed in more detail below), and this endogeneity has then been incorporated into quantitative models. That is, actions taken by the farmer, particularly certain investments in the land, demonstrate responsible use of the land and defend against expropriation by others in the community who recognize these investments as land stewardship (Awanyo, 2009). The following is far from comprehensive, but serves to illustrate the variety of ways investments have been considered to influence tenure security. Robinson (2005) focuses on the state's role in guaranteeing tenure security, while Deininger and Jin (2006) emphasize the visibility of an investment to others in the community as key to its efficacy in securing tenure rights, for tenure security is fundamentally about social recognition of rights. Place and Otsuka (2002) explore this concretely by contrasting three possible investments: planting trees, which is visible and thus reduces the probability of losing the land; management effort, which is invisible and thus has no effect on tenure security; and fallowing, which in a tenure system predicated on land *use*, may actually increase the risk of expropriation.

Goldstein and Udry (2008) focus on this latter effect in their work on tenure security in Ghana, where fallowing is the primary investment in land productivity. They add an important dimension, allowing an individual's social status to interact with these incentives: "farmers who lack political power are not confident of maintaining their land rights over a long fallow. As a consequence, they fallow their land for much shorter durations than would be technically optimal, at the cost of a large proportion of their potential farm output." Crucially, this effect is primarily driven by land obtained through customary tenure (within a household), and social elites do not face the same disincentives (as they would be the ones to transfer lands if unused), so empirically they fallow land similarly regardless of how it was accessed.

2.2.3 Empirical Evidence

Despite the seeming clarity of the theoretical relationship between tenure security and investment, the discussion of Fenske's model foreshadows the empirically mixed evidence on customary tenure and investment (Place and Hazell, 1993; Fenske, 2011). Although there is some convincing evidence that tenure regimes do influence investment decisions, particularly in West Africa, many other papers have found no statistically significant results or at times results contrary to theory. Fenske reviews much of the literature in his 'quantitative review,' but I will consider a few of them here.

Goldstein and Udry (2008), in a paper in Ghana, find that even after controlling for household and spatial fixed effects (as well as plot characteristics), the tenure status of a given plot is a significant predictor of how long it is fallowed. The particular dimension of tenure they consider is whether land was allocated by

the matrilineage (to a man from his maternal uncles, typically, or his larger maternal group) or purchased. This relationship does not hold as strongly for social elites who have less insecurity over matrilineal land, particularly for those who inherited their office through the matrilineage (thus ruling out reverse causality, where more secure rights-holders would be able to secure social status). The authors argue that this tenure pathway explains much of the gender productivity gap in agriculture in Ghana, as women are more likely to control plots accessed through the matrilineage. Fenske (2011), however, notes that a household fixed effects specification may select those households with the greatest differences in tenure security (and thus those households most likely to invest differently across plots); only those households who feel insecure about land allocated through customary mechanisms will purchase other plots.

Despite the strong evidence from Ghana, other papers have found little or no relationship between tenure insecurity and investment. In Madagascar, for instance, Bellemare (2013) finds that, after controlling for household fixed effects and soil quality, titling has almost no effect on agricultural productivity. However, an individual's subjective beliefs about their rights do seem to have important (although at times counter-intuitive) implications for productivity. Fenske (2011), in reviewing the dispiriting body of evidence, suggests that perhaps investment is high across all plots because, despite insecurity, returns in agriculture may be that much higher than the outside option. He also conducts a 'quantitative review' of other papers by similarly analyzing nine data sets from West Africa. He argues that small sample sizes have driven some of the lack of empirical results, as larger samples are more likely to find results. He also takes issue with the use of binary investment measures, which have been often used to deal with frequent zeroes in investment.

Yet another potential issue in the empirical literature lies in precisely defining tenure security, as 'security' could be composed of (multiple) elements of duration of tenure, assurance, and completeness of rights (Place et al., 1994; Doss and Meinzen-Dick, 2020). Although it is theoretically clear, "there is no agreed upon way to measure tenure security and results may be related to choice of proxy" (Place, 2009). Bellemare (2013)'s results in Madagascar highlight this: one measure of tenure security, the presence of title, seems unimportant for investment, while beliefs about rights do matter. However, the questions asked about rights are designed to elicit the bundle of rights an individual has over a given piece of land, such as whether they can sell it or lease it. Even without 'complete' rights, tenure may be quite secure and persist for generations, and thus empirical measures diverge from the proposed theoretical pathway. Other papers have dealt with this more explicitly, such as Brasselle et al. (2002) who use questions on nine different rights in Burkina Faso to categorize households into five hierarchical groups based on the (overlapping) sets of rights they have. Other (generally older) papers have avoided the question entirely by simply comparing regions with different predominant tenure systems, although it is unclear if other factors could be at work (Place and Otsuka, 2002).

Instead of modeling tenure security as the fundamental parameter of interest, and then using land institutions as a (very imperfect) proxy for tenure security, I follow Abdulai et al. (2011) in explicitly modeling particular institutional arrangements and the incentives they create for investment. This seems a more robust treatment: rather than *ex post* justifying results as a product of the 'context,' I account for the tenure context from the start.

2.2.4 Land Rights in Uganda

Given the enormous diversity of customary tenure arrangements throughout Sub-Saharan Africa, it is worth delving into the particular case of Uganda. Somewhere between 12-14% of land is subject to formal title, so customary tenure remains significant throughout the country (Alden Wily, 2011). Customary authorities still play a major role in Uganda: in lab-in-the-field experiments, references to traditional authorities such as the *kabaka* (the king of Buganda, one of the major regions in Uganda) induce higher contributions to public goods games, and this seems to operate through vertical signaling to the traditional authority rather than horizontal signaling to others in the community (Goist and Kern, 2018).

Even within Uganda, there is some variation in the relative strength and allocation of bundles of rights. In the west, where population pressures on the land are higher, there is more individualized tenure, while the relatively land-abundant north retains stronger rights for customary authorities (Van Leeuwen, 2014). Qualitative work has documented throughout the country that rights to the land in perpetuity are differentiated from responsibility for managing the land (Adoko and Akin, 2011). Specific land rights regimes can be incredibly precise: Howard and Nabanoga (2007) document that rights are determined for individual people over individual plants on different types of land under different circumstances (for instance, that a woman who is pregnant or sick is allowed to pick certain medicinal plants from someone else's river plot, but not from a home garden).

Deininger and Castagnini (2004) examine land-related disputes in Uganda, and their work can illuminate how customary tenure functions and the margins at which it breaks down. They estimate that up to 5% of the population in rural areas is involved in a pending land-related conflict at any given time, and most of these conflicts occur between neighbors because boundaries have been exceeded. The prevalence of boundary disputes has led to many farmers planting trees to demarcate their land; "boundary trees are useful evidence when the land can be visited during a case by customary authorities, but they are less useful when the case is heard in a court of law far away from the land" (Adoko and Akin, 2011). However, there has been a push to incorporate customary leaders into statutory court systems, with mixed success (Van Leeuwen, 2014).

Much of the literature on land rights in Uganda has considered the *mailo* system, a remnant of British

indirect colonial rule. In 1900, the British signed a treaty with the Kingdom of Buganda which allocated square-mile tracts in the center of the country to Buganda elites for their 'ownership' as absentee landlords. These tracts were then sub-leased to the actual inhabitants and land users (Deininger and Castagnini, 2004). Ever since, there has been a significant tension over government policy towards *mailo* owners and tenants and how to balance the two parties' competing interests. The 1998 Land Act attempted to balance these by giving *mailo* owners the powers of a freehold owner, while still recognizing the rights of 'lawful occupants' of the land who had used it for more than 12 years (Coldham, 2000). This guaranteed occupants' tenure security (including inheritance rights and the ability to sub-let with consent of the owner), while requiring continuous possession of the land and a nominal rent payment.

The Land Act of 1998 did more than merely regulate *mailo* land, however. Proclamations of state ownership of all land under the dictatorship of Idi Amin in 1975 were largely unenforced and ignored by the population (Hunt, 2004). The Land Act of 1998 regarded land as the property of the citizens of Uganda and recognized four tenure types: freehold, leasehold, customary, and *mailo* (Joireman, 2007). The law provides for an extensive and decentralized land administration (Tripp, 2004) that could issue titles as well as 'certificates of customary ownership.' These certificates registered rights held by multiple people and could, in time, be converted into freehold titles (Coldham, 2000). Unlike compulsory registration in other countries in the region, registering rights was voluntary. This leads Coldham (2000) to observe that "where the grant of certificates of title is based on individual applications, there is always a risk of land-grabbing, that is, that an applicant may lay claim to a larger area of land than that to which he is customarily entitled." Furthermore, the widely-lauded land reform has been largely unfunded and thus little-implemented (Deininger and Castagnini, 2004; Joireman, 2007).

Two previous economic analyses have looked at the impacts of tenure on agricultural investment in Uganda. Deininger and Castagnini (2004) focus on land conflicts, but argue that the intensive multi-cropping system prevalent in much of Uganda implies individual crop production functions are inappropriate for productivity measures or investment. Deininger and Ali (2008) use household fixed effects to control for unobservables such as farming skill and find that households invest in both long-term and short-term inputs significantly more on plots they own outright rather than plots they have only customary rights over. Furthermore, they find that registering customary rights (by acquiring a certificate of customary ownership) has little impact on investment, but legal efforts to strengthen occupancy rights do increase investment.[3]

[3]They find that investment increases with length of occupancy, with a discontinuity at the 12 year mark when rights become recognized by law.

2.3 A Model of Tenure and Investment

Consider a two-period model. In the first period, a farmer chooses to apply fertilizer, F_1, and trees, T, to his or her exogenously given land L under tenure system h in order to produce according to $f(F,T)$. The farmer also has some wealth endowment and can choose to borrow B_1 against the value of the land (depending on the tenure system), to be repaid at the end of the period. The farmer faces an exogenous interest rate r and has a discount rate β for second period returns (the optimized expected second-period profit is given by π_2^*). There is some probability that the farmer's land will be expropriated before the second period, in which case fixed investments (trees) would also be lost. This probability is given by $(1-\phi(T,h,vL))$ (where v is the per-unit value of the land) and may be a function of tree investment, tenure systems, and the value of the land. For convenience, I use the word 'expropriate' to capture both 'horizontal' expropriation (where others in the community take over the farmer's use rights), as well as the exertion of sales rights by local elites without the permission of the land user ('vertical' expropriation). After working through the main features of the model, I consider what different forms of this ϕ function could imply for the farmer's decisions.

The first period optimization problem faced by the farmer is therefore

$$\max_{F_1,T,B_1} \; p_a f(F_1,T) - p_F F_1 - p_T T - rB_1 + \beta\phi(T,h,vL)\pi_2^*(F_1,T,B_1)$$

$$\text{subject to:} \quad \begin{aligned} p_F F_1 + p_T T &\leq w_1 + B_1 \\ B_1 &\leq s(vL,h). \end{aligned}$$

In the second period, the farmer only chooses fertilizer (F_2) and therefore maximizes according to the following:

$$\max_{F_2} \; p_a f(F_2,T) - p_F F_2$$

$$\text{subject to:} \quad \begin{aligned} p_F F_2 &\leq w_2 \\ w_2 &= w_1 + (1-r)B_1 + p_a f(F_1,T) - p_F F_1 - p_T T. \end{aligned}$$

2.3.1 Land Values and Investment

To begin with, consider the case where the farmer is certain their land will not be expropriated before the second period (that is, the land is under freehold ($h=1$), and $\phi(T,vL|h=1)=1 \;\forall\; T,vL$).

Figure 1 follows Carter and Olinto (2003) in depicting the constrained solution to the model. The width of the horizontal axis represents the available liquidity, $w+s(vL,h)$. Parameters γ and τ represent the total expected marginal productivity of inputs F and T, respectively. Fertilizer is modeled to only last for one

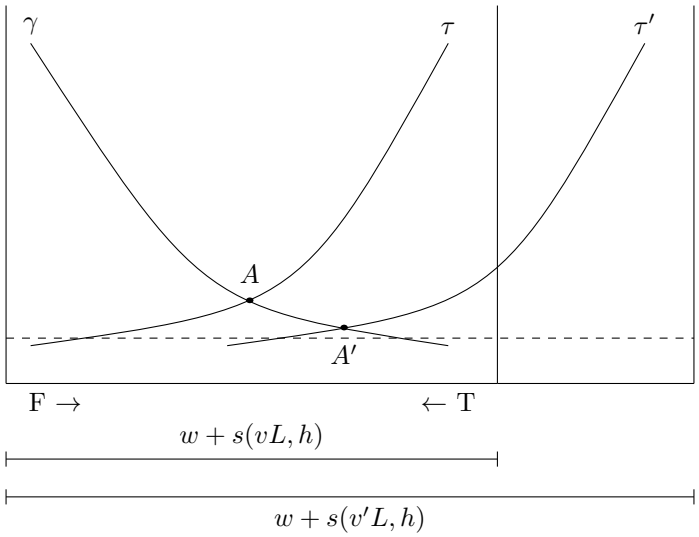


Figure 2.1: Land Values Increasing Investment

period, while trees continue to produce in both periods, therefore:

$$\gamma = p_a \frac{\partial f}{\partial F_1} - p_F$$
$$\tau = p_a \frac{\partial f}{\partial T} - p_T + \beta \frac{\partial \phi}{\partial T} \pi_2^* + \beta \phi \frac{\partial \pi_2^*}{\partial T}$$

However, as mentioned above, for the moment ϕ is constant with respect to trees, so $\frac{\partial \phi}{\partial T} = 0$.

As in Carter and Olinto (2003), the liquidity-constrained farmer will choose inputs F and T such that the expected rates of return are equal between the two, labeled A in figure 2.1. These input levels will be necessarily lower than the unconstrained optimums (where γ and τ each cross the dashed line and summing to more than the available liquidity).

If, however, there is an exogenous increase in the value of the land, $v' > v$, then the available liquidity provided by that land will increase, illustrated as an expansion of the horizontal axis to $w + s(v'L, h)$. τ is measured from the right-hand axis, and so as the available liquidity space expands, this curve graphically shifts to the right (to τ'). The marginal productivity curves now cross at A', indicating higher investments in both fertilizer and trees. Therefore, increasing land values will allow for increased investment in both short and long-term inputs for liquidity-constrained farmers.

2.3.2 Customary Tenure and Investment

However, the threat of future expropriation of the land is real for many farmers, particularly on customary land. The model captures this risk in two ways, as illustrated in figure 2.2.

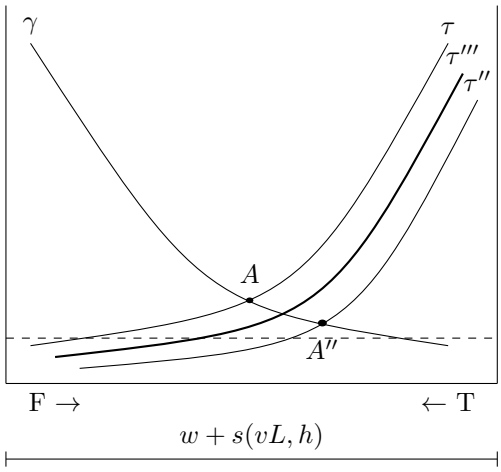


Figure 2.2: Customary Tenure Influences Long-Term Investment

The simplest models of customary tenure and investment merely consider customary land to have a higher risk of alienation than freehold land: $\phi(T, vL|h = 0) < \phi(T, vL|h = 1) \ \forall \ T, v, L$, with $\frac{\partial \phi}{\partial T} = 0$. That is, for any level of investment in trees or land values, the risk of expropriation is higher on customary land, and this risk does not change in response to investment in the land. This lowers the expected total marginal productivity of investment in trees, as shown by a shift right (towards the origin for T) from τ to τ'', decreasing the investment in trees to the equilibrium shown at A''.

Drawing upon qualitative understandings of customary tenure, though, more subtle models have sought to capture the endogenous nature of tenure security on customary land. Place and Otsuka (2002), for instance, model the probability of losing land as a decreasing function of planting trees, a visible investment in the land. In my model, this implies that $\frac{\partial \phi}{\partial T} > 0$, which would attenuate the rightward shift of the τ curve (and could perhaps even lead to an 'overinvestment' in trees relative to the unconstrained optimum if the tenure-enhancing effect is large, although empirically this is rarely documented). This combined effect leads to the marginal productivity of trees indicated by τ'''.

The equilibrium determined by the marginal productivity of trees under (less-secure) customary tenure, then, sees under-investment in trees relative to the allocation under freehold tenure.

2.3.3 Expropriation Risk under Customary Tenure

Customary tenure is not simply insecure tenure. Earlier, I showed that an attention to the complexities of how customary tenure functions can have important implications: visible investment decisions such as planting trees can demonstrate responsible land use (a condition of tenure), thus endogenously strengthening tenure rights. It is worth devoting some attention to how this works. By planting trees on a plot, a farmer demonstrates to the community that it is under use. If another member of the community tries to encroach

on the plot, these visible investment decisions can be used as evidence of responsible land use, and thus make it more likely that disputes will be resolved in the farmer's favor.

The model so far has ignored the particular bundles of rights and their distribution among individuals that are hallmarks of customary tenure systems. That is, many customary tenure systems in Sub-Saharan Africa, and those in Uganda in particular, do not vest all types of rights over a given piece of land in the same individual or household. Primary use rights may be held by one household, while other members of the lineage or extended family have access rights or even claims to certain plants (Howard and Nabanoga, 2007). Importantly for this analysis, local elites (such as lineage heads or traditional chiefs) often hold transfer rights over large areas of customary land.

The long-term stability of customary tenure systems is evidence that these decentralized rights did not in themselves cause major tenure insecurity (Bruce and Migot-Adholla, 1994). This is perhaps due to mechanisms (such as planting trees) that allow use-holders to demonstrate tenure against other claimants, with local elites serving as arbiters and rights-holders for the community.

However, there has been recent concern in policy spheres about the potential for local elites to make deals with outsiders (often national or international investors) that alienate local rights-holders. While the details of such deals, termed 'Large-Scale Land Acquisitions' (Smalley and Corbera, 2012; Purdon, 2014), are beyond the scope of this model, they represent but one example of local elites using their traditional rights to the land for their own gain. Outside investors often find it difficult to navigate the complex realities of customary rights, and thus they may not realize that they are expropriating land from existing users without their consent.

In the context of this model, it suffices to note that increasing land values may not only increase the value of the asset for the primary land user, but also for other rights-holders. This could increase the value of expropriation for these other individuals (namely, local elites with transfer rights). Local elites may not have found it profitable to exercise their traditional rights in an inactive land market, preferring instead to maintain the traditional status quo. However, as land values rise (whether due to offers from outside investors, population pressures from growing urban areas, or other exogenous forces that introduce potential outside buyers who are less familiar with the customary) they may be more likely to expropriate from the land user in order to alienate the land to others.

Within the model, then, ϕ is written as a function of vL as well as h, the tenure system, and T, tree

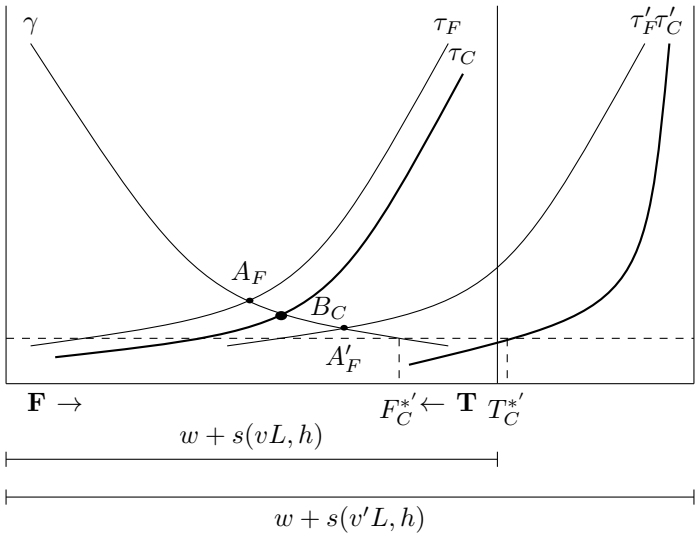


Figure 2.3: Land Values and Strategic Interactions

investment. In particular, $\phi(T, h, vL)$ could have the following properties:

$$\phi(T, h, vL) = \begin{cases} 1 & \text{if } h = \text{Freehold,} \\ g(T, vL) & \text{if } h = \text{Customary.} \end{cases}$$

where $\frac{\partial g}{\partial T} > 0$, as in Place and Otsuka (2002), and $\frac{\partial g}{\partial v} < 0$ following the intuition outlined above.

The land user (farmer/decision-maker) can anticipate these changing incentives for their co-rights-holders, as captured in $\frac{\partial \phi}{\partial v} < 0$. Rising land values may mean that no matter the level of their own investment in production, the risk of expropriation increases. This could outweigh the liquidity constraint-relaxing effects of increasing land values, and perhaps even on net decrease longer-term investments in the land, as illustrated by figure 2.3. The shift from A to A' reflects the effect of increasing land values on investment on freehold land: although still bound by the liquidity constraint, investment in both fertilizer and trees increases. However, for customary land, increasing the value of the land and relaxing the liquidity constraint does not simply shift the marginal productivity of trees rightward, but changes the shape due to the effect of $\frac{\partial \phi}{\partial v}$ discussed above. Graphically, the farmer has actually left the liquidity-constrained case, but investment in trees has decreased to $T_C^{*'}$.

2.4 Context and Data

To test this model empirically, I use data from the baseline survey I conducted for a proposed impact evaluation of Uganda's Agriculture Cluster Development Project (ACDP).[4] This baseline survey was conducted in early 2019 in four districts throughout Uganda. Respondents were chosen in a two-stage process: first, 133 farmer organizations that were registered and had at least 20 members were chosen in the target districts, and membership rosters were drawn up. Member households were then randomly selected to be interviewed, with a total of 2,189 interviews in the baseline survey used here.

The districts selected for the impact evaluation are located throughout the country and thus encompass some of the diversity of customary tenure arrangements in Uganda. Selected districts are located in the east, southwest, center (where *mailo* land predominates), and north (where instability has led to many internally displaced people).

As part of the impact evaluation, the Ministry of Agriculture, Animal Industry and Fisheries and a team from UC Davis conducted an extensive baseline survey,[5] which has data well-suited to the structure of this model. Given that the program was designed to induce investment in agriculture, the survey has an exhaustive plot-level elicitation of all inputs and outputs as well as continuous measures of the value of investment. Furthermore, the survey asks detailed questions about the tenure status of each agricultural parcel farmed by the respondent household. These questions ask about the tenure system the parcel is under; which individual members of the household are owners; what kind(s) of documentation exist for the parcel, if any, and whose names are on the documentation; who within or outside the household holds particular rights (such as transfer rights); and questions on perceived tenure security. Finally, the survey asks about land rental prices in the region and contains GPS coordinates for the household, allowing me to match households to other geospatial datasets. For most specifications, I use a dataset of 3,076 parcels observed over two seasons, for a total of 5,760 parcel-season observations.

As a measure of the external pressure on land values modeled above, I use data from the Global Grid of Probabilities of Urban Expansion to 2030 (Seto et al., 2012, 2016). For each 2.5 arc-minute[6] grid cell that was

[4]This project, supported by the Government of Uganda and the World Bank, aims to provide farmers in five crop-specific 'clusters' (maize, rice, beans, cassava, and coffee) with the resources needed to move from subsistence farmers to commercialized producers. To that end, the project provides subsidized farm inputs to selected farmers, improves agricultural infrastructure, and supports post-harvest handling technologies. The impact evaluation was planned as part of the pilot phase of the project, focusing on the provision of electronic vouchers for subsidized inputs that are redeemable at certified local agro-input dealers. The impact evaluation was planned in 4 districts throughout Uganda, each assigned one of 4 target crops (maize, rice, beans, and coffee; cassava was omitted as it has a longer growing season). The impact evaluation randomly assigned farmer organizations eligible for the ACDP subsidy to one of two treatment groups (defined by the timing of benefits) or to a 'downstream' control group. Approximately 36 farmer organizations were assigned to each treatment arm, from each of which an average of 20 members were selected to be surveyed throughout the four districts.

[5]Subsequent mid-line and end-line surveys were planned but were cancelled along with the implementation of the Impact Evaluation in November 2020, due to compliance issues and COVID-19.

[6]2.5 arc-minutes contain approximately 5km at the equator, which Uganda spans

non-urban in 2000, the data include an estimated probability of becoming urban by the year 2030, forecast using a population density driver map. This map is primarily driven by patterns of urbanization, and thus is reasonably exogenous to local agricultural patterns of land values; instead, it isolates the dimension of land values that will also create pressure on local elites to expropriate and sell customary land to outsiders.

I match households to a grid cell using GPS locations collected during the survey (taken at the household residence, not at agricultural fields which could be at some remove). This measure is correlated with the per-acre rental values households reported for their land; the correlation is low across the whole sample (.0450), but when I winsorize several outliers in estimated rental price (among those who own their land and are estimating how much they could rent it out for), this correlation increases to .1492. When I look instead at the median rental price in a given district, the correlation with the probability of urbanization jumps to .6556,[7] implying (as expected) that this measure is more closely related to broader trends than individual parcel values which may be influenced by soil quality or other agricultural value considerations. A limitation, however, is the sparse support of values of the probability of urbanization in the four districts where the baseline study occurred. Thirty-eight percent of parcels fall in a grid cell with a 100% probability of urbanization; another 19% have a 99% probability. There is another grouping at very low levels of predicted urbanization, including the entire northern district of Amuru which has a probability of zero,[8] and then some parcels are assigned a probability between .5 and .8. In future work, I hope to use data from additional regions of Uganda to both have a more complete support and perhaps look at non-linearities in insecurity caused by rising land pressures.

2.5 Empirical Strategy

In order to test the predictions outlined in the model, I examine differential patterns of short- and long-term agricultural investments on parcels under different tenure regimes as land values exogenously increase. These predictions go beyond existing models of land tenure and investment by considering how multiple rights-holders respond to rising land prices, and thus how incentives may change differently on customary land. Furthermore, I make two improvements over the empirical strategies commonly used in the literature. First, rather than modeling tenure *security* (or the expected probability of expropriation before realizing the fruits of investment) as the sole parameter of interest but then only empirically measuring rough proxies such as tenure *type*, I explicitly model the relationship between tenure *type* and investment (operating through tenure security). The theoretical model explored above shows how a rough proxy may be insufficient: in low land-value environments, customary land may be equally secure as freehold, but as land values increase, customary

[7] Similarly, the correlation with median village rental prices is .6697.
[8] Results using this measure are robust to the exclusion of Amuru.

land may become less secure.[9] Secondly, there has been some discussion as to whether binary measures of investment are appropriate for this question. The ACDP survey's detailed agricultural production module allows me to construct continuous measures of investment.

Outside these two advancements, I use empirical methods generally accepted in the literature. At heart, the empirical specification involves regressing a given investment measure on a continuous measure of land values interacted with a dummy for a parcel being under freehold (as opposed to customary) tenure. Investments should respond to rising land values on freehold land due to a relaxation of the liquidity constraint; on customary land, however, this effect is attenuated by the rising insecurity caused by local elites' incentives to expropriate newly-valuable land to sell to outsiders.

However, several concerns are apparent with this strategy. First, the tenure regime of particular parcels may not be exogenous (for example, households may be more likely to pursue titling for higher-quality plots). Deininger and Ali (2008) argue that Uganda has what amounts to an "exogenous historical assignment of land rights... and the absence of readily available opportunities to change the tenure status of occupied land to full ownership imply that the case at hand can be considered akin to a natural experiment." Second, there may be unobserved heterogeneity in household farming decisions caused by factors such as household shadow prices or farming skill, which may be correlated with the tenure of parcels farmed by households. Ideally, this would be addressed using a household fixed-effects strategy. However, of the 2,189 households surveyed, only 6.5% of respondents reported having parcels under both freehold and customary tenure, which is much lower than the rates observed in the LSMS-ISA in Uganda, a high-quality nationally-representative dataset (Deininger and Ali, 2008). Furthermore, these households are concentrated in two of the four surveyed districts. This limits the power of a household fixed-effects model to detect changing investment patterns as land prices increase. I plan to address this limitation using LSMS data in future work.

Despite this, the ACDP data sampling strategy involving farmer groups allows me to extend the intuition of household fixed effects to farmer group fixed effects. These farmer groups are co-located, self-selected groups of farmers who can purchase inputs in bulk, share farming methods, and aggregate outputs in order to receive better output prices, in addition to meeting regularly for mutual support. Therefore, it seems plausible that many unobservable characteristics are shared by members of the same farmer group. By including a farmer group fixed effect, I am able to control for a portion of the unobserved heterogeneity while still retaining some identifying variation. However, this does restrict the identifying variation substantially for regressions using the probability of urbanization. This probability is measured at a fairly coarse geographic scale, meaning that most farmer groups are all within the same probability grid square. Therefore, my

[9]The lack of results in previous studies which elide tenure security and tenure type may be understood, then, as an issue of this poor proxy.

preferred specification includes farmer group fixed effects (and clusters standard errors at the farmer group level) for regressions using the standardized rental price as the measure of land pressures (column (5) in results tables 2.1 - 2.10) but without the fixed effects for regressions using the probability of urbanization (column (4) in tables 2.1 - 2.10). In the appendix, I present results with a more traditional parish fixed effects specification for robustness.

2.5.1 Hypotheses

First, I illustrate the hypothesized comparative statics from the model represented in figure 2.3 and identify which terms would capture them in regressions. Consider the following cross-sectional empirical specification which closely follows the model discussed above:

$$I_i^Q = \gamma_0 + \gamma_1^Q D_i + \gamma_2^Q \bar{v} + \gamma_3^Q D_i * \bar{v} + \beta' X_j + \eta_f + \epsilon_{fi}$$

where I_i^Q is a continuous measure of investment of type Q (either short- or long-term) by household j (a member of farmer group f) on parcel i; D_i is a dummy equal to one if the parcel is freehold; $\bar{v}$ is the exogenous component of land price in the locality; X_j is a vector of household characteristics; and η_f controls for household fixed effects. This equation would be separately estimated for long and short-term inputs.

The particular hypotheses predicted by the model are derived in the mathematical appendix. Here I summarize proposed tests of the predicted signs of the following in cross-sectional data:

1. $\frac{\partial F}{\partial v}\Big|_{h=1}$: That is, how does short-term input use vary with respect to land values on freehold land? The model would predict that *ceteris paribus*, a liquidity-constrained farmer would use more short-term inputs as land values increase. This is tested by examining the sign of $\gamma_2^S + \gamma_3^S$.

2. $\frac{\partial T}{\partial v}\Big|_{h=1}$: That is, how does long-term input use vary with respect to land values on freehold land? The model would predict that *ceteris paribus*, a liquidity-constrained farmer would use more long-term inputs as land values increase. This is tested by examining the sign of $\gamma_2^L + \gamma_3^L$.

3. $\frac{\partial F}{\partial v}\Big|_{h=0}$: That is, how does short-term input use vary with respect to land values on customary land? The model would predict that *ceteris paribus*, a liquidity-constrained farmer would use more short-term inputs as land values increase. This is tested by examining the sign of γ_2^S.

4. $\frac{\partial T}{\partial v}\Big|_{h=0}$: That is, how does long-term input use vary with respect to land values on customary land? The model would predict that *ceteris paribus*, a liquidity-constrained farmer would use fewer long-term inputs as land values increase. This is tested by examining the sign of γ_2^L.

with the last of these being the primary innovation of this model. Without considering the changing incentives of local elites, the impact of rising land values on customary land would parallel that on freehold. This stems from the qualitative fact that tree planting behavior is effective at securing tenure within the community, but less so to outside investors who find this demonstration of rights illegible.

2.5.2 Measuring Tenure Security

In 'taking stock' of the body of empirical evidence on tenure security and investment, several papers have noted the variety of definitions of tenure security as well as proxies used empirically (Arnot et al., 2011; Deininger and Ali, 2008). Common empirical measures include the existence of legal title, duration of tenure, method of acquisition, tenure type, existence of a conflict over the land, subjective perceptions of tenure security, and existence of particular rights (often transfer rights) (Arnot et al., 2011). However, it is often left implicit how these proxies are related to tenure *security*, which is the parameter modeled. Fenske (2011) notes that the choice of proxy does seem to be related to the effect found, and therefore this is a crucial choice.

My model, however, addresses these concerns by explicitly considering the relationship of the empirically observable tenure type to the fundamental parameter of interest, tenure security. The importance of this consideration is illustrated by the final hypothesis, that customary tenure exists in an institutional context that responds differently to changes in land value, and therefore the relationship between tenure type and security is different in high and low land value areas. Arnot et al. (2011) distinguish between the 'content' and 'assurance' aspects of tenure, and rather than eliding between those, I consider how the two are related.

2.5.3 Measuring Investment

Another point at which many papers allow their model and empirics to diverge is in the measurement of agricultural investment, the outcome of interest. Because many smallholders operate low-input, even subsistence farms, it is difficult to measure investment well. Therefore, many papers have used binary investment outcomes (Fenske, 2011). I do present binary outcomes using a linear probability model in order to allow for farmer group fixed effects (much as Deininger and Ali (2008) do).

However, the ACDP data also allows for more nuanced continuous measures of investment. Fenske (2011) has argued that measuring investment in a continuous way can make a substantial difference to the results. He argues for the trimmed LAD estimator to deal with the prevalence of zeroes in types of investment. This is the panel equivalent of the Tobit estimator (Honore, 1992); as I only have a cross-section of data in this paper, I use the Tobit for continuous investment measures. Coefficients on a Tobit model are interpreted as

in a linear model; however, the linear effect is on the uncensored (non-zero) outcome.

2.5.4 Land Values

Importantly, the model presented above takes land values to be an exogenous force shaping the incentives faced by farmers. This modeling choice was driven by the qualitative literature, which has focused on the breakdown of customary institutions caused by outside pressures, such as the rapid urban expansion in much of Africa or international large-scale land acquisitions. However, in reality, the value of an individual parcel of land is a product of its particular features, including any investments made. In my results, I present some specifications using land rental values (both reported for individual parcels as well as predicted for all parcels using latitude, longitude, tenure status, presence of trees, village fixed effects, and the probability of urbanization). These results carry the crucial caveat that land prices are likely a result of land quality, which may change optimal investment behavior through pathways other than those modeled.

Therefore, I also present results where I proxy for the exogenous pressures on land values with the probability of urbanization by 2030. This measure should impact agricultural investment through the pathways described in the model: certainly, more (peri-)urban areas have more active credit markets, which would relax the credit constraint faced by the household, and a pool of urban buyers is the canonical situation incentivizing local elites to expropriate customary land. The process of urbanization, however, should not impact agricultural investment through other channels, such as via an increase in total factor productivity.

This measure could potentially be used as an instrument for local land values (as seen above, it is correlated with regional patterns in land values and would therefore be valid); however, I choose to treat it as a proxy for the underlying phenomenon of interest, external pressures and demand for land. Rental values for individual parcels are perhaps an even more problematic proxy for the forces modeled, so I focus on this more exogenous measure which should be better-identified. Nevertheless, these results are not strictly causal and should be understood as descriptive of patterns consistent with a theoretical model.

2.6 Results

In this section, I present results for a variety of agricultural investments, following the empirical strategy outlined above. The model predicts that long-term inputs respond to rising land values more strongly on freehold land than on customary land due to the attenuating effect of increased insecurity on customary land induced by elite incentives to expropriate.

Before turning to the regressions with individual agricultural inputs, consider figures 2.4 and 2.5. Each of these presents the difference in the coefficients for (binary) input use between freehold and customary

parcels as a function of land values in the area (measured by rental values in figure 2.4 and the probability of urbanization in figure 2.5). For short-term inputs such as pesticides and inorganic fertilizer, the model would predict equivalent responses to rising land pressures on all parcels, which would appear as a flat line on these graphs. As can be seen, however, there is a slight divergence in short-term input use on freehold vs. customary parcels as rental prices or the probability of urbanization rise, reflected by a positive (although shallow) slope in these figures for short-term inputs. This result, explored further below, can be explained by a shift toward pesticide-intensive crops near urban markets.[10] As urban markets expand, so does the local demand for cash crops (such as vegetables and fruits which are difficult to transport long distances). Farmers facing this increased demand therefore shift their production away from staples and towards cash crops. This shift is stronger on freehold parcels, perhaps because such parcels remain secure.[11] Cash crops, in turn, may have a higher return to inputs, and particularly to pesticides, than staple crops (Riwthong et al., 2017).

However, if the model holds, this effect of changing crop choices on long-term inputs should be compounded by the direct impact of additional insecurity on customary land prompted by rising land pressures. In figures 2.4 and 2.5, there is a stronger response for trees, the most long-term of the inputs measured, than for short-term inputs, as shown by the steeper slope in the difference in predicted input use. Visually, the insecurity effect can be seen in the difference in slopes between the short- and long-term graphs in these figures.

Figure 2.4 also depicts the difference in reported insecurity between freehold and customary land. This measure is discussed in further detail below, but note that at low rental prices, parcels under customary and freehold tenure are perceived as roughly equivalently secure. As rental prices rise, respondents report higher perceived likelihoods of losing their customary parcels without an equivalent rise on freehold parcels.

In each table, I present several different specifications; additional robustness checks are provided in the appendix. I include two distinct measures of land values. First, I use the standardized per-acre rental price in shillings as reported for a given parcel (either actual paid rental price or estimated potential rent if the parcel were rented out, and predicted using similar nearby parcels if the respondent did not report a rental price). However, as discussed above, this measure is not solely driven by exogenous land market pressures, and it could be capturing unobserved land quality (or even influenced by prior long-term investments in

[10] An alternate explanation could be different collateralizability of customary and freehold parcels. Farmers may be less able to internalize rising land values to relax their liquidity constraint on customary parcels. This would be less concerning if farmers held parcels under different tenure systems, due to the fungibility of loans. However, when I examine household credit usage in my sample, those in areas more likely to urbanize are actually slightly less likely to take out loans; the relationship between credit usage and normalized individual rental prices is insignificant. This suggests that collateral is not driving the results for short-term inputs.

[11] It may also be that households with freehold parcels are better placed to take advantage of new markets for cash crops; future work with household fixed effects could eliminate this pathway.

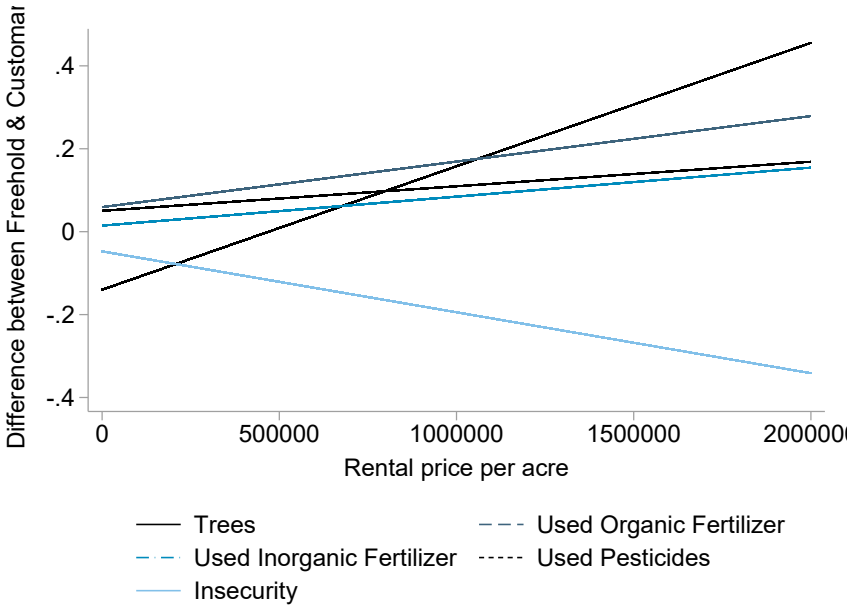


Figure 2.4: Disparities in tenure types increase with rental values more strongly for long-term than short-term inputs. Customary parcels become relatively more insecure than freehold as rental prices increase.

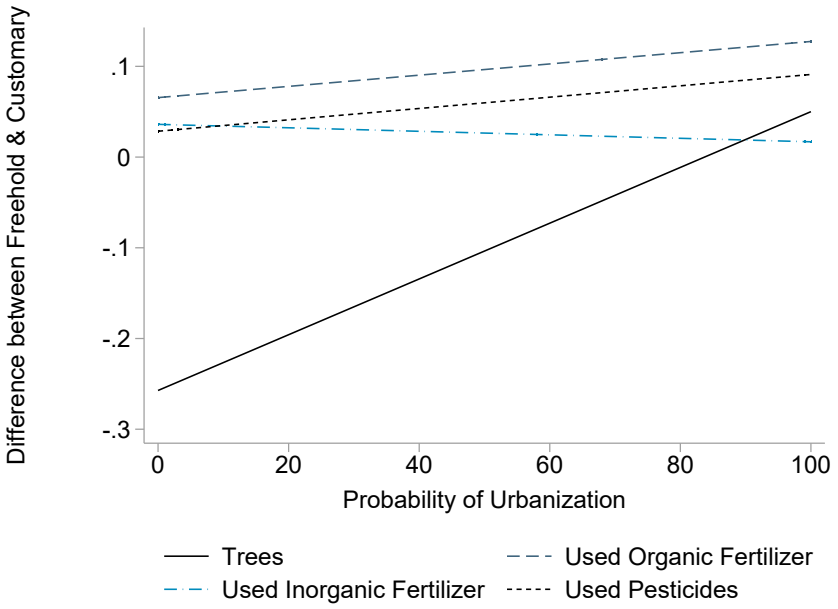


Figure 2.5: Disparities in tenure types increase with the probability of urbanization more strongly for long-term than short-term inputs.

the land).[12] Therefore, I also show results using the probability of urbanization as a proxy for underlying pressures. These measures of land values are interacted with a dummy for the tenure status of a parcel, so the coefficient on 'Freehold*Land Value' represents the additional responsiveness to land values on freehold land as opposed to customary.[13]

In all regressions shown, I control for household characteristics: the Probability of Poverty Index (PPI) as well as for a household's total landholdings in acres. The PPI uses low-cost survey indicators to estimate the likelihood that a household has consumption below a given poverty line, and it can be interpreted approximately as a wealth index (with higher values indicating a lower likelihood of poverty) (Schreiner, 2012). In columns (1) and (2), pooled regressions are run without clustering standard errors. In columns (3) and (4), parcels are still pooled but standard errors are clustered at the farmer-group level; and in columns (5) and (6) farmer-group fixed effects are added to the clustered model. This final model is the most conservative and my preferred specification, but because of relatively low input use results are at times insignificant (although patterns are consistent with the pooled models presented in earlier columns).

2.6.1 Tenure Security

Before turning to agricultural inputs used on parcels, recall that exogenous land pressures should influence input decisions through two pathways: relaxing the liquidity constraint (which should be equally true for all parcels), and increased tenure insecurity (attenuating the liquidity effect, but only under customary tenure). Customary tenure is not necessarily less secure than freehold; rather, it can become less secure if local elites face incentives to expropriate customary land. These incentives, I argue, increase with local land values.

Actual elite expropriation of customary land to sell to outsiders is relatively rare and therefore difficult to detect statistically in random-sample surveys such as this one. However, even if respondents have not personally experienced elite expropriation, they may worry about it, particularly as their community experiences the external pressures that have led to elite expropriation elsewhere. If this pattern holds, I would expect respondents to express greater concern about losing customary parcels as land pressures increase. These land pressures should not affect the perceived security of freehold land to the same extent, however, as titles provide some legal recourse in case of expropriation.

Table 2.1 presents regression results using the average perceived insecurity of a parcel as the outcome. That is, for each parcel, respondents were asked first who in the household had rights to that parcel, and what the likelihood was that each rights-holder would involuntarily lose the land (on a scale of 1 to 5, with higher

[12] In the appendix, I show that results are similar when using predicted rental prices for all parcels, predicted using the probability of urbanization, latitude and longitude of the household, tenure status, existence of trees on the parcel, and village fixed effects.

[13] Although conceptually similar to the slopes in figures 2.4 and 2.5, they are computed differently, include the addition of controls, and use clustered standard errors.

VARIABLES	(1) Insecurity	(2) Insecurity	(3) Insecurity	(4) Insecurity	(5) Insecurity	(6) Insecurity
Customary*Rental Price	0.204***		0.204***		0.149***	
	(0.0251)		(0.0172)		(0.0134)	
Freehold*Rental Price	0.373***		0.373*		-0.540*	
	(0.140)		(0.199)		(0.280)	
Customary*Urbanization		0.123***		0.123**		0.0659
		(0.0246)		(0.0479)		(0.115)
Freehold*Urbanization		0.0220		0.0220		-0.0256
		(0.0223)		(0.0347)		(0.105)
PPI	0.000599	0.000378	0.000599	0.000378	-6.69e-05	-0.000440
	(0.000708)	(0.000763)	(0.000958)	(0.00111)	(0.00127)	(0.00132)
Landholdings	-0.00147**	-0.00145**	-0.00147**	-0.00145**	-0.00103*	-0.000910
	(0.000683)	(0.000688)	(0.000636)	(0.000655)	(0.000590)	(0.000606)
Constant	1.187***	1.138***	1.187***	1.138***	1.019***	1.070***
	(0.0295)	(0.0296)	(0.0396)	(0.0414)	(0.0595)	(0.0823)
Observations	4,364	4,315	4,364	4,315	4,364	4,315
R-squared	0.018	0.009	0.018	0.009	0.118	0.109
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.1: Tenure insecurity increases on customary land as land pressures rise

numbers representing a greater chance of losing it). These responses were averaged across all rights-holders to each parcel to measure household-level insecurity about that parcel.

In table 2.1, tenure insecurity increases significantly with higher land pressures on customary land. This result is attenuated slightly (albeit without statistical significance) on freehold land, implying that freehold land becomes no more insecure than customary as land pressures rise. These results suggest that the hypothesized mechanism for agricultural investment (rising insecurity on customary land) does indeed hold in Uganda.

2.6.2 Tree Planting

Planting trees in Uganda represents a long-term investment in agricultural productivity. In an inter-cropped system, trees provide structure for climbing crops (increasing the productivity of those crops), prevent soil erosion, and produce fruit or coffee themselves (Deininger and Ali, 2008), though this value takes some time to be realized. Therefore, the expected benefits of tree planting are lessened as the risk of expropriation increases, as modeled above.

Trees have a more nuanced relationship with tenure security on customary land. Because trees are such

a visible investment in the land, planting trees on a parcel can actually reduce the risk of expropriation, particularly by neighbors who understand the social context of customary tenure. Therefore, it might be expected that in more isolated (low land-pressure areas) where local social dynamics dominate, tree-planting might actually be more valuable on customary land than on freehold. As external land pressures increase and the primary security concern shifts to elite expropriation to sell to outsiders, this security-enhancing effect may not be as strong. Therefore, the model would predict that as external land pressures increase, tree-planting on customary land may increase; on freehold land, tree-planting would increase substantially.

When looking at table 2.2, this pattern does hold. When land pressures are measured using standardized rental prices, there is no increase in tree-planting on customary land; when using the probability of urbanization to proxy these pressures, customary land sees more trees as external pressures mount. With both measures, however, there is a stronger response in tree-planting on freehold land, as predicted by the model. Note that when controlling for farmer-group fixed effects I lose statistical significance, but the pattern is broadly the same.

As a point of interest, note that in figures 2.4 and 2.5, tree planting is actually more common on customary plots than freehold at low land values. This stems from the role of trees in establishing tenure in customary systems: trees demonstrate to neighbors effective control and serve as a visible investment in land stewardship, thereby forestalling 'horizontal' encroachment. This is less effective when dealing with outsiders to the social system, so the effect reverses as land pressures increase; in this case, trees serve primarily as a long-term investment in the agricultural productivity of the parcel. Note also the negative coefficient on PPI; poorer households are more likely to plant trees, perhaps because they serve as a way to signal ownership if other avenues are unavailable to poor households. In contrast, other inputs (particularly those requiring up-front cash purchases such as commercial fertilizers) are more common among wealthier households, as seen by the positive coefficient on PPI in tables 2.3 - 2.10.

2.6.3 Organic Fertilizer Use

Organic fertilizer use both improves agricultural productivity in the season in which it is applied, and can also have medium-term effects by improving soil organic content (Johansen et al., 2015).[14] The model would predict, then, that organic fertilizer use would increase along with land values on freehold land, but the effect will be attenuated on customary land.

Indeed, when looking at a binary indicator for the application of organic fertilizer in table 2.3, there is no significant relationship between land pressures and organic fertilizer use on customary land, but a positive

[14]Improved soil content can also have complementarities with inorganic fertilizer use, although this is not studied in detail in the current analysis.

VARIABLES	(1) Trees	(2) Trees	(3) Trees	(4) Trees	(5) Trees	(6) Trees
Customary*Rental Price	-0.0201		-0.0201		-0.0402***	
	(0.0209)		(0.0325)		(0.00577)	
Freehold*Rental Price	1.979***		1.979***		0.316	
	(0.118)		(0.308)		(0.215)	
Customary*Urbanization		0.101***		0.101*		0.0331
		(0.0211)		(0.0562)		(0.0957)
Freehold*Urbanization		0.143***		0.143***		0.0563
		(0.0192)		(0.0517)		(0.0972)
PPI	-0.00276***	-0.00462***	-0.00276**	-0.00462***	0.000251	0.000244
	(0.000593)	(0.000658)	(0.00113)	(0.00137)	(0.00108)	(0.00109)
Landholdings	-0.000334	-0.000245	-0.000334	-0.000245	-0.000817*	-0.000860*
	(0.000569)	(0.000588)	(0.000544)	(0.000572)	(0.000467)	(0.000470)
Constant	0.793***	0.749***	0.793***	0.749***	0.227***	0.169**
	(0.0247)	(0.0255)	(0.0503)	(0.0703)	(0.0471)	(0.0737)
Observations	4,322	4,270	4,322	4,270	4,322	4,270
R-squared	0.065	0.018	0.065	0.018	0.253	0.256
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.2: Tree-planting, a long-term investment, increases more on freehold land than customary as land pressures increase

and significant relationship on freehold land in most specifications. Table 2.4 uses the value of organic fertilizer applied[15] as the outcome. On customary parcels, there is at times a negative correlation between the value of the land and the value of organic fertilizer applied (for those who apply organic fertilizer); this effect is attenuated (although not completely) on freehold land. Broadly, these results are consistent with the model's predictions for an intermediate-term input that is not immediately visible to potential tenure challengers.

2.6.4 Inorganic Fertilizer Use

Inorganic fertilizer, by contrast, largely exhibits short-term returns to agricultural land. The model predicts that for short-term inputs, rising land values will relax the liquidity constraint and thus increase short-term input use equivalently on freehold and customary land. In tables 2.5 and 2.6, this describes inorganic fertilizer use well when measuring land values with the standardized rental price (although there is very little response on either freehold or customary land); when instead using the proxy of the probability of urbanization, the story is slightly more complex. This is likely explained by increased planting of cash crops

[15]Standardized from a shilling value; this data is often imputed as many farmers generate and apply their own organic fertilizer including manure outside of the market.

on freehold land near urban markets; cash crop yields are often highly responsive to inorganic fertilizer, and farmers integrated with output markets may be better able to purchase commercial inputs. Therefore, I do observe additional increases in inorganic fertilizer use on freehold land as the area is more likely to urbanize. However, this marginal effect is much smaller in magnitude for short-term inputs: compare the estimates from table 2.3 to those in table 2.5, or those in table 2.4 to table 2.6. The difference in these estimates can be understood as driven by the changing crop patterns as land pressures rise.

2.6.5 Pesticide Use

Pesticides, another short-term input, are generally used as-needed in the Ugandan agricultural sector rather than being applied proactively. Cash crops such as vegetables sold to urban markets are particularly vulnerable to pests, so farmers generally use more pesticides on these crops, which in turn are more likely to be planted on freehold land facing urban pressures. This link between crop choice and land tenure explains the small, significant differences in responses on freehold land apparent in tables 2.7 and 2.8. These differences are smaller than those observed for long-term inputs, as the increasing insecurity on customary land does not impact decisions about pesticide use.

2.6.6 Crop Choice

In order to understand this slightly surprising result for pesticides and inorganic fertilizer, I examine the primary crops planted on each parcel to determine whether changing cropping patterns may influence input use. In tables 2.9 and 2.10, I present regressions where the outcome of interest is an indicator for at least one plot on the parcel being primarily planted to a staple crop (table 2.9) or a cash crop (table 2.10). Overall, cropping patterns do not significantly change on customary parcels as land values increase; however, staple crops are less common on freehold parcels (and cash crops more so) in higher land-pressure environments. This is unsurprising: nearby urban markets increase demand locally for fragile cash crops such as fruits and vegetables. Farmers are more likely to shift their crop production to meet this demand on freehold parcels. This could be due to the perceived insecurity of customary parcels near urban centers discouraging investment in commercial crops. There may also be some systematic differences between households who own freehold land and those who own customary in their ability to take advantage of urban output markets, although the observed effect holds even controlling for a rough measure of household wealth in the PPI.[16] Importantly, the effect of changing crop patterns on input use should be no greater for long-term inputs than short-term ones such as pesticides and inorganic fertilizer (which are more commercial). Therefore, the

[16]There may also be some regional patterns driving these results, which I will explore more fully in the LSMS data in future research.

additional responsiveness of long-term inputs to land pressures on freehold land can be attributed directly to insecurity and is not wholly mediated by crop choice. In the appendix, I also show results for inputs controlling for whether or not any plot on the parcel is primarily devoted to a cash crop. These results show that the effects of insecurity remain for long-term inputs.

VARIABLES	(1) Used Organic Fertilizer	(2) Used Organic Fertilizer	(3) Used Organic Fertilizer	(4) Used Organic Fertilizer	(5) Used Organic Fertilizer	(6) Used Organic Fertilizer
Customary*Rental Price	0.0263*		0.0263		-0.00813***	
	(0.0146)		(0.0225)		(0.00104)	
Freehold*Rental Price	0.523***		0.523***		-0.00793	
	(0.0829)		(0.120)		(0.0517)	
Customary*Urbanization		-0.0104		-0.0104		-0.0375
		(0.0142)		(0.0251)		(0.0410)
Freehold*Urbanization		0.115***		0.115***		0.00265
		(0.0129)		(0.0318)		(0.0398)
PPI	0.00648***	0.00553***	0.00648***	0.00553***	0.00113**	0.00112**
	(0.000414)	(0.000441)	(0.000835)	(0.000840)	(0.000546)	(0.000508)
Landholdings	0.000574	0.000671*	0.000574	0.000671	0.000382	0.000352
	(0.000398)	(0.000395)	(0.000459)	(0.000465)	(0.000293)	(0.000281)
Constant	-0.119***	-0.138***	-0.119***	-0.138***	-0.0491**	-0.0385
	(0.0172)	(0.0171)	(0.0217)	(0.0251)	(0.0225)	(0.0279)
Observations	4,321	4,269	4,321	4,269	4,321	4,269
R-squared	0.064	0.083	0.064	0.083	0.284	0.289
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.3: Organic fertilizer use is more common on freehold land as land pressures increase

VARIABLES	(1) Value Organic Fertilizer (std)	(2) Value Organic Fertilizer (std)	(3) Value Organic Fertilizer (std)	(4) Value Organic Fertilizer (std)	(5) Value Organic Fertilizer (std)	(6) Value Organic Fertilizer (std)
Customary*Rental Price	0.709		0.709		-12.49***	
	(0.479)		(0.434)		(0.480)	
Freehold*Rental Price	12.89***		12.89		0.295	
	(3.844)		(8.489)		(0.540)	
Customary*Urbanization		0.0387		0.0387		-3.043***
		(0.778)		(1.203)		(0.253)
Freehold*Urbanization		2.881***		2.881		-1.735***
		(0.656)		(1.813)		(0.0666)
PPI	0.237***	0.225***	0.237**	0.225**	0.142***	0.148***
	(0.0258)	(0.0268)	(0.111)	(0.106)	(0.00289)	(0.00257)
Landholdings	0.0265	0.0292	0.0265	0.0292	0.0655***	0.0622***
	(0.0170)	(0.0182)	(0.0192)	(0.0222)	(0.00875)	(0.00747)
Constant	-20.31***	-21.80***	-20.31**	-21.80**	-41.91***	-41.37***
	(1.513)	(1.659)	(9.657)	(10.66)	(0.160)	(0.144)
Observations	4,323	4,271	4,323	4,271	4,323	4,271
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.4: The value of organic fertilizer applied increases on freehold land as compared with customary as land pressures increase

VARIABLES	(1) Used Inorganic Fertilizer	(2) Used Inorganic Fertilizer	(3) Used Inorganic Fertilizer	(4) Used Inorganic Fertilizer	(5) Used Inorganic Fertilizer	(6) Used Inorganic Fertilizer
Customary*Rental Price	0.0238*		0.0238		0.00381	
	(0.0129)		(0.0231)		(0.00234)	
Freehold*Rental Price	0.486***		0.486***		0.0284	
	(0.0730)		(0.0621)		(0.120)	
Customary*Urbanization		0.0395***		0.0395**		-0.0123
		(0.0127)		(0.0197)		(0.0455)
Freehold*Urbanization		0.0553***		0.0553***		-0.00739
		(0.0115)		(0.0179)		(0.0447)
PPI	0.00352***	0.00275***	0.00352***	0.00275***	0.00171***	0.00143**
	(0.000366)	(0.000394)	(0.000488)	(0.000588)	(0.000571)	(0.000559)
Landholdings	0.000362	0.000408	0.000362	0.000408	0.000638**	0.000613**
	(0.000351)	(0.000352)	(0.000281)	(0.000258)	(0.000275)	(0.000272)
Constant	-0.0389**	-0.0522***	-0.0389**	-0.0522***	-0.0687***	-0.0553*
	(0.0152)	(0.0152)	(0.0171)	(0.0157)	(0.0252)	(0.0310)
Observations	4,319	4,267	4,319	4,267	4,319	4,267
R-squared	0.033	0.025	0.033	0.025	0.126	0.123
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.5: Inorganic fertilizer use patterns are roughly similar between customary and freehold land as rental prices rise; as the probability of urbanization increases, changing crop patterns induce slightly stronger responses on freehold land.

VARIABLES	(1) Value Inorganic Fertilizer	(2) Value Inorganic Fertilizer	(3) Value Inorganic Fertilizer	(4) Value Inorganic Fertilizer	(5) Value Inorganic Fertilizer	(6) Value Inorganic Fertilizer
Customary*Rental Price	0.515		0.515		1.893***	
	(0.400)		(0.418)		(0.301)	
Freehold*Rental Price	13.21***		13.21*		2.128***	
	(3.467)		(8.022)		(0.0302)	
Customary*Urbanization		0.232***		0.232**		0.0294***
		(0.0687)		(0.105)		(0.00798)
Freehold*Urbanization		0.220***		0.220**		0.0440***
		(0.0642)		(0.100)		(0.00823)
PPI	0.0996***	0.00852***	0.0996*	0.00852**	0.0815***	0.00705***
	(0.0188)	(0.00214)	(0.0561)	(0.00430)	(0.00287)	(0.000155)
Landholdings	-0.0628	-0.00663	-0.0628	-0.00663	-0.0110	-0.00281***
	(0.0405)	(0.00454)	(0.0445)	(0.00451)	(0.00681)	(0.000520)
Constant	-13.36***	-1.548***	-13.36*	-1.548***	-37.04***	-3.971***
	(1.064)	(0.131)	(6.989)	(0.558)	(0.144)	(0.00787)
Observations	4,323	4,271	4,323	4,271	4,323	4,271
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.6: The value of inorganic fertilizer used on customary and freehold land follows similar patterns to its use

VARIABLES	(1) Used Pesticides	(2) Used Pesticides	(3) Used Pesticides	(4) Used Pesticides	(5) Used Pesticides	(6) Used Pesticides
Customary*Rental Price	0.0298*		0.0298		-0.0232***	
	(0.0153)		(0.0263)		(0.00174)	
Freehold*Rental Price	0.698***		0.698***		0.00770	
	(0.0867)		(0.108)		(0.0622)	
Customary*Urbanization		0.0337**		0.0337		0.0221
		(0.0150)		(0.0223)		(0.0525)
Freehold*Urbanization		0.122***		0.122***		0.0680
		(0.0136)		(0.0269)		(0.0521)
PPI	0.00638***	0.00513***	0.00638***	0.00513***	0.00225***	0.00220***
	(0.000435)	(0.000467)	(0.000674)	(0.000754)	(0.000737)	(0.000719)
Landholdings	0.000821**	0.000983**	0.000821	0.000983	0.000744*	0.000715
	(0.000416)	(0.000417)	(0.000566)	(0.000597)	(0.000448)	(0.000439)
Constant	-0.0996***	-0.125***	-0.0996***	-0.125***	-0.0955***	-0.120***
	(0.0181)	(0.0180)	(0.0213)	(0.0253)	(0.0298)	(0.0436)
Observations	4,316	4,264	4,316	4,264	4,316	4,264
R-squared	0.064	0.068	0.064	0.068	0.186	0.188
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.7: Pesticide use is slightly more responsive to land pressures on freehold land where cash crops are more often grown.

VARIABLES	(1) Value Pesticides	(2) Value Pesticides	(3) Value Pesticides	(4) Value Pesticides	(5) Value Pesticides	(6) Value Pesticides
Customary*Rental Price	0.435**		0.435***		-2.787***	
	(0.213)		(0.0895)		(0.386)	
Freehold*Rental Price	11.21***		11.21*		-1.112***	
	(2.006)		(6.147)		(0.216)	
Customary*Urbanization		0.0608		0.0608		-0.133
		(0.307)		(0.545)		(0.0991)
Freehold*Urbanization		1.490***		1.490***		0.738***
		(0.269)		(0.520)		(0.0451)
PPI	0.0994***	0.0842***	0.0994***	0.0842**	0.0462***	0.0410***
	(0.00995)	(0.00998)	(0.0383)	(0.0401)	(0.00138)	(0.00123)
Landholdings	0.00430	0.00354	0.00430	0.00354	0.0138***	0.00884**
	(0.00973)	(0.0101)	(0.00940)	(0.00944)	(0.00459)	(0.00423)
Constant	-8.762***	-8.905***	-8.762**	-8.905**	-22.30***	-21.17***
	(0.529)	(0.551)	(3.464)	(3.792)	(0.0743)	(0.0687)
Observations	4,323	4,271	4,323	4,271	4,323	4,271
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.8: The value of pesticides used per acre responds more to land pressures on freehold land due to changing crop patterns.

VARIABLES	(1) Staple Planting	(2) Staple Planting	(3) Staple Planting	(4) Staple Planting	(5) Staple Planting	(6) Staple Planting
Customary*Rental Price	0.00107		0.00107		0.000632	
	(0.0175)		(0.00953)		(0.00180)	
Freehold*Rental Price	-0.521***		-0.521***		-0.0112	
	(0.0991)		(0.147)		(0.109)	
Customary*Urbanization		0.0304*		0.0304		0.0777*
		(0.0172)		(0.0357)		(0.0410)
Freehold*Urbanization		-0.0856***		-0.0856**		0.0468
		(0.0156)		(0.0401)		(0.0376)
PPI	-0.00363***	-0.00308***	-0.00363***	-0.00308**	0.000807	0.000730
	(0.000496)	(0.000536)	(0.00121)	(0.00119)	(0.000771)	(0.000767)
Landholdings	-0.000981**	-0.001000**	-0.000981*	-0.001000*	0.000557	0.000549
	(0.000476)	(0.000480)	(0.000498)	(0.000550)	(0.000507)	(0.000506)
Constant	0.954***	0.967***	0.954***	0.967***	0.877***	0.847***
	(0.0206)	(0.0207)	(0.0369)	(0.0432)	(0.0327)	(0.0399)
Observations	4,326	4,274	4,326	4,274	4,326	4,274
R-squared	0.019	0.028	0.019	0.028	0.266	0.269
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.9: Freehold parcels are less likely to be planted with staple crops as land pressures rise

VARIABLES	(1) Cash Crop Planting	(2) Cash Crop Planting	(3) Cash Crop Planting	(4) Cash Crop Planting	(5) Cash Crop Planting	(6) Cash Crop Planting
Customary*Rental Price	0.0210		0.0210		-0.00307	
	(0.0193)		(0.0258)		(0.00357)	
Freehold*Rental Price	0.845***		0.845***		0.177	
	(0.109)		(0.169)		(0.147)	
Customary*Urbanization		-0.00777		-0.00777		-0.106**
		(0.0188)		(0.0479)		(0.0407)
Freehold*Urbanization		0.150***		0.150***		-0.0893**
		(0.0171)		(0.0522)		(0.0385)
PPI	0.00727***	0.00622***	0.00727***	0.00622***	-0.000910	-0.000868
	(0.000546)	(0.000586)	(0.00140)	(0.00138)	(0.000718)	(0.000714)
Landholdings	0.00225***	0.00228***	0.00225**	0.00228**	0.000834	0.000767
	(0.000524)	(0.000525)	(0.00103)	(0.00107)	(0.000843)	(0.000834)
Constant	-0.0285	-0.0601***	-0.0285	-0.0601	0.165***	0.200***
	(0.0227)	(0.0227)	(0.0409)	(0.0480)	(0.0329)	(0.0397)
Observations	4,326	4,274	4,326	4,274	4,326	4,274
R-squared	0.055	0.070	0.055	0.070	0.403	0.408
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.10: Freehold parcels are significantly more likely to be devoted primarily to cash crops as land pressures increase

2.7 Conclusion

In this paper, I developed a theoretical model of short- and long-term agricultural investments on customary and freehold land. This model incorporates how expropriation incentives change as land pressures increase. Local elites, observing outsiders' new demand for land and inability to distinguish between overlapping customary rights, may choose to expropriate land used by non-elites in the community to sell. Even if uncommon in practice, the perception and fear of elite expropriation reduces tenure security on customary tenure parcels. This, in turn, reduces the expected returns to long-term inputs.

The model predicts that long-term input use will diverge between customary and freehold parcels as land pressures increase in an area. Indeed, when I test the model's implications using survey data from four regions of Uganda, I find that long-term inputs (such as trees and organic fertilizer) are used more often on freehold land as land pressures increase, while on customary land this relationship is attenuated by tenure insecurity. Changing cropping patterns due to the proximity of urban markets appears to also influence short-term input use, but the effects on long-term inputs are larger, suggesting an independent effect of tenure security on long-term inputs. In future work, I will work with a household fixed-effects model.[17]

The theoretical model and empirical results together suggest the importance of expanding beyond a simplification of customary tenure as less secure to thinking carefully about the social nature of land rights and the interacting incentives of multiple stakeholders. This insight allows researchers to make more detailed predictions about agricultural investment and may help explain the mixed results in much of the empirical literature. Secure customary tenure may may become less secure as tenure systems intersect. This also suggests targeted policy to document and clarify rights as land pressures mount to protect the rights of the most vulnerable from elites within their communities and without.

[17] Despite many households initially reporting having multiple parcels under distinct tenure systems, the current sample does not have input use for all parcels.

2.8 References

A. Abdulai, V. Owusu, and R. Goetz. Land tenure differences and investment in land improvement measures: Theoretical and empirical analyses. *Journal of Development Economics*, 96(1):66–78, 2011.

J. Adoko and J. Akin. Understanding and strengthening women's land rights under customary tenure in Uganda. Technical report, 2011.

L. Alden Wily. Customary land tenure in the modern world: Rights to resources in crisis: Reviewing the fate of customary tenure in Africa. Technical report, 2011.

C. D. Arnot, M. K. Luckert, and P. C. Boxall. What is tenure security? Conceptual implications for empirical analysis. *Land Economics*, 87(2):297–311, 2011.

L. Awanyo. Exploring the connections: Land tenure, social identities, and agrobiodiversity practices in Ghana. *Geografiska Annaler, Series B: Human Geography*, 91(2):137–155, 2009.

M. Barry and E. K. Danso. Tenure security, land registration and customary tenure in a peri-urban Accra community. *Land Use Policy*, 39:358–365, 2014.

M. F. Bellemare. The productivity impacts of formal and informal land rights : Evidence from Madagascar. *Land Economics*, 89(May):272–290, 2013.

E. Boserup. *The Conditions of Agricultural Growth.* 1965.

A. S. Brasselle, F. Gaspart, and J.-P. Platteau. Land tenure security and investment incentives: Puzzling evidence from Burkina Faso. *Journal of Development Economics*, 67(2):373–418, 2002.

J. W. Bruce and S. E. Migot-Adholla, editors. *Searching for Land Tenure Security in Africa.* World Bank, 1994.

M. R. Carter and P. Olinto. Getting institutions "right" for whom? Credit constraints and the impact of property rights on the quantity and composition of investment. *American Journal of Agricultural Economics*, 85(1):173–186, 2003.

S. Coldham. Land reform and customary rights: The case of Uganda. *Journal of African Law*, 44(1):65–77, 2000.

L. Cotula, J.-P. Chauveau, S. Cissé, J.-P. Colin, P. Lavigne Delville, B. Neves, J. Quan, and C. Toulmin. Changes in 'customary' land tenure systems in Africa. Technical report, iied, 2007.

K. Deininger and D. A. Ali. Do overlapping land rights reduce agricultural investment? Evidence from Uganda. *American Journal of Agricultural Economics*, 90(4):869–882, 2008.

K. Deininger and R. Castagnini. Incidence and impact of land conflict in Uganda. 2004.

K. Deininger and S. Jin. Tenure security and land-related investment: Evidence from Ethiopia. *European Economic Review*, 50(5):1245–1277, 2006.

B. Dillon and A. Voena. Inheritance customs and agricultural investment. 2015.

C. Doss and R. Meinzen-Dick. Land tenure security for women: A conceptual framework. *Land Use Policy*, 99:105080, 2020.

J. Ensminger. Changing property rights: Reconciling formal and informal rights to land in Africa. In J. N. Droback and J. V. Nye, editors, *The Frontiers of the New Institutional Economics*, chapter 8, pages 165–196. Academic Press, San Diego, 1997.

J. Fenske. Land tenure and investment incentives: Evidence from West Africa. *Journal of Development Economics*, 95(2):137–156, 2011.

M. Goist and F. G. Kern. Traditional institutions and social cooperation: Experimental evidence from the Buganda Kingdom. 2018.

M. Goldstein and C. Udry. The profits of power: Land rights and agricultural investment in Ghana. *Journal of Political Economy*, 116(6):981–1022, 2008.

R. E. Goodhue and N. McCarthy. Traditional property rights, common property, and mobility in semi-arid African pastoralist systems. *Environment and Development Economics*, 14(01):29–50, 2008.

B. E. Honore. Trimmed LAD and least squares estimation of truncated and censored regression models with fixed effects. *Econometrica*, 60(3):533, 1992.

P. L. Howard and G. Nabanoga. Are there customary rights to plants? An inquiry among the Baganda (Uganda), with special attention to gender. *World Development*, 35(9):1542–1563, 2007.

D. Hunt. Unintended consequences of land rights reform: The case of the 1998 Uganda Land Act. *Development Policy Review*, 22(2):173–191, 2004.

H. G. Jacoby and B. Minten. Land titles, investment, and agricultural productivity in Madagascar: A poverty and social impact analysis. 2006.

A. Johansen, R. Pommeresche, H. Riley, and A.-K. Loes. Anaerobic digestion of animal manure - implications for crop yields and soil biota in organic farming. *"Nordic View to Sustainable Rural Development", Proceedings of the 25th NJF Congress, Riga, Latvia, 16-18 June 2015*, pages 97–102, 2015.

S. F. Joireman. Enforcing new property rights in Sub-Saharan Africa: The Ugandan Constitution and the 1998 Land Act. *Comparative Politics*, 39(4):463–480, 2007.

D. C. Mattingly. Elite capture: How decentralization and informal institutions weaken property rights in China. *World Politics*, 68(3):383–412, 2016.

F. Place. Land tenure and agricultural productivity in Africa: A comparative analysis of the economics literature and recent policy strategies and reforms. *World Development*, 37(8):1326–1336, 2009.

F. Place and P. Hazell. Productivity effects of indigenous land tenure systems in Sub-Saharan Africa. *American Journal of Agricultural Economics*, 75(1):10–19, 1993.

F. Place and K. Otsuka. Land tenure systems and their impacts on agricultural investments and productivity in Uganda. *Journal of Development Studies*, 38(6):105–128, 2002.

F. Place, M. Roth, and P. Hazell. Land tenure security and agricultural performance in Africa: Overview of research methodology. In J. W. Bruce and S. Migot-Adholla, editors, *Searching for land tenure security in Africa*. The World Bank, Washington, D.C., 1994.

J.-P. Platteau. The evolutionary theory of land rights as applied to Sub-Saharan Africa: A critical assessment. *Development and Change*, 27:29–86, 1996.

M. Purdon. Land and sustainable industrial policy in Sub-Saharan Africa: The relationship between land tenure and foreign investment strategy in Uganda and Tanzania. 2014.

S. Riwthong, P. Schreinemachers, C. Grovermann, and T. Berger. Agricultural commercialization: Risk perceptions, risk management and the role of pesticides in Thailand. *Kasetsart Journal of Social Sciences*, 38(3):264–272, 2017.

E. J. Robinson. Reassessing the interaction between investment and tenure uncertainty. *Environment and Development Economics*, 10(2):143–157, 2005.

M. Schreiner. Uganda 2012 Poverty Probability Index (PPI ®): Design Memo Poverty Probability Index (PPI ®) for Uganda. 2012.

K. Seto, B. Guneralp, and L. Hutyra. Global grid of probabilities of urban expansion to 2030, 2016.

K. C. Seto, B. Güneralp, and L. R. Hutyra. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences of the United States of America*, 109(40):16083–16088, 2012.

R. Smalley and E. Corbera. Large-scale land deals from the inside out: Findings from Kenya's Tana Delta. *The Journal of Peasant Studies*, 39(3-4):1039–1075, 2012.

A. M. Tripp. Women's movements, customary law, and land rights in Africa: the case of Uganda. *African Studies Quarterly*, 7(4):1–19, 2004.

J. M. Ubink. *In The Land of the Chiefs: Customary Law, Land Conflicts, and the Role of the State in Peri-Urban Ghana*. 2008.

J. M. Ubink and J. Quan. How to combine tradition and modernity? Regulating customary land management in Ghana. *Land Use Policy*, 25(2):198–213, 2008.

M. Van Leeuwen. Renegotiating customary tenure reform - Land governance reform and tenure security in Uganda. *Land Use Policy*, 39:292–300, 2014.

General Analytical Solution

Consider a two-period model. In the first period, the farmer chooses to apply fertilizer, F_1 and trees, T, to his or her exogenously-given land L under tenure system h. The farmer also has some wealth endowment, but can choose to borrow B_1 against the value of the land (and the tenure system). The farmer faces an exogenous interest rate, r, and has a discount rate of β for second period returns. There is some probability that the farmer's land will be expropriated before the second period, and fixed investments (trees) would be lost then as well. This probability is given by $(1 - \phi(T, h, vL))$ and could be a function of tree investment, tenure systems, as well as the value of the land. After working through the main features of the model, I will consider what different forms of this ϕ function could imply for the farmer's decisions.

The first period problem faced by the farmer is then to:

$$\max_{F_1,T,B_1} p_a f(F_1, T) - p_F F_1 - p_T T - rB_1 + \beta\phi(T, h, vL)\pi_2^*(F_1, T, B_1)$$

$$\text{subject to: } \begin{aligned} p_F F_1 + p_T T &\leq w_1 + B_1 \\ B_1 &\leq s(vL, h) \end{aligned}$$

While in the second period, the farmer only chooses fertilizer (F_2):

$$\max_{F_2} p_a f(F_2, T) - p_F F_2$$

$$\text{subject to: } \begin{aligned} p_F F_2 &\leq w_2 \\ w_2 &= w_1 - rB_1 + p_a f(F_1, T) - p_F F_1 - p_T T \end{aligned}$$

The First Order Conditions of this second stage are:

$$\frac{p_a}{p_F}\frac{\partial f}{\partial F_2} - p_F - \lambda_1 p_F = 0$$

$$\lambda_1[p_F F_2 - w_1 + rB_1 - p_a f(F_1, T) + p_F F_1 + p_T T] = 0$$

There are two cases: Either the budget constraint binds in the second stage, or it does not.

Case A: Unconstrained Second Stage

First consider the case where the budget constraint does not bind in the second stage, $\lambda_1 = 0$

Then F_2^* such that:

$$\frac{\partial f}{\partial F_2} = \frac{p_F}{p_a}$$

Therefore

$$\pi_2^* = p_a f(F_2^*, T) - p_F F_2^*$$

and the derivatives are:

$$\begin{aligned} \frac{\partial \pi_2^*}{\partial F_1} &= 0 \\ \frac{\partial \pi_2^*}{\partial T} &= p_a \frac{\partial f}{\partial T}\Big|_{F_2^*} \\ \frac{\partial \pi_2^*}{\partial B_1} &= 0 \end{aligned}$$

Turning to the first stage, then:

$$\begin{aligned} \max_{F_1,T,B_1} \; & p_a f(F_1, T) - p_F F_1 - p_T T - r B_1 + \beta \phi(T, h, vL) \pi_2^*(F_1, T, B_1) \\ & \text{subject to } p_F F_1 + p_T T \leq w_1 + B_1 \\ & B_1 \leq s(vL, h) \end{aligned}$$

FOCs are:

$$\begin{aligned} p_a \frac{\partial f}{\partial F_1} - p_F + \beta \phi(T, h, vL) \frac{\partial \pi_2^*}{\partial F_1} - \lambda_2 p_F &= 0 \\ p_a \frac{\partial f}{\partial T} - p_T + \beta \frac{\partial \phi}{\partial T} \pi_2^* + \beta \phi(T, h, vL) \frac{\partial \pi_2^*}{\partial T} - \lambda_2 p_T &= 0 \\ -r + \beta \phi(T, h, vL) \frac{\partial \pi_2^*}{\partial B_1} + \lambda_2 - \lambda_3 &= 0 \\ \lambda_2 (p_F F_1 + p_T T - w_1 - B_1) &= 0 \\ \lambda_3 (B_1 - s(vL, h)) &= 0 \end{aligned}$$

Which simplify to:

$$
\begin{aligned}
p_a \frac{\partial f}{\partial F_1} - p_F - \lambda_2 p_F &= 0 \\
p_a \frac{\partial f}{\partial T} - p_T + \beta \frac{\partial \phi}{\partial T} \pi_2^* + \beta \phi(T, h, vL) \frac{\partial \pi_2^*}{\partial T} - \lambda_2 p_T &= 0 \\
-r + \lambda_2 - \lambda_3 &= 0 \\
\lambda_2 (p_F F_1 + p_T T - w_1 - B_1) &= 0 \\
\lambda_3 (B_1 - s(vL, h)) &= 0
\end{aligned}
$$

Case 1A: Totally Unconstrained

As a benchmark, consider a farmer who has a sufficient initial endowment of wealth w_1 that neither the borrowing nor the budget constraint bind ($\lambda_1 = \lambda_2 = \lambda_3 = 0$

The FOCs are then:

$$
\begin{aligned}
p_a \frac{\partial f}{\partial F_1} - p_F &= 0 \\
p_a \frac{\partial f}{\partial T} - p_T + \beta \frac{\partial \phi}{\partial T} \pi_2^* + \beta \phi(T, h, vL) p_a \frac{\partial f}{\partial T}\Big|_{F_2^*} &= 0
\end{aligned}
$$

This then gives us:

$$
\frac{\partial f}{\partial F_1} = \frac{p_F}{p_a}
$$

Therefore, in the totally unconstrained case, $F_1^* = F_2^*$. Furthermore, if I assume that under freehold tenure, $\phi = 1$ and $\frac{\partial \phi}{\partial T} = 0$ (tenure is perfectly secure and planting trees has no effect on tenure security), then

$$
\frac{\partial f}{\partial T}\Big|_{h=1} = \frac{p_T}{p_a} \frac{1}{(1+\beta)}
$$

However, if $\phi < 1$, such as is possible under customary tenure, then the marginal productivity of trees in equilibrium would be higher, and therefore investment in trees would be lower. This effect would be

attenuated by $\frac{\partial \phi}{\partial T} > 0$, as would be the case if planting trees helped secure tenure.

This is only a benchmark case, as our real interest is in the liquidity-constrained farmer (where the borrowing constraint, and therefore the budget constraint, bind). However, it demonstrates that our model accords with most theoretical models of tenure and long-term investments.

Case 2A: Binding Budget Constraint

Now consider a world in which the farmer is not constrained in their ability to borrow, but they do exhaust their budget constraint ($\lambda_1 = \lambda_3 = 0$; $\lambda_2 \neq 0$)

The FOCs in this case are:

$$\begin{aligned} p_a \frac{\partial f}{\partial F_1} - p_F - \lambda_2 p_F &= 0 \\ p_a \frac{\partial f}{\partial T} - p_T + \beta \frac{\partial \phi}{\partial T} \pi_2^* + \beta \phi(T, h, vL) \frac{\partial \pi_2^*}{\partial T} - \lambda_2 p_T &= 0 \\ -r + \lambda_2 &= 0 \\ p_F F_1 + p_T T - w_1 - B_1 &= 0 \end{aligned}$$

I now have fertilizer use in the first stage determined by setting the marginal product not equal to the relative price, as in the totally unconstrained case, but instead to a (higher) shadow price determined by the interest rate, and thus lower than optimal fertilizer usage.

$$\frac{\partial f}{\partial F_1} = \frac{p_F}{p_a}(1 + r)$$

Similarly, in the freehold case, where tree planting has no effect on (full) tenure security,

$$\frac{\partial f}{\partial T}\Big|_{h=1} = \frac{p_T}{p_a} \frac{(1 + r)}{(1 + \beta)}$$

Which mirrors the unconstrained case, but has the marginal product of trees (discounted across both periods) equal to a shadow price which is higher than the true price and thus tree planting will be lower than in 1A. Furthermore, as in 1A, if tenure security was incomplete ($\phi < 1$), but unresponsive to tree planting, the condition would be:

$$\frac{\partial f}{\partial T}\Big|_{h=0} = \frac{p_T}{p_a}\frac{(1+r)}{(1+\beta\phi)} > \frac{p_T}{p_a}\frac{(1+r)}{(1+\beta)} = \frac{\partial f}{\partial T}\Big|_{h=1}$$

Therefore, the marginal productivity of trees is higher under customary tenure and thus under normal assumptions of diminishing marginal returns, the level of investment in trees is lower on customary land than freehold. If $\frac{\partial \phi}{\partial T} > 0$, that would attenuate this result somewhat (as the marginal product of trees in equilibrium would be reduced by the (positive) term $\beta \frac{\partial \phi}{\partial T}\pi_2^*$), for reasonable parameter values the net effect would be similar to that found empirically: that investment in trees on customary land is no higher than on freehold.

Case 3A: Binding Borrowing Constraint

This case will never occur, as the farmer would not exhaust the (costly) borrowing option if wealth was high enough for the budget constraint not to bind.

Case 4A: Both Constraints Binding

Finally, consider a liquidity-constrained farmer who faces both a binding borrowing and budget constraint: $\lambda_1 = 0, \lambda_2 \neq 0, \lambda_3 \neq 0$

This is the case depicted in Figures 1-3, so I will devote particular attention to it.

Working with the constraints, the FOCs are:

$$\begin{aligned}
p_a \frac{\partial f}{\partial F_1} - p_F - \lambda_2 p_F &= 0 \\
p_a \frac{\partial f}{\partial T} - p_T + \beta \frac{\partial \phi}{\partial T}\pi_2^* + \beta\phi(T,h,vL)\frac{\partial \pi_2^*}{\partial T} - \lambda_2 p_T &= 0 \\
-r + \lambda_2 - \lambda_3 &= 0 \\
p_F F_1 + p_T T - w_1 - s(vL,h) &= 0 \\
B_1 = s(vL,h)
\end{aligned}$$

First, consider the freehold case ($\phi = 1$). Then the equilibrium condition is:

$$\frac{\partial f}{\partial T}\Big|_{F_1^*} + \beta \frac{\partial f}{\partial T}\Big|_{F_2^*} = \frac{p_T}{p_F}\frac{\partial f}{\partial F_1}$$

Despite not being able to solve this explicitly for F_1 and T, I can use the implicit function theorem to see how input choices respond to the parameters of interest. The Jacobian for choice variables is the following:

$$D_x = \begin{bmatrix} \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2} & \frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} + \beta \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1^*} \\ p_F & p_T \end{bmatrix}$$

and its inverse is:

$$D_x^{-1} = \frac{1}{|D_x|}\begin{bmatrix} p_T & -\frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} - \beta \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*} + \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1^*} \\ -p_F & \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2} \end{bmatrix}$$

Where the determinant, $|D_X|$, is given by:

$$\begin{aligned} |D_x| &= (\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2})p_T - (\frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} + \beta \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1^*})p_F \\ &= \left(2p_T \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta p_T \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T^2}{p_F}\frac{\partial^2 f}{\partial F_1^2} - p_F \frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} - \beta p_F \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*}\right) \end{aligned}$$

or equivalently,

$$D_x^{-1} = \frac{1}{|D_x|}\begin{bmatrix} p_T & -\frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} - \beta \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*} + \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1^*} \\ -p_F & \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2} \end{bmatrix}$$

And for the parameters (v is the primary parameter of interest for the empirical hypotheses):

$$D_q = \begin{bmatrix} 0 \\ -\frac{\partial s}{\partial v L}L \end{bmatrix}$$

The product is therefore:

$$\frac{-1}{\left(2p_T \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta p_T \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T^2}{p_F}\frac{\partial^2 f}{\partial F_1^2} - p_F \frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} - \beta p_F \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*}\right)} \begin{bmatrix} (-\frac{\partial s}{\partial v L}L)[-\frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} - \beta \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*} + \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1^*}] \\ (-\frac{\partial s}{\partial v L}L)[\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2}] \end{bmatrix}$$

In order to sign these, I need to specify reasonable assumptions about signs. First, many inter-cropping systems such as are commonly used in Uganda mean that the cross-partials are positive: $\frac{\partial^2 f}{\partial F \partial T} > 0$. Prices are all positive, as is β. The borrowing constraint is increasing in the value of land used as collateral, so

$\frac{\partial s}{\partial vL} > 0$. Finally, diminishing marginal returns implies that $\frac{\partial^2 f}{\partial i^2} < 0$, for $i \in F, T$.

These assumptions allow me to sign the matrix: the determinant is negative (therefore the fraction is positive), and both terms inside the matrix are positive. Therefore I can say that $\frac{\partial F_1}{\partial v} > 0$ and $\frac{\partial T}{\partial v} > 0$: both optimal fertilizer and tree investment are increasing in the value of land if the freeholder farmer is liquidity constrained. This allows me to make hypotheses (3) and (4).

$$\frac{1}{\left(2p_T \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta p_T \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T^2}{p_F}\frac{\partial^2 f}{\partial F_1^2} - p_F \frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} - \beta p_F \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*}\right)} \begin{bmatrix} \left(\frac{\partial s}{\partial vL} L\right)\left[-\frac{\partial^2 f}{\partial T^2}\Big|_{F_1^*} - \beta \frac{\partial^2 f}{\partial T^2}\Big|_{F_2^*} + \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1^*}\right] \\ \left(\frac{\partial s}{\partial vL} L\right)\left[\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2}\right] \end{bmatrix}$$

If I instead consider customary tenure, the equilibrium condition is:

$$p_a \frac{\partial f}{\partial T}\Big|_{F_1^*} + \beta \frac{\partial \phi}{\partial T}(p_a f(F_2^*, T) - p_F F_2^*) + \beta \phi p_a \frac{\partial f}{\partial T}\Big|_{F_2^*} = \frac{p_T p_a}{p_F}\frac{\partial f}{\partial F_1}$$

Which can also be written as:

$$\frac{\partial f}{\partial T}\Big|_{F_1^*} + \beta \frac{\partial \phi}{\partial T}(f(F_2^*, T) - \frac{p_F}{p_a} F_2^*) + \beta \phi \frac{\partial f}{\partial T}\Big|_{F_2^*} = \frac{p_T}{p_F}\frac{\partial f}{\partial F_1}$$

I can again use the implicit function theorem on this condition, along with the budget constraint. The Jacobian for choice variables is:

$$\begin{bmatrix} \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta\phi \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2} & \frac{\partial^2 f}{\partial T^2}\Big|_{F_1} + \beta \frac{\partial^2 \phi}{\partial T^2}\left[f(F_2^*, T) - \frac{p_F}{p_a}F_2^*\right] + 2\beta \frac{\partial \phi}{\partial T}\frac{\partial f}{\partial T}\Big|_{F_2} + \beta\phi \frac{\partial^2 f}{\partial T^2}\Big|_{F_2} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1} \\ p_F & p_T \end{bmatrix}$$

Which I invert:

$$D_x^- 1 = \frac{1}{|D_x|}\begin{bmatrix} p_T & -\left[\frac{\partial^2 f}{\partial T^2}\Big|_{F_1} + \beta \frac{\partial^2 \phi}{\partial T^2}\left[f(F_2^*, T) - \frac{p_F}{p_a}F_2^*\right] + 2\beta \frac{\partial \phi}{\partial T}\frac{\partial f}{\partial T}\Big|_{F_2} + \beta\phi \frac{\partial^2 f}{\partial T^2}\Big|_{F_2} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1}\right] \\ -p_F & \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta\phi \frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2} \end{bmatrix}$$

Where $|D_x|$ is the determinant,

$$|D_x| = \left[\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta\phi\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2}\right] p_T$$
$$- \left[\frac{\partial^2 f}{\partial T^2}\Big|_{F_1} + \beta\frac{\partial^2 \phi}{\partial T^2}\left[f(F_2^*, T) - \frac{p_F}{p_a}F_2^*\right] + 2\beta\frac{\partial \phi}{\partial T}\frac{\partial f}{\partial T}\Big|_{F_2} + \beta\phi\frac{\partial^2 f}{\partial T^2}\Big|_{F_2} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1}\right] p_F$$

The Jacobian with respect to land values is:

$$D_q = \begin{bmatrix} \beta\frac{\partial^2 \phi}{\partial T \partial v}\left[f(F_2^*, T) - \frac{p_F}{p_a}F_2^*\right] + \beta\frac{\partial \phi}{\partial v}\frac{\partial f}{\partial T}\Big|_{F_2} \\ -\frac{\partial s}{\partial v L}L \end{bmatrix}$$

The product is therefore:

$$\frac{-1}{|D_x|}\begin{bmatrix} p_T\left[\beta\frac{\partial^2 \phi}{\partial T \partial v}\left[f(F_2^*, T) - \frac{p_F}{p_a}F_2^*\right] + \beta\frac{\partial \phi}{\partial v}\frac{\partial f}{\partial T}\Big|_{F_2}\right] + \left[\frac{\partial^2 f}{\partial T^2}\Big|_{F_1} + \beta\frac{\partial^2 \phi}{\partial T^2}\left[f(F_2^*, T) - \frac{p_F}{p_a}F_2^*\right] + 2\beta\frac{\partial \phi}{\partial T}\frac{\partial f}{\partial T}\Big|_{F_2} + \beta\phi\frac{\partial^2 f}{\partial T^2}\Big|_{F_2} - \frac{p_T}{p_F}\frac{\partial}{\partial F} \\ -p_F\left[\beta\frac{\partial^2 \phi}{\partial T \partial v}\left[f(F_2^*, T) - \frac{p_F}{p_a}F_2^*\right] + \beta\frac{\partial \phi}{\partial v}\frac{\partial f}{\partial T}\Big|_{F_2}\right] - \left[\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta\phi\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2}\right]\frac{\partial s}{\partial v L}L \end{bmatrix}$$

It is convenient to make a few further minor assumptions:

- $\frac{\partial^2 \phi}{\partial T \partial v} = 0$ Without substantial loss of generality, assume the risk of elite expropriation (which responds to land values) is unrelated to the risk of neighbor expropriation (which responds to trees), so the cross-partial of ϕ is zero.
- $\frac{\partial \phi}{\partial v} < 0$: tenure security is decreasing in land values as risk of elite expropriation increases, the fundamental new insight of this model
- $\frac{\partial^2 \phi}{\partial T^2} = 0$ For the current purposes, assume the risk of expropriation by neighbors is a linear function of tree investment, or a close enough approximation.

This matrix product then simplifies to:

$$\frac{-1}{|D_x|}\begin{bmatrix} \beta\frac{\partial \phi}{\partial v}\frac{\partial f}{\partial T}\Big|_{F_2} + \left[\frac{\partial^2 f}{\partial T^2}\Big|_{F_1} + 2\beta\frac{\partial \phi}{\partial T}\frac{\partial f}{\partial T}\Big|_{F_2} + \beta\phi\frac{\partial^2 f}{\partial T^2}\Big|_{F_2} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1 \partial T}\Big|_{F_1}\right]\frac{\partial s}{\partial v L}L \\ -p_F\left[\beta\frac{\partial \phi}{\partial v}\frac{\partial f}{\partial T}\Big|_{F_2}\right] - \left[\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_1^*} + \beta\phi\frac{\partial^2 f}{\partial T \partial F_1}\Big|_{F_2^*} - \frac{p_T}{p_F}\frac{\partial^2 f}{\partial F_1^2}\right]\frac{\partial s}{\partial v L}L \end{bmatrix}$$

The top component of the matrix is then positive under reasonable parameter values (the determinant is also generally positive). This implies that, as in Hypothesis (5), a liquidity-constrained farmer on customary land will increase fertilizer application as land values increase and the liquidity constraint relaxes.

The sign of the second term, however, depends on the relative magnitudes of the different mechanisms. If tenure insecurity responds drastically enough to rising land values (captured by the term $\frac{\partial \phi}{\partial v}$) to counteract the increasing ability to invest given by the second term, then net investment in trees will actually decrease. This is noted in Hypothesis (6).

Finally, comparing the equilibria conditions for customary and freehold tenure allows me to show that the marginal productivity of tree investment will be higher in the customary case, meaning that liquidity-constrained farmers plant fewer trees on customary land than on freehold. This also means, because the budget constraint binds, that they invest more in fertilizer. This speaks to hypotheses (1) and (2).

Case B: Constrained Second Stage

A detailed solution to Case B, where the budget constraint binds in the second period, does not add substantively to the understanding and so is omitted here.

Robustness Checks

Predicted Rental Prices

Tenure Insecurity

VARIABLES	(1) Insecurity	(2) Insecurity	(3) Insecurity
Customary*Predicted Rental Price	4.92e-07***	4.92e-07***	4.16e-07**
	(6.14e-08)	(1.57e-07)	(2.04e-07)
Freehold*Predicted Rental Price	2.12e-07***	2.12e-07*	1.52e-07
	(5.69e-08)	(1.14e-07)	(2.23e-07)
PPI	0.000383	0.000383	-0.000309
	(0.000727)	(0.00107)	(0.00132)
Landholdings	-0.00158**	-0.00158**	-0.000901
	(0.000683)	(0.000670)	(0.000611)
Constant	1.109***	1.109***	1.037***
	(0.0298)	(0.0404)	(0.0585)
Observations	4,366	4,366	4,366
R-squared	0.017	0.017	0.115
Fixed Effect	None	None	Farmer Group
Cluster	None	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Trees

VARIABLES	(1) Trees	(2) Trees	(3) Trees
Customary*Predicted Rental Price	1.44e-08	1.44e-08	1.39e-07
	(5.27e-08)	(1.33e-07)	(1.82e-07)
Freehold*Predicted Rental Price	2.34e-07***	2.34e-07**	3.35e-07*
	(4.95e-08)	(1.13e-07)	(1.80e-07)
PPI	-0.00333***	-0.00333**	0.000479
	(0.000627)	(0.00134)	(0.00107)
Landholdings	-0.000645	-0.000645	-0.000899**
	(0.000585)	(0.000572)	(0.000448)
Constant	0.759***	0.759***	0.155***
	(0.0257)	(0.0646)	(0.0506)
Observations	4,324	4,324	4,324
R-squared	0.011	0.011	0.257
Fixed Effect	None	None	Farmer Group
Cluster	None	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Organic Fertilizer

VARIABLES	(1) Used Organic Fertilizer	(2) Used Organic Fertilizer	(3) Used Organic Fertilizer
Customary*Predicted Rental Price	2.94e-08	2.94e-08	-1.27e-07
	(3.54e-08)	(7.23e-08)	(8.82e-08)
Freehold*Predicted Rental Price	3.68e-07***	3.68e-07***	-7.85e-09
	(3.32e-08)	(1.28e-07)	(1.02e-07)
PPI	0.00547***	0.00547***	0.00120**
	(0.000421)	(0.000957)	(0.000535)
Landholdings	0.000595	0.000595	0.000366
	(0.000392)	(0.000433)	(0.000291)
Constant	-0.136***	-0.136***	-0.0417*
	(0.0172)	(0.0226)	(0.0224)
Observations	4,323	4,323	4,323
R-squared	0.086	0.086	0.287
Fixed Effect	None	None	Farmer Group
Cluster	None	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Organic Fertilizer	(2) Value Organic Fertilizer	(3) Value Organic Fertilizer
Customary*Predicted Rental Price	-1.11e-06	-1.11e-06	-1.83e-06***
	(1.64e-06)	(1.75e-06)	(4.86e-07)
Freehold*Predicted Rental Price	5.56e-06***	5.56e-06	1.48e-06***
	(1.12e-06)	(3.47e-06)	(1.37e-07)
PPI	0.229***	0.229**	0.143***
	(0.0261)	(0.109)	(0.00267)
Landholdings	0.0249	0.0249	0.0613***
	(0.0180)	(0.0194)	(0.00800)
Constant	-20.98***	-20.98**	-41.92***
	(1.575)	(10.17)	(0.150)
Observations	4,325	4,325	4,3255
Fixed Effect	None	None	Farmer Group
Cluster	None	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Inorganic Fertilizer

VARIABLES	(1) Used Inorganic Fertilizer	(2) Used Inorganic Fertilizer	(3) Used Inorganic Fertilizer
Customary*Predicted Rental Price	-1.27e-08	-1.27e-08	-5.36e-08
	(3.18e-08)	(5.54e-08)	(7.50e-08)
Freehold*Predicted Rental Price	3.28e-08	3.28e-08	-4.71e-08
	(2.99e-08)	(5.96e-08)	(8.78e-08)
PPI	0.00351***	0.00351***	0.00166***
	(0.000378)	(0.000545)	(0.000573)
Landholdings	0.000228	0.000228	0.000631**
	(0.000353)	(0.000267)	(0.000272)
Constant	-0.0484***	-0.0484***	-0.0636**
	(0.0155)	(0.0168)	(0.0254)
Observations	4,321	4,321	4,321
R-squared	0.022	0.022	0.125
Fixed Effect	None	None	Farmer Group
Cluster	None	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Inorganic Fertilizer	(2) Value Inorganic Fertilizer	(3) Value Inorganic Fertilizer
Customary*Predicted Rental Price	-1.40e-06	-1.40e-06	-2.24e-06***
	(1.39e-06)	(1.83e-06)	(2.87e-07)
Freehold*Predicted Rental Price	-1.40e-06	-1.40e-06	-1.02e-06**
	(1.32e-06)	(1.30e-06)	(4.14e-07)
PPI	0.104***	0.104*	0.0796***
	(0.0189)	(0.0580)	(0.00249)
Landholdings	-0.0692*	-0.0692	-0.0117*
	(0.0401)	(0.0467)	(0.00647)
Constant	-13.26***	-13.26*	-37.03***
	(1.068)	(6.920)	(0.127)
Observations	4,325	4,325	4,325
Fixed Effect	None	None	Farmer Group
Cluster	None	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Pesticides

VARIABLES	(1) Used Pesticides	(2) Used Pesticides	(3) Used Pesticides
Customary*Predicted Rental Price	3.72e-08	3.72e-08	-1.20e-07
	(3.75e-08)	(7.35e-08)	(8.17e-08)
Freehold*Predicted Rental Price	2.84e-07***	2.84e-07***	3.15e-08
	(3.51e-08)	(7.63e-08)	(8.55e-08)
PPI	0.00565***	0.00565***	0.00237***
	(0.000446)	(0.000826)	(0.000734)
Landholdings	0.000761*	0.000761	0.000721
	(0.000416)	(0.000529)	(0.000443)
Constant	-0.120***	-0.120***	-0.0939***
	(0.0183)	(0.0215)	(0.0317)
Observations	4,318	4,318	4,318
R-squared	0.065	0.065	0.189
Fixed Effect	None	None	Farmer Group
Cluster	None	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Pesticide	(2) Value Pesticide	(3) Value Pesticide
Customary*Predicted Rental Price	2.86e-06***	2.86e-06	-9.60e-08
	(5.63e-07)	(2.89e-06)	(2.32e-07)
Freehold*Predicted Rental Price	3.53e-06***	3.53e-06*	-7.70e-07***
	(4.93e-07)	(1.93e-06)	(3.62e-08)
PPI	0.0926***	0.0926***	0.0482***
	(0.00985)	(0.0352)	(0.00131)
Landholdings	0.00401	0.00401	0.0172***
	(0.00964)	(0.00900)	(0.00389)
Constant	-9.229***	-9.229**	-22.38***
	(0.536)	(3.688)	(0.0731)
Observations	4,325	4,325	4,325
Fixed Effect	None	None	Farmer Group
Cluster	None	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Parish Fixed Effects

Tenure Insecurity

VARIABLES	(1) Insecurity	(2) Insecurity	(3) Insecurity	(4) Insecurity
Customary*Rental Price	0.203***		0.165***	
	(0.0183)		(0.0135)	
Freehold*Rental Price	0.357		-0.408	
	(0.215)		(0.375)	
Customary*Urbanization		0.123***		0.0870
		(0.0418)		(0.0768)
Freehold*Urbanization		0.0220		-0.0215
		(0.0399)		(0.0587)
PPI	0.000678	0.000378	0.000860	0.000268
	(0.000825)	(0.000958)	(0.000989)	(0.00113)
Landholdings	-0.00139**	-0.00145*	-0.00114	-0.00109
	(0.000673)	(0.000775)	(0.000692)	(0.000734)
Constant	1.180***	1.138***	1.026***	1.000***
	(0.0370)	(0.0465)	(0.0233)	(0.0254)
Observations	4,317	4,315	4,317	4,315
R-squared	0.018	0.009	0.061	0.056
Fixed Effect	None	None	Parish	Parish
Cluster	Parish	Parish	Parish	Parish

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Trees

VARIABLES	(1) Trees	(2) Trees	(3) Trees	(4) Trees
Customary*Rental Price	-0.0211		-0.0474***	
	(0.0411)		(0.00388)	
Freehold*Rental Price	1.978***		0.184	
	(0.330)		(0.238)	
Customary*Urbanization		0.101		-0.0143
		(0.0695)		(0.0632)
Freehold*Urbanization		0.143**		0.00749
		(0.0701)		(0.0610)
PPI	-0.00301**	-0.00462***	-0.000445	-0.000245
	(0.00131)	(0.00155)	(0.00115)	(0.00120)
Landholdings	-0.000356	-0.000245	-0.000770	-0.000788
	(0.000528)	(0.000626)	(0.000507)	(0.000499)
Constant	0.802***	0.749***	1.002***	1.009***
	(0.0673)	(0.105)	(0.0248)	(0.0265)
Observations	4,272	4,270	4,272	4,270
R-squared	0.067	0.018	0.183	0.183
Fixed Effect	None	None	Parish	Parish
Cluster	Parish	Parish	Parish	Parish

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Organic Fertilizer

VARIABLES	(1) Used Organic	(2) Used Organic	(3) Used Organic	(4) Used Organic
Customary*Rental Price	0.0259		-0.00307***	
	(0.0265)		(0.000872)	
Freehold*Rental Price	0.516**		-0.0483	
	(0.216)		(0.0667)	
Customary*Urbanization		-0.0104		-0.0567*
		(0.0253)		(0.0334)
Freehold*Urbanization		0.115**		-0.0152
		(0.0499)		(0.0240)
PPI	0.00640***	0.00553***	0.00133***	0.00146***
	(0.00142)	(0.00121)	(0.000471)	(0.000500)
Landholdings	0.000581	0.000671	0.000402	0.000407
	(0.000454)	(0.000480)	(0.000379)	(0.000381)
Constant	-0.118***	-0.138***	-0.0316***	-0.0337***
	(0.0257)	(0.0304)	(0.00967)	(0.0105)
Observations	4,271	4,269	4,271	4,269
R-squared	0.063	0.083	0.250	0.252
Fixed Effect	None	None	Parish	Parish
Cluster	Parish	Parish	Parish	Parish

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Organic	(2) Value Organic	(3) Value Organic	(4) Value Organic
Customary*Rental Price	0.709*		-4.164***	
	(0.421)		(0.689)	
Freehold*Rental Price	13.00		1.243**	
	(8.270)		(0.632)	
Customary*Urbanization		0.0387		-2.031***
		(1.090)		(0.162)
Freehold*Urbanization		2.881		-1.140***
		(2.085)		(0.0524)
PPI	0.237**	0.225**	0.140***	0.145***
	(0.103)	(0.0940)	(0.00208)	(0.00176)
Landholdings	0.0268	0.0292	0.0833***	0.0857***
	(0.0170)	(0.0212)	(0.00561)	(0.00504)
Constant	-20.45**	-21.80**	-42.10***	-41.43***
	(8.282)	(9.361)	(0.114)	(0.0996)
Observations	4,273	4,271	4,273	4,271
Fixed Effect	None	None	Parish	Parish
Cluster	Parish	Parish	Parish	Parish

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Inorganic Fertilizer

VARIABLES	(1) Used Inorganic	(2) Used Inorganic	(3) Used Inorganic	(4) Used Inorganic
Customary*Rental Price	0.0239		-0.00664***	
	(0.0224)		(0.00178)	
Freehold*Rental Price	0.478***		0.0202	
	(0.0628)		(0.129)	
Customary*Urbanization		0.0395		-0.0157
		(0.0251)		(0.0148)
Freehold*Urbanization		0.0553**		-0.00633
		(0.0239)		(0.0212)
PPI	0.00334***	0.00275***	0.00205***	0.00206***
	(0.000392)	(0.000616)	(0.000552)	(0.000560)
Landholdings	0.000343	0.000408	0.000634**	0.000633**
	(0.000314)	(0.000278)	(0.000315)	(0.000311)
Constant	-0.0336***	-0.0522***	-0.0494***	-0.0479***
	(0.00981)	(0.00999)	(0.0125)	(0.0129)
Observations	4,269	4,267	4,269	4,267
R-squared	0.031	0.025	0.068	0.068
Fixed Effect	None	None	Parish	Parish
Cluster	Parish	Parish	Parish	Parish

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Inorganic	(2) Value Inorganic	(3) Value Inorganic	(4) Value Inorganic
Customary*Rental Price	0.0555		-0.137***	
	(0.0451)		(0.0248)	
Freehold*Rental Price	1.479*		0.224***	
	(0.795)		(0.00180)	
Customary*Urbanization		0.232*		0.0151**
		(0.122)		(0.00727)
Freehold*Urbanization		0.220*		0.0514***
		(0.124)		(0.00709)
PPI	0.0102**	0.00852*	0.00807***	0.00797***
	(0.00470)	(0.00460)	(0.000163)	(0.000137)
Landholdings	-0.00760	-0.00663	-0.000572	-0.000658**
	(0.00511)	(0.00488)	(0.000357)	(0.000314)
Constant	-1.418**	-1.548***	-3.995***	-3.958***
	(0.553)	(0.595)	(0.00815)	(0.00693)
Observations	4,273	4,271	4,273	4,271
Fixed Effect	None	None	Parish	Parish
Cluster	Parish	Parish	Parish	Parish

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Pesticides

VARIABLES	(1) Used Pesticides	(2) Used Pesticides	(3) Used Pesticides	(4) Used Pesticides
Customary*Rental Price	0.0293		-0.0102***	
	(0.0276)		(0.00165)	
Freehold*Rental Price	0.691***		0.0119	
	(0.144)		(0.0639)	
Customary*Urbanization		0.0337		0.00848
		(0.0291)		(0.0228)
Freehold*Urbanization		0.122***		0.0494
		(0.0398)		(0.0424)
PPI	0.00625***	0.00513***	0.00238***	0.00255***
	(0.00118)	(0.00113)	(0.000811)	(0.000906)
Landholdings	0.000832	0.000983	0.000858	0.000852
	(0.000595)	(0.000610)	(0.000515)	(0.000510)
Constant	-0.0964***	-0.125***	-0.0583***	-0.0598***
	(0.0270)	(0.0341)	(0.0182)	(0.0205)
Observations	4,266	4,264	4,266	4,264
R-squared	0.062	0.068	0.153	0.155
Fixed Effect	None	None	Parish	Parish
Cluster	Parish	Parish	Parish	Parish

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Pesticides	(2) Value Pesticides	(3) Value Pesticides	(4) Value Pesticides
Customary*Rental Price	0.413***		-1.361***	
	(0.121)		(0.462)	
Freehold*Rental Price	10.72***		-1.633***	
	(2.163)		(0.413)	
Customary*Urbanization		0.0608		-1.001***
		(0.573)		(0.122)
Freehold*Urbanization		1.490***		-0.196***
		(0.529)		(0.0407)
PPI	0.0937**	0.0842**	0.0364***	0.0393***
	(0.0408)	(0.0399)	(0.00151)	(0.00102)
Landholdings	0.00436	0.00354	0.0145***	0.0139***
	(0.00747)	(0.00763)	(0.00329)	(0.00238)
Constant	-8.388**	-8.905**	-21.82***	-21.54***
	(3.887)	(4.011)	(0.0800)	(0.0589)
Observations	4,273	4,271	4,273	4,271
Fixed Effect	None	None	Parish	Parish
Cluster	Parish	Parish	Parish	Parish h

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Crop Change

Tenure Insecurity

VARIABLES	(1) Insecurity	(2) Insecurity	(3) Insecurity	(4) Insecurity	(5) Insecurity	(6) Insecurity
Customary*Rental Price	0.204***		0.204***		0.151***	
	(0.0252)		(0.0172)		(0.0134)	
Freehold*Rental Price	0.373***		0.373*		-0.554*	
	(0.144)		(0.206)		(0.288)	
Customary*Urbanization		0.122***		0.122**		0.0575
		(0.0249)		(0.0487)		(0.119)
Freehold*Urbanization		0.0199		0.0199		-0.0362
		(0.0228)		(0.0355)		(0.108)
PPI	0.000893	0.000534	0.000893	0.000534	-7.43e-05	-0.000487
	(0.000730)	(0.000784)	(0.000967)	(0.00113)	(0.00129)	(0.00134)
Landholdings	-0.00138**	-0.00141**	-0.00138**	-0.00141**	-0.00102*	-0.000879
	(0.000687)	(0.000693)	(0.000604)	(0.000640)	(0.000580)	(0.000592)
Cash Crops	-0.0343*	-0.0155	-0.0343	-0.0155	-0.0170	-0.0157
	(0.0199)	(0.0202)	(0.0229)	(0.0221)	(0.0311)	(0.0319)
Constant	1.184***	1.138***	1.184***	1.138***	1.019***	1.081***
	(0.0298)	(0.0300)	(0.0398)	(0.0415)	(0.0614)	(0.0856)
Observations	4,305	4,258	4,305	4,258	4,305	4,258
R-squared	0.019	0.010	0.019	0.010	0.118	0.109
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Trees

VARIABLES	(1) Trees	(2) Trees	(3) Trees	(4) Trees	(5) Trees	(6) Trees
Customary*Rental Price	-0.0216		-0.0216		-0.0399***	
	(0.0209)		(0.0309)		(0.00606)	
Freehold*Rental Price	1.918***		1.918***		0.299	
	(0.119)		(0.309)		(0.222)	
Customary*Urbanization		0.102***		0.102*		0.0432
		(0.0211)		(0.0561)		(0.0957)
Freehold*Urbanization		0.130***		0.130**		0.0648
		(0.0193)		(0.0517)		(0.0972)
PPI	-0.00329***	-0.00518***	-0.00329***	-0.00518***	0.000333	0.000323
	(0.000604)	(0.000664)	(0.00111)	(0.00131)	(0.00109)	(0.00110)
Landholdings	-0.000498	-0.000450	-0.000498	-0.000450	-0.000896*	-0.000933**
	(0.000569)	(0.000588)	(0.000558)	(0.000583)	(0.000467)	(0.000465)
Cash Crops	0.0725***	0.0898***	0.0725***	0.0898***	0.0942***	0.0949***
	(0.0165)	(0.0171)	(0.0253)	(0.0261)	(0.0280)	(0.0276)
Constant	0.795***	0.754***	0.795***	0.754***	0.211***	0.150**
	(0.0246)	(0.0254)	(0.0498)	(0.0689)	(0.0485)	(0.0737)
Observations	4,322	4,270	4,322	4,270	4,322	4,270
R-squared	0.070	0.025	0.070	0.025	0.258	0.260
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Organic Fertilizer

VARIABLES	(1) Used Organic	(2) Used Organic	(3) Used Organic	(4) Used Organic	(5) Used Organic	(6) Used Organic
Customary*Rental Price	0.0221		0.0221		-0.00801***	
	(0.0141)		(0.0175)		(0.00111)	
Freehold*Rental Price	0.350***		0.350***		-0.0150	
	(0.0804)		(0.0977)		(0.0548)	
Customary*Urbanization		-0.00877		-0.00877		-0.0334
		(0.0137)		(0.0200)		(0.0416)
Freehold*urbanization		0.0860***		0.0860***		0.00610
		(0.0125)		(0.0248)		(0.0402)
PPI	0.00500***	0.00431***	0.00500***	0.00431***	0.00117**	0.00115**
	(0.000407)	(0.000432)	(0.000650)	(0.000654)	(0.000543)	(0.000505)
Landholdings	0.000114	0.000222	0.000114	0.000222	0.000349	0.000323
	(0.000384)	(0.000382)	(0.000301)	(0.000302)	(0.000271)	(0.000260)
Cash Crops	0.203***	0.196***	0.203***	0.196***	0.0403*	0.0387
	(0.0111)	(0.0111)	(0.0238)	(0.0242)	(0.0234)	(0.0241)
Constant	-0.113***	-0.126***	-0.113***	-0.126***	-0.0557**	-0.0461
	(0.0166)	(0.0165)	(0.0190)	(0.0208)	(0.0225)	(0.0285)
Observations	4,321	4,269	4,321	4,269	4,321	4,269
R-squared	0.132	0.145	0.132	0.145	0.286	0.291
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Organic	(2) Value Organic	(3) Value Organic	(4) Value Organic	(5) Value Organic	(6) Value Organic
Customary*Rental Price	0.655		0.655*		-13.10***	
	(0.544)		(0.394)		(0.510)	
Freehold*Rental Price	9.321**		9.321		-0.211	
	(3.967)		(6.736)		(0.551)	
Customary*Urbanization		-0.128		-0.128		-2.999***
		(0.785)		(1.012)		(0.252)
Freehold*Urbanization		2.086***		2.086		-1.699***
		(0.660)		(1.363)		(0.0634)
PPI	0.214***	0.204***	0.214**	0.204**	0.143***	0.149***
	(0.0260)	(0.0270)	(0.0992)	(0.0950)	(0.00279)	(0.00253)
Landholdings	0.0173	0.0185	0.0173	0.0185	0.0630***	0.0598***
	(0.0209)	(0.0221)	(0.0187)	(0.0205)	(0.00850)	(0.00740)
Cash Crops	3.546***	3.392***	3.546*	3.392*	0.740***	0.651***
	(0.459)	(0.476)	(1.832)	(1.803)	(0.0878)	(0.0705)
Constant	-20.68***	-21.67***	-20.68**	-21.67**	-41.99***	-41.83***
	(1.560)	(1.670)	(9.768)	(10.47)	(0.155)	(0.142)
Observations	4,323	4,271	4,323	4,271	4,323	4,271
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Inorganic Fertilizer

VARIABLES	(1) Used Inorganic	(2) Used Inorganic	(3) Used Inorganic	(4) Used Inorganic	(5) Used Inorganic	(6) Used Inorganic
Customary*Rental Price	0.0236*		0.0236		0.00385*	
	(0.0129)		(0.0230)		(0.00231)	
Freehold*Rental Price	0.479***		0.479***		0.0259	
	(0.0735)		(0.0639)		(0.120)	
Customary*Urbanization		0.0395***		0.0395**		-0.0112
		(0.0127)		(0.0197)		(0.0456)
Freehold*Urbanization		0.0537***		0.0537***		-0.00653
		(0.0116)		(0.0176)		(0.0448)
PPI	0.00346***	0.00268***	0.00346***	0.00268***	0.00172***	0.00144**
	(0.000373)	(0.000399)	(0.000490)	(0.000589)	(0.000573)	(0.000560)
Landholdings	0.000344	0.000383	0.000344	0.000383	0.000626**	0.000605**
	(0.000352)	(0.000353)	(0.000281)	(0.000257)	(0.000273)	(0.000271)
Cash Crops	0.00833	0.0110	0.00833	0.0110	0.0140	0.00974
	(0.0102)	(0.0103)	(0.0141)	(0.0135)	(0.0128)	(0.0128)
Constant	-0.0387**	-0.0515***	-0.0387**	-0.0515***	-0.0710***	-0.0573*
	(0.0152)	(0.0153)	(0.0170)	(0.0156)	(0.0255)	(0.0313)
Observations	4,319	4,267	4,319	4,267	4,319	4,267
R-squared	0.033	0.026	0.033	0.026	0.126	0.123
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Inorganic	(2) Value Inorganic	(3) Value Inorganic	(4) Value Inorganic	(5) Value Inorganic	(6) Value Inorganic
Customary*Rental Price	0.518		0.518		1.552***	
	(0.399)		(0.419)		(0.294)	
Freehold*Rental Price	13.44***		13.44*		1.135***	
	(3.495)		(7.947)		(0.0875)	
Customary*Urbanization		0.233***		0.233**		0.0282***
		(0.0688)		(0.105)		(0.00775)
Freehold*Urbanization		0.232***		0.232**		0.0430***
		(0.0651)		(0.102)		(0.00716)
PPI	0.101***	0.00887***	0.101*	0.00887**	0.0862***	0.00699***
	(0.0191)	(0.00216)	(0.0559)	(0.00450)	(0.00294)	(0.000134)
Landholdings	-0.0598	-0.00589	-0.0598	-0.00589	-0.0134*	-0.00277***
	(0.0404)	(0.00448)	(0.0450)	(0.00423)	(0.00783)	(0.000420)
Cash Crops	-0.259	-0.0636	-0.259	-0.0636	1.464***	-0.0160***
	(0.446)	(0.0505)	(0.405)	(0.0578)	(0.0913)	(0.00521)
Constant	-13.39***	-1.556***	-13.39*	-1.556***	-37.21***	-3.965***
	(1.066)	(0.132)	(6.989)	(0.561)	(0.147)	(0.00692)
Observations	4,323	4,271	4,323	4,271	4,323	4,271
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Pesticides

VARIABLES	(1) Used Pesticides	(2) Used Pesticides	(3) Used Pesticides	(4) Used Pesticides	(5) Used Pesticides	(6) Used Pesticides
Customary*Rental Price	0.0267*		0.0267		-0.0230***	
	(0.0150)		(0.0228)		(0.00190)	
Freehold*Rental Price	0.574***		0.574***		-0.00515	
	(0.0858)		(0.0944)		(0.0647)	
Customary*Urbanization		0.0350**		0.0350		0.0301
		(0.0147)		(0.0214)		(0.0517)
Freehold*Urbanization		0.100***		0.100***		0.0747
		(0.0135)		(0.0221)		(0.0515)
PPI	0.00530***	0.00422***	0.00530***	0.00422***	0.00232***	0.00226***
	(0.000436)	(0.000465)	(0.000534)	(0.000624)	(0.000733)	(0.000710)
Landholdings	0.000492	0.000650	0.000492	0.000650	0.000684*	0.000658*
	(0.000410)	(0.000411)	(0.000434)	(0.000462)	(0.000403)	(0.000393)
Cash Crops	0.146***	0.146***	0.146***	0.146***	0.0727***	0.0750***
	(0.0119)	(0.0120)	(0.0202)	(0.0190)	(0.0171)	(0.0174)
Constant	-0.0951***	-0.116***	-0.0951***	-0.116***	-0.107***	-0.135***
	(0.0178)	(0.0178)	(0.0187)	(0.0215)	(0.0301)	(0.0432)
Observations	4,316	4,264	4,316	4,264	4,316	4,264
R-squared	0.096	0.100	0.096	0.100	0.191	0.194
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) Value Pesticides	(2) Value Pesticides	(3) Value Pesticides	(4) Value Pesticides	(5) Value Pesticides	(6) Value Pesticides
Customary*Rental Price	0.410*		0.410***		-3.013***	
	(0.222)		(0.0801)		(0.393)	
Freehold*Rental Price	9.217***		9.217*		-1.666***	
	(2.027)		(5.474)		(0.239)	
Customary*Urbanization		0.0347		0.0347		-0.0394
		(0.309)		(0.525)		(0.0981)
Freehold*Urbanization		1.113***		1.113***		0.835***
		(0.272)		(0.371)		(0.0427)
PPI	0.0847***	0.0720***	0.0847**	0.0720**	0.0475***	0.0422***
	(0.0100)	(0.0101)	(0.0338)	(0.0363)	(0.00132)	(0.00118)
Landholdings	-0.00428	-0.00557	-0.00428	-0.00557	0.0112***	0.00604
	(0.0123)	(0.0126)	(0.0128)	(0.0138)	(0.00435)	(0.00406)
Cash Crops	1.781***	1.712***	1.781***	1.712**	0.838***	0.816***
	(0.208)	(0.206)	(0.627)	(0.698)	(0.0200)	(0.0143)
Constant	-8.770***	-8.758***	-8.770**	-8.758**	-22.51***	-21.33***
	(0.538)	(0.552)	(3.477)	(3.767)	(0.0712)	(0.0666)
Observations	4,323	4,271	4,323	4,271	4,323	4,271
Fixed Effect	None	None	None	None	Farmer Group	Farmer Group
Cluster	None	None	Farmer Group	Farmer Group	Farmer Group	Farmer Group

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 3

Markets and Child Nutrition in Rural Burkina Faso

Laura Meinzen-Dick and Stephen A. Vosti

3.1 Introduction

Early childhood nutrition has been identified consistently as one of the most crucial leverage points for improving adult outcomes. There is a wealth of evidence that children who receive better nutrition in the first thousand days of life have higher human capital accumulation and better labor market outcomes, and this has been identified as one mechanism for inter-generational poverty traps. It is less clear how early childhood nutrition can be improved at scale, however. Around the world, it seems that places with better markets seem to have better nutrition, although we lack substantial micro-level confirmation of this. There also is an intuitive pathway for this correlation: markets are where people buy food for themselves and their children, and, in particular, they provide dietary diversity even in rural agricultural areas that focus on staple production. In the food policy sphere, there is also an increasing focus on looking at broader 'food systems' in order to capture the complex web of relationships between value chains and the availability and consumption of healthy food by entire populations (de Brauw et al., 2019); this has not yet been matched by quality data on the food environments faced by consumers.

In this paper, we explore the empirical relationship between local markets and the nutritional status of young children in rural Burkina Faso. We use a unique set of data collected in rural village markets, including complete censuses of shops and weekly open-air market vendors as well as product listings for a sample of retailers, which allows us to capture many rarely-measured aspects of these markets. By pairing

this with biometric measurements of nine-month-old children served by these markets, we are able to examine important correlations and probe whether consumer 'market access' really matters for well-being.

We use a cross-section of biometric markers of children measured at the baseline of a clinical field trial for a Small-Quantity Lipid Nutrient Supplement (SQ-LNS) product as well as detailed measures of the markets that serve their families, covering breadth, depth, and concentration. Although our empirical work only documents correlations, we trace out a conceptual impact pathway to show the multifaceted relationships between markets, nutritional outcomes, and a multitude of other factors. After documenting broad features of the markets in question, we use dimension reduction methods to create an index of market sophistication (as well as individual indices for broad theoretical dimensions of markets). We do find a weak positive relationship between the sophistication of a market and the nutritional outcomes of the children it serves, with patterns generally following what the conceptual pathway would predict. Although markets have small predictive power for the nutritional outcomes of children, they are more important for more responsive measures of nutrition (such as weight-for-length rather than length-for-age) and explain more of the variation than village fixed effects can. Market breadth, capturing the variety of products available in the market, seems to be more important than depth (the extent to which products are available from multiple retailers) or concentration (the dominance of a few retailers in the market), again consistent with the conceptual pathway.

Given these broad patterns of correlation between market sophistication and nutritional outcomes, we then explore what particular features of the market seem to matter most. After looking at theoretically selected variables, we use a Lasso algorithm to select particular market variables that are predictive of short-term nutritional outcomes. Here, the size and dynamism of local markets seem particularly important.

From a public-welfare perspective, however, the average child's nutritional status is not the only concern. The children in the extreme left tail of the distribution, the very smallest (lowest weight-for-age or weight-for-length), are of particular concern.[1] We therefore turn to the distribution of nutritional outcomes near markets of varying sophistication. We are limited in the quantitative techniques we can use by the structure of the market data, but a visual inspection of the distributional outcome suggests that the mean effects of better markets documented in regressions may not hold for the very smallest children. In fact, these most-deprived children in a given market seem to be equally left out of markets of any level of sophistication. This implies a strong rationale for not simply relying on economic growth and market development to 'lift all boats:' some children are clearly being left behind. Instead, public health investments must be made in these rural areas and targeted in particular at these children who seem to be found in all communities.

This paper makes among the first steps towards filling a crucial empirical gap in understanding rural

[1] This is particularly true given the extreme non-linearities between nutrition and other health and productivity outcomes.

lives and well-being in developing countries. Despite the importance of rural consumer markets in Africa, we know remarkably little about their size, functioning, or what products they carry. Scholars and policymakers of transforming food systems have highlighted the scarcity of quality data on the food environments where consumers get their food (McDermott and de Brauw, 2020; Global Panel, 2017), and we seek to begin to address that gap. We use a rich novel dataset with detailed information about markets, retailers, and products in rural markets in Burkina Faso near children participating in a field trial of SQ-LNS products.

We also begin to document the importance of the quality of rural markets for consumer welfare in Africa. In particular, we document a relationship between measures of market quality and the nutritional outcomes of young children. Given the weak correlation we show, it seems all the more important to study those relationships with a stronger theoretical link, such as between markets and dietary diversity and among older children and adults who are likely to consume foods from the markets.

Finally, this paper opens up avenues for further policy-relevant research. We document the importance of the breadth and size of markets for nutritional outcomes, suggesting another domain of potential impacts for market-based interventions. Policies to improve the availability of healthy, non-staple foods, and particularly nutritionally important ones such as dairy products and targeted nutritional supplements, seem likely to improve health and well-being. Our findings also suggest that market-based policies may not work for all individuals; investments in public health and programs targeted at the very-smallest children are crucial complements, as these people may be left out of market-driven progress. In evaluating nutritional impacts, it is vital to pay attention to the distribution of individuals and effects from the design of studies through to policy recommendations.

3.2 Motivation

In recent years, global policymakers have begun to emphasize the first one thousand days of life as key to later outcomes (Lutter et al., 2013). Particularly in developing country contexts such as Burkina Faso, nutrition decisions made in this crucial early period can have long-term ramifications and have been posited as one cause of poverty traps. That is, poor nutrition for children is not only a symptom of household poverty, but also a mechanism for its inter-generational transmission. Hoddinott et al. (2013), in an economic framework, trace the pathways by which stunting, one key measure of early childhood undernutrition, can affect later human capital and thereby economic outcomes, and they estimate that preventing even one fifth of stunting can increase per capita incomes by 11%. This implies extremely favorable cost-benefit ratios between 3.6 and 48 for nutrition interventions early in life. Early childhood stunting can, most obviously, affect the physical status of adults, such as reducing realized heights (Stein et al., 2010). While this embodied physical

capital is immediately important for work that requires physical labor, even nonphysical labor can see labor market penalties for shorter adults, as documented by Schultz (2003). The lack of proper nutrition during crucial periods of brain plasticity and development can also harm cognitive skills. Kar et al. (2008) document lower test scores for children who are undernourished at earlier stages, and there are a plethora of medical and nutritional studies exploring pathways of damage to key parts of the brain. Impaired cognitive ability has clear implications for earnings in almost every occupation (Behrman et al., 2009). There is also somewhat controversial emerging evidence suggesting that early childhood malnutrition can lead to higher risk of chronic disease (such as obesity or cardiovascular disease) (Victora et al., 2008), which have immediate economic implications both in the costs of treatment and of foregone employment. And finally, there is evidence that socio-emotional skills and executive function are developed very early in life, and poor nutrition may damage their development. The economic impacts of this pathway are diffuse but pernicious, as poor executive function can prevent individuals from making choices later in life that would substitute for their earlier shortfall. This is another key feature of Hoddinott et al. (2013)'s model, where they have multiple stages of life, and economic outcomes are not determined solely by the first thousand days. Instead, later individual and public policy decisions can either complement or substitute dynamically for those made earlier, and this in turn could ameliorate earlier problems or reinforce harmful patterns.

It is clear, then, that early childhood nutrition has crucial economic implications later in life. It also seems intuitive that the economic conditions of the (local) world into which a child is born will affect their nutrition early in life, an idea that is is at the heart of nutrition-based multi-generational poverty traps. Indeed, there seems to be broad evidence that wealthier and faster-growing countries do have better nutritional outcomes for children (Smith and Haddad, 2002), which can be pithily summarized as "wealthier is healthier." Smith and Haddad try to parse out the degree to which this relationship is causal, with a particular focus on the distribution of growth and thus the extent to which we might expect growth to improve the purchasing ability of the parents of those children at most risk of undernutrition. On a more micro level, however, there is very little research looking at specific features of markets and how they relate to child nutritional outcomes. Some policy-focused discussion of food deserts in the US has implicitly understood the characteristics of local markets to be important for nutrition, but the data is often of too poor quality to undertake more rigorous analysis (Bitler and Haider, 2009). Our rich dataset, encompassing a complete enumeration of every shop and vendor in open-air markets for 34 villages in the Dande Health Catchment Area of Burkina Faso, as well as detailed product-level data for a sample of these retailers, allows us to undertake one of the first explorations of the relationships between rural market conditions and early childhood measures of mal- and under-nutrition.

This paper is situated at the crossroads of two exciting areas of inquiry for those interested in dimensions

of poverty beyond income. However, it is striking how sparse the literature in this intersection is.

The first, and perhaps the less well-developed of the two, begins to consider the social implications of market development. Throughout much of the developing world, there has been a rapid expansion of consumer markets. This has been described as integrating the 'last mile' into the global supply chain. However, the scholarship on this phenomenon has been focused primarily on the supply side, looking at integrating rural (agricultural) producers into supply chains (Barrett, 2007). There has been remarkably little examination of the implications for rural inhabitants as consumers, and often-used proxies for market access rarely capture the quality of available markets. One important exception is a recent paper by **?**, who examine variation in rural consumer markets and find that market characteristics, particularly a greater diversity of available non-staple foods, is significantly related to higher dietary diversity among children, although this effect is small.[2] More often, there are studies on the importance of markets for rural livelihoods, with policies designed to improve markets advocated for by (among others) the World Bank (Barrett et al., 2017)[3]. However, much of this literature has focused on rural areas as producers to be integrated into supply chains (Reardon, 2015), rather than considering rural households as consumers with welfare implications of improved access to markets. One key component of welfare is human nutrition, particularly in early stages of life, and this is our entrance to the broader understudied question. In this paper we begin to address this gap and, importantly, look beyond consumption as an end in itself to the long-term well-being of newly market-integrated households and communities. Markets shape more than just consumption; they can have transformative effects on community social relationships as well as on a multitude of realms (such as nutrition) affected by consumption.

The second, and more robust (both within and beyond economics) literature, focuses on the importance of early childhood nutrition. The first one thousand days of life, from conception to age 2, have been identified in particular as key to physical and cognitive development (Hoddinott et al., 2013). The outsize importance of these early stages of development contribute to the incredibly high returns on investment for interventions targeted at infants, particularly when increased lifespans and improved lifetime earnings are considered. But much as the literature on markets has not considered nutrition as an important outcome, empirical work focusing on early childhood nutrition has largely ignored markets. However, we can understand markets to be an important mechanism or means for the complementary (to breastfeeding) foods which nutritionists have identified as important for diverse diets and robust development, and which are surprisingly resistant to change (Hemsworth et al., 2016). The lack of progress seen in field trials in Malawi encouraging parents to

[2]The measure used in that paper only captures nutritional 'inputs', while in the current paper we measure 'outcomes': that is, weight-for-length or age z-scores. Another feature of their paper is the relationship between household agricultural production and markets; they find that some substitution occurs.

[3]Some of these market interventions (as distinguished from market-based interventions with other ends) include rural electrification, transport infrastructure, and telecommunications networks (UNCTAD, 2015).

feed their children more or better-quality complementary foods may seem puzzling, but sparse markets may be a crucial constraint on parents' ability to make these changes. This is despite evidence from Chad that better-quality complementary foods improve linear growth as well as reduce anemia and morbidity (Dewey and Arim, 2012). The current paper seeks to uncover if a better understanding of the market context can begin to flesh out the constraints rural families face in meeting their nutritional needs.

3.3 Conceptual Impact Pathway

It is perhaps useful to consider diagrammatically how markets are potentially be related to key early-life nutritional outcomes. Figure 3.1 presents a highly simplified map of the mechanisms by which markets could influence measurable nutritional outcomes, along with some of the many mediating factors and other key components. As this diagram makes clear, consumed food is only one contributor to biometric outcomes, and therefore we should not expect strong relationships between market characteristics and nutritional outcomes if we cannot account for these other (more) important factors. This pathway does highlight, though, the important fact that most of the food people eat comes from markets, so policies aimed at improving nutrition should consider market-based interventions (**?**). Empirical questions emerge from close study of figure 3.1. It is clear that markets are pathways for nutrition, but what, precisely, does that mean? In particular, as the characteristics of markets evolve, how do the foods available to children change? At one extreme, even if policies improve market infrastructure, the goods available and purchased are entirely demand-driven, so the current poor nutrition for children will not improve without public-health interventions aimed at improving household knowledge of what young children need. In this paper, we seek to uncover if there are any structural aspects of markets that are strongly related to nutritional outcomes, as these could be powerful policy levers.

At the left of the diagram are what we consider underlying features of the community for the purposes of this analysis, although there are clearly important general equilibrium effects that determine them endogenously in turn. For instance, incomes in the community (on average) determine how much can be bought by the community, and the distribution of aggregate incomes can have important implications for the kinds of products purchased. There is extensive evidence from rich countries that consumption patterns differ across the income distribution, such as the share of income spent on food declining as income rises (USDA Economic Research Service, 2019). Community incomes, then, are key determinants of how many products, and what kinds of products, are available. We capture this using two dimensions of the market: breadth (what kinds of products are sold) and depth (at how many places they're available) (see companion paper Meinzen-Dick et al. (2017) for more detail and theoretical underpinning of these dimensions).

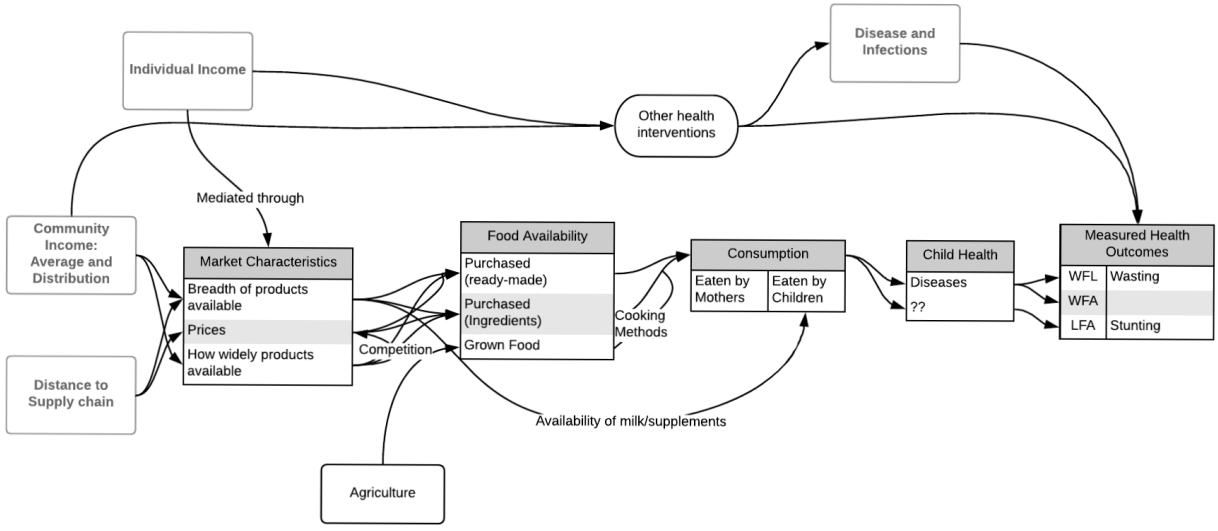


Figure 3.1: Impact Pathway between Markets and Nutrition

Incomes matter not only in the aggregate, however. An individual household's income matters for their welfare only insofar as it can purchase goods and services (a basic if often-ignored tenet of microeconomics). Therefore, the value of income is mediated through and determined by the market in which it is used. This underlines how crucial the prices of goods can be. Incomes are not the only factors determining prices; the physical location of the market is key in rural Burkina Faso. It is simply difficult to get many products to remote markets, particularly those far from paved roads. On the supply side, this problem of poor infrastructure and insurmountable distances has been addressed in getting agricultural products out of rural areas and into supply chains (Poulton et al., 2006), but the converse – of supplying to remote areas – is less well-understood by academics. For some products, this transport 'distance' is insurmountable and prevents them reaching remote markets at all; other products merely become substantially more expensive, but this limits the value of already limited incomes.

Beyond the purchasing power of individuals, the relationship between what is available in the market and food consumed by households is more complex than it may seem at first glance, if we are interested in thinking deeply about what, exactly, those markets look like and what food is actually being consumed by households. It is perhaps easier to begin with food, seen in the second of the two shaded boxes on the impact pathway diagram. Much of the region we consider is primarily agricultural, and thus families consume food they grow themselves. Although we do not focus on agriculture in this paper, it should be noted that markets can play an important role in the inputs used. Households primarily grow their own staples (nearly half of respondents listed their primary occupation as farmers, and 75% of those consuming

staples such as sorghum or maize had produced it themselves), which are combined with other ingredients produced at home or purchased off-farm. In addition to direct consumption of own farm (and garden) production, purchased foods are often available from local markets (which essentially allow local farmers to purchase from each other), or from local processors such as milling facilities. Thus, they are likely to be available in the most remote of markets, although there may be seasonality which we cannot examine with our single cross-section of data.[4] There also could be an important degree of price variability for any crops grown, either spatially or temporally. For these foods made at home, the cooking methods used have direct implications for nutritional bioavailability (how well bodies can retain nutrients). This is outside the scope of this paper, but it highlights the complexities in the translation from food in the market to nutritional outcomes. Finally, markets carry ready-made food, which, although likely only a small portion of diets, can be an important source of dietary diversity, including SQ-LNS products (Lybbert et al., 2016). Although tighter supply-chain control to improve consistency of prices is possible for some of these products, they are less likely to be available at all in extremely remote markets (Prahalad, 2004). Indeed, we find a negative correlation between the distance to a paved road and the number of products offered in shops in a village, indicating that some products are unable to reach more remote markets. This does have one troubling implication; namely, that existing market infrastructure may not be sufficient for the market-based distribution of public health products, such as SQ-LNS.

The next stage in translating food into nutrition requires thinking closely about consumption patterns within the household. Food is consumed by different members of the household, and that distribution is very important for childhood nutrition outcomes. For instance, do pregnant and lactating women receive the balance of nutrients they require from the food they consume? How soon are infants weaned, and onto what kinds of foods? For this latter question in particular, the availability in the market of appropriate weaning foods (such as dairy products and other nutritious foods aimed at children) is important.[5] Luckily, our dataset allows us to look at individual product availability, and we shall see that the availability of foods targeted at young children is an important predictor of their nutritional outcomes.

It is well beyond the ability of this paper to comment in detail on the complexities of human nutrition, but it is important to note as a caveat for our analysis that there is an important distinction between the food consumed by an individual and the bioavailability of the nutrients in that food. Furthermore, nutrients consumed play only a part in the health outcomes we measure – biometrics such as height and weight measures are affected equally (if not more so) by disease and infections (Victora et al., 2008). The impact

[4] **?** discuss programs to increase the diversity of products grown by farming households with the goal of improving dietary diversity, although effects have been weak.

[5] However, **?** find that local, even home production, of dairy products is more important for children's consumption than availability in commercial markets.

pathway in figure 3.1 highlights that these diseases are themselves (in part) a product of health interventions in the community (such as water, sanitation and hygiene programs), as well as incomes and the broader economic environment that shape the market. This is only to emphasize the immense complexity of the observable outcomes of nutrition, which is compounded further by the inherent distribution of heights and weights in the population.

Each of the three nutritional outcomes that we measure merits further explication. The World Health Organization has developed Child Growth Standards to measure and document infant and child growth compared to a growth standard (WHO, 2008; Preedy, 2012).[6] (Despite some variations in development patterns between ethnic groups, these are not considered significant enough when compared with the effect of environment to invalidate a single standard's use globally: across 6 countries, only 3% of the variation in growth patterns was explained by race or country.) Importantly, these standards take the form of normalized z-scores to allow comparison across ages and sexes, and cutoffs have been chosen to determine sub-normal growth as well as conditions such as severe acute malnutrition. (Z-scores are also an intuitive way of capturing extreme values.)

The survey we use collected data on three major biometric measures for children at baseline enrollment. The first, weight-for-(recumbent)-length (WFL), is the underlying parameter which determines wasting, defined as a WFL z-score of below -2 (that is, WFL less than two standard deviations below the standard of acceptable growth). Wasting is an indicator of (current) acute malnutrition (Preedy, 2012). This is the most short-term of our measures, as it is the most responsive to calories consumed in the recent past and can be affected by seasonal fluctuations in weight. Our rolling enrollment structure, where children were recruited at 9 months of age over a period of 11 months across all study sites, should smooth over some of this seasonality, and in some specifications we control for season-of-measurement dummies. The second measure is weight-for-age (WFA), which is considered less indicative of child growth and development than either of the other measures. Finally, we have standardized length for age (LFA) z-scores, which measure linear growth. Significant shortfalls in linear growth (z-scores below -2) are considered stunting and are indicative of long-term chronic malnutrition. However, this measure is influenced by genetics, very early in-utero nutrition, and infections and diseases that can harm growth plates. Therefore, although the SQ-LNS trial was aimed to reduce chronic malnutrition and thus was particularly concerned with LFA outcomes, we might expect market characteristics to be of little predictive value for LFA due to the importance of these confounding factors.

[6] Because we use the Child Growth Standards which imply a universal potential for growth, rather than a growth reference which simply gives a distribution for comparison, the bulk of our distributions are well below a z-score of zero, as children in rural Burkina Faso are being compared to wealthy children in other regions of the world (Preedy, 2012). These prescriptive charts were a change from the traditional approach taken by the WHO prior to 2006.

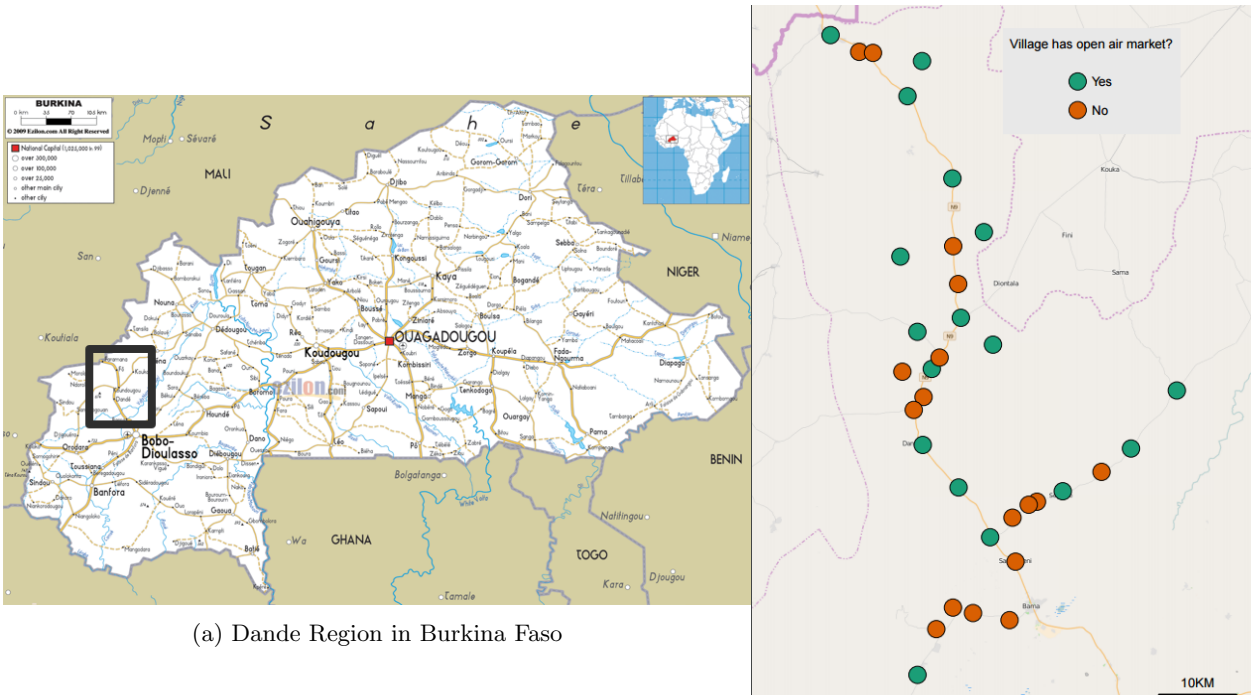
In Burkina Faso, both wasting and stunting are remarkably prevalent: in 2012, 32.9% of children under the age of 5 were stunted and 10.9% were wasted, when under normal circumstances only 2.3% of the population should fall below a z-score threshold of -2 (Ministere de la Sante et al., 2012). Although these anthropometric measures are recommended by the WHO and widely used by pediatric medical professionals, they are intended not as a sole diagnostic measure but instead as one component of a holistic "clinical impression" of the child (Preedy, 2012). Additionally, it is worth noting that these 'cut-points' of -2 are based on statistical properties of the (hypothesized) underlying normal distribution of children rather than their relationship to health risks (such as morbidity or mortality), but this relationship is still contested among experts due to its complexity, especially among young children (Preedy, 2012). However, these universal cut points are powerful mobilizers for the international community, and so we continue their use in this paper.

3.4 Context

The SQ-LNS trials were conducted in the Dande Health Catchment Area in Southwestern Burkina Faso (indicated in figure 3.2a), and nine-month-old children were recruited from periodic censuses of 34 village areas, shown in figure 3.2b.[7] These villages are all very rural, although as discussed in a companion paper, there is substantial variation in these markets. Some are located along a major road leading to the border with Mali, while others are some distance from this road; one village (Dande) is the location of the regional hospital and health center. Some have the infrastructure for weekly open-air markets that draw commerce from the surrounding areas, while others have as few as one shop. Our data, discussed in more detail later, allows us to capture some of the diversity of these small-scale markets. We explore this diversity in conjunction with detailed anthropometrics collected as part of the health intervention.

This randomized control trial was intended to measure the effectiveness of a small-quantity lipid nutrient supplement formulated to improve children's growth and development (although results from RCTs in home settings have been mixed) (Hess et al., 2015). This analysis uses only the baseline data, so the details of the intervention are less crucial, and the impact of the intervention is tangential. However, it is important to note how participants were selected. Communities were stratified on population size, distance from the main road and the largest regional city (Bobo-Dioulasso), and health district affiliation, then randomly selected into treatment and control communities. Within treatment communities, a rolling sample of nine-month-old

[7] During these censuses, children between 8.8 and 9.9 months of age were recruited if they met several baseline health criteria Hess et al. (2015). The 34 communities were stratified by population size, proximity to the road, and health clinic affiliation, and then randomly assigned to treatment (25 villages) or control (9). We use the anthropometric measurements (children's length, weight, mid-upper arm circumference, and head circumference) collected in all treatment and control conditions. In each community, enrollment continued until the target sample size was met (Arsenault et al., 2014).



(a) Dande Region in Burkina Faso

(b) Market and Village Locations

Figure 3.2: Study Location

children who met inclusion criteria were randomly assigned to one of four treatment types for the next 9 months, which varied on the nutritional content of the supplements. The rolling sample continued to enroll children for 11 months, and this seasonal dispersion should, on average, allow us to smooth over seasonal fluctuations in short-term anthropometric measures (such as weight-for-length), although we include season dummies to control for lean-season and post-harvest fluctuations.

3.5 Data

As mentioned in the introduction, there are very few existing detailed studies of consumer-facing rural African markets. Therefore, our data is somewhat novel in both its scope and level of detail. In each study site, enumerators conducted a census of all shops and open-air vendors, including periodic markets (weekly markets are an important feature of these rural areas), noting both the infrastructure of the retailer and the broad categories of products on offer. To do this, they used a list of 17 categories including fruits and vegetables, fish, packaged goods, prepared foods, meat, poultry, grains, clothing, and traditional medicines, to name a few. For a random sub-sample of retailers that had food available, they conducted a more detailed survey with the shopkeeper that asked about trends in the market over time and how they made decisions about their shop. For this sub-sample, enumerators catalogued every individual product available, as well as

brand, size, and price. These products could include, for example, sugar, cookies, matches, bottled water, oil, powdered milk, multivitamins, tomato paste, rice, soap, and airtime. Finally, enumerators conducted a qualitative interview with the "market master" who plays an administrative role in most open-air periodic markets.

Using this extensive raw data, we constructed variables that captured some characteristics of the market as a whole. Despite having access to this rich data, the relevant unit of analysis is the market itself, not individual shops and products. In the companion paper Meinzen-Dick et al. (2017), we discuss the justification for each measure in more depth, but we are interested in variables that describe the local market's breadth, depth, and concentration. Summary statistics for key variables are given in Table 3.1.

Breadth refers to the variety of products available in a market. Although most developed-country markets are so broad as to make these measures incomprehensible, rural Burkinabe markets are sparse enough that we can count the products meaningfully, and there is substantial variation in these measures. Breadth is an important intuitive measure of what the market is like for consumers – what are they able to find for purchase? Some of the particular variables constructed to give a sense of the breadth of these rural markets include the number of categories of goods available in the market (using the list of 17 categories from the vendor census), the number of distinct product types available in the shops surveyed, as well as the total number of product options (including duplicates of the same product offered by different retailers; for example, counting each retailer carrying powdered milk separately).

Consumers do not only care about whether or not a given product is available in their village: it also matters how widely the product is available within a village, or whether they must seek it out in one particular shop which may not be convenient. This dimension of the market is often termed depth, and in our data is summarized by variables such as the percentage of retailers in a market carrying a given category of interest, such as fruits and vegetables or packaged foods.

Finally, we create measures of the degree of concentration in a market. Although concentration does not have the immediate consumer relevance of the other two dimensions, many economic assumptions about the efficiencies of markets rest on deeper assumptions about the level of market concentration, and so these are important to look at. Additionally, although this analysis does not examine prices, market power can lead to monopolistic pricing, and as seen in the theoretical framework, prices are an important mediator for household welfare. Furthermore, market concentration can have important implications for market-based distribution strategies. If one or a few shops have captured a large share of the market, they are the most efficient inroads for a new product. Most standard concentration measures involve the share of sales in a given market; we cannot create these precisely, as we do not have sales records for individual retailers, but we approximate other kinds of concentration. For instance, we look at the percentage of total products

Variable	Mean	St. Dev.	Min	Max
Child-Level Variables (N=3461)				
Weight-for-age z-score (9 months)	-1.41	1.14	-6.13	2.13
Length/height-for-age z-score (9 months)	-1.21	1.10	-6.59	2.36
Weight-for-length/height z-score (9 months)	-0.98	1.04	-4.85	2.41
Stunted	1.00	0.048	0	1
Wasted	1.00	0.024	0	1
Household-Level Variables (N=3428)				
Household Income	336371.8	449934.7	0	7500000
Household Size	7.57	3.90	1	29
Asset Index	0.010	1.00	-1.98	3.20
Housing Index	0.0056	1.00	-1.67	3.51
Distance to Nearest Market (m)	1690.4	1807.6	24.8	6902.4
Village-Level Variables (N=34)				
2012 Population	2525.3	2580.8	319	12903
Total number households	357.4	371.2	58	1397
Average Number of People per Household	7.20	3.70	2.64	21.5
Distance to Paved Road (km)	5.41	6.93	0.092	29.1
Number of Categories Available	10.8	4.34	3	17
Average Number New Products Introduced	3.71	2.59	0.83	10.3
Percentage of Retailers with Fruits and Vegetables	0.17	0.15	0	0.50
Percentage of Retailers with Packaged Foods	0.52	0.35	0.099	1
Percentage of Retailers with Food	0.84	0.32	0.36	2.25
Market Sophistication Index	-0.31	4.98	-6.14	11.1
Open-Air Markets (N=17)				
Number of Open-Air Market Sellers	267.1	265.8	4	829
Sellers per 100 population	6.24	4.66	0.27	16.0
Percentage of Food-Only Open-Air Market Sellers	0.59	0.073	0.50	0.74
Percent of sellers with one category	0.72	0.065	0.57	0.78
Average number of categories available from sellers	1.44	0.16	1.31	1.85
Shops (N=34)				
Number of shops in village	18.0	27.2	2	115
Shops per 100 population	0.68	0.38	0.17	1.46
Percentage of food-only shops	0.61	0.28	0	1
Percent of shops with one category	0.24	0.20	0	0.54
Average number of categories available in shops	3.50	0.90	2.08	5.50
Average Shop Score	3.11	0.61	1.50	5
Dairy and Nutritional Supplements				
Number of Distinct Dairy Products Available	3.24	2.44	0	13
Total Number of Dairy Products Available	20.9	28.4	2	121
Number of Shops Carrying Dairy Products	7.47	8.99	0	39
Percentage of Shops Carrying Dairy Products	0.69	0.22	0	1

Table 3.1: Summary Statistics

available in the market offered by the 10% of retailers with the largest selection (looking both at distinct and total products, as delineated above). For more detail on the measures we use, please see the companion paper which delves more into these measures which (as we shall see) are perhaps more important to the supply side of markets than in how they impact consumers (Meinzen-Dick et al., 2017).

Our rich data on retailers in each village allows us to consider many dimensions of market sophistication, with several measures of each dimension. The companion paper demonstrates that although there are strong correlations between these measures (indicating that they are capturing some underlying features of the market) this correlation is not perfect, and it becomes unwieldy to simultaneously consider so many variables in thinking about the market (Meinzen-Dick et al., 2017). To this end, we created an index using principal component analysis to both identify underlying structural latent variables as well as summarize how sophisticated a village's market is using a single measure.

This index is constructed by weighting each normalized, appropriately signed factor by the factor loading so as to unambiguously have an increase in the index represent an increase in market sophistication. We use this index as an explanatory factor in order to avoid problems with multicollinearity and provide easily interpretable results when thinking about the market as a whole.

3.6 Analysis

As our analysis in the companion paper makes clear, our study site encompasses a variety of markets that differ along the dimensions discussed in the preceding sections. Even the basic sketch of an impact pathway presented above suggests that there could be important relationships between these market features and nutritional outcomes, although these are likely to be dwarfed by other factors in explanatory power. Nevertheless, the analysis in this paper attempts to discover if the market characteristics we measure are in any way predictive of the nutritional outcomes of the children served by these markets. This serves two purposes: first, if markets are found to be important, this broadens the scope of potential measurable impacts of improving rural developing-country markets. Second, if we find that certain dimensions appear to be especially important, there could be simple policies to improve those aspects of markets. For instance, if we find that even controlling for household income, a greater array of products available in a market is associated with healthier children, then programs to knit rural markets more tightly into global supply chains (such as infrastructure improvements) could be called for.

To briefly outline our empirical strategy, we begin by checking that children in the same market do, indeed, have correlated nutritional outcomes. To do this, we simply regress each of the three z-scores on both household income and market (village) fixed effects, and we find that being in the same market

is predictive of similar z-scores. This, however, could be due to any number of other factors, including geography, genetic similarity, or other health interventions. To examine whether the market in particular is playing a role in this correlation among village children, we instead regress the nutritional outcomes on household income and our index of market sophistication (created using principal component analysis, as described above). This aims to see if the index, as constructed to summarize the market, is more predictive of biometric scores than simple correlation within a village. Although we cannot simultaneously control for village fixed effects and this market index as the index is measured at the village level, we present these specifications side by side in tables 3.2 - 3.4 and do an F-test to see whether the market index has additional explanatory power over the village. The explanatory power of the index is minimal, as can be seen in the exceptionally low R-squared values for all three outcomes. Column (2) in each table shows that villages with more sophisticated markets (as captured by our index) do, on average, have healthier children: they are heavier for their age, taller for their age, and heavier for their height. This is an important finding, offering evidence of a (statistically insignificant, not hugely powerful, and certainly endogenous) relationship between the market and nutritional status of children in rural Burkina Faso. The magnitude of this relationship is small, as expected: around 2% of a standard deviation of the baseline outcome z-scores (both in the human population and our samples).

Despite the importance of this first result demonstrating the relationship between market sophistication and early childhood nutrition, the constructed nature of the index makes it difficult to speculate as to which components are driving this result. This is particularly valuable in thinking about potential policy levers: simply 'improving markets' is somewhat vague, and efforts to do so without a nutrition angle have had mixed results. If we can point to a few key components of the market that are particularly important with plausible causal explanations for children's nutrition (a high-leverage outcome), policymakers can focus on improving these. However, as mentioned previously, many of the factors in the index (and that otherwise describe the market) are by definition multicollinear, as they are constructed from the same underlying variables such as the products available. The principal component analysis used in constructing the index is designed to strip out this multicollinearity, but in a regression framework identifying the marginal effect of each aspect this is problematic. Therefore, we use two approaches to consider the relationship of these individual market characteristics to children's nutritional outcomes.

The first approach consists of running a series of regressions of a nutritional outcome on a suite of household controls and a single market characteristic from the closest market to the child's home. These characteristics fall into broad categories, such as market breadth, depth, and concentration. By considering how many measures of a given dimension of market sophistication have a strong relationship with nutritional outcomes, we can get a sense of the relative importance of each dimension. Many of the particular measures

for which we have data are difficult to influence directly through policy. For instance, if the number of shops carrying only one product category is statistically significant in our regressions, that does not indicate that policies designed to limit the types of goods a shop can carry would improve childhood nutritional outcomes. However, it may suggest that a competitive market environment is beneficial, and so policies could be designed to foster competition in rural markets more broadly.

Secondly, we look at the relative impacts of particular dimensions within the same regression framework. However, multicollinearity remains a hurdle. In order to select the variables to include in a principled manner, we use the Lasso estimator (Least Absolute Shrinkage and Selection Operator). This estimator, developed by Tibshirani (1996), seeks to solve the following optimization problem:

$$\min_\beta \{\frac{1}{N}\sum_{i=1}^{N}(y_i - x_i^T\beta)^2\} \text{ subject to } \sum_{j=1}^{p}|\beta_j| \leq t$$

Intuitively, much like Ordinary Least Squares (OLS), the Lasso minimizes the residual sum of squares, but does so subject to a 'penalty term' which specifies that the sum of the absolute values of the coefficients must be less than some constant. This penalty term has the property that it generally will cause some coefficients to exactly equal zero, and thus Lasso gives interpretable results much like subset selection methods. The Lasso process is continuous rather than discrete and thus is less sensitive to minor changes in the data. That is, in step-wise subset selection methods, at each step a given variable is either retained or dropped; minor deviations from the true process can thus lead to completely different outcomes. The Lasso is an increasingly common way to perform both variable subset selection and estimation simultaneously.

Several important caveats hold with the Lasso. It is not a method of inference but rather a predictive one, so the Lasso itself does not find the true coefficients (like all forms of regularization in the general ridge family, it introduces some bias towards zero in an effort to exploit the bias/variance trade-off of minimizing mean squared error). Second, the variables chosen are not invariant to scale, so normalization is necessary prior to estimation. As with all machine learning methods, inference on particular coefficients can be problematic due to the potential for over-fitting, which introduces endogeneity bias. Essentially, these methods were developed for predictive power, and thus their application to inference should be done with caution. There are not standard methods for determining the significance of coefficients, although a variety of post-penalized estimation methods have been suggested. We follow Belloni et al. (2011), who suggest re-running a standard OLS regression with the coefficients selected by the Lasso process. If the initial selection of variables was correct, this should give unbiased estimates of both the coefficients and their standard errors.

3.7 Results

Tables 3.2 - 3.4 present the results of our primary regressions. In each, column (1) regresses the outcome variable (weight-for-age, height-for-age, and weight-for-length, respectively) on a vector of household characteristics and village fixed effects, many of which are individually highly significant. Column (2) replaces the village fixed effects with our market sophistication index, which is positive although not statistically significant for all three outcomes. The third column includes separate indices constructed for each conceptual dimension of markets: breadth, depth, and concentration. It is interesting to note that the coefficient on household income is statistically indistinguishable from zero across the board; this may be due to excessive noise in our (imperfect) income measure, but is unexpected given the importance of income in the impact pathway described above.

In Table 3.2, we see that in the village fixed effects regression, the only individual-level controls that are statistically significant are household distance to the nearest market (with more centrally located households having slightly heavier children for their age) and a dummy for measuring children during the post-harvest season when food is more available. The entire regression is only able to explain 0.4% of the variation in weight-for-age. When we replace the village fixed effects with the constructed market sophistication index in column (2), our explanatory power increases slightly. Although this index is statistically insignificant, it does (encouragingly) have a positive sign. In column (3), we can see that the breadth measure is most strongly related to weight-for-age z-scores, and this is positive and significant.

Table 3.3 presents the output for the most long-term of our measures, length-for-age, which we predicted would be less influenced by the local market. Indeed, we see lower explanatory power than in table 3.2, and no covariate is statistically significant in columns (1) or (2). This congruence between our theoretical understanding of the nutritional processes at work and the empirical findings is encouraging, despite our rather weak results. Indeed, particularly for this most long-term of measures that is strongly influenced by factors outside the purview of this study, it is in fact encouraging that we have not picked up too much spurious correlation when we do find significant results. Our index of concentration measures is negatively and significantly related to length-for-age in a village, perhaps indicating that market power does not benefit rural consumer households.

Finally, table 3.4 has results for the most short-term (even seasonal) measure of nutritional status, and thus the measure most likely to be affected by the availability of food in the market. Our explanatory power is still extremely limited; even the regression using the constructed index only accounts for a little more than one-half a percent of the observed variation in weight-for-length z-scores. Here again, market breadth seems to be the most important for nutritional outcomes; this effect may be slightly offset by market depth,

VARIABLES	(1)	(2)	(3)
	Weight-for-age z-score (9 months)		
Household Income	-2.20e-08	-7.38e-09	-1.77e-08
	(4.04e-08)	(4.32e-08)	(4.46e-08)
Asset Index	0.0415	0.0768	0.0777
	(0.0659)	(0.0721)	(0.0718)
Housing Index	0.00671	0.000253	0.00511
	(0.0550)	(0.0614)	(0.0629)
Distance to Nearest Market (m)	-4.41e-05**	-4.44e-05	-3.66e-05*
	(2.11e-05)	(2.97e-05)	(2.05e-05)
Lean Season	-0.0374	-0.0278	-0.0289
	(0.0444)	(0.0504)	(0.0510)
Post-Harvest	0.0915*	0.0377	0.0492
	(0.0499)	(0.0578)	(0.0569)
Market Sophistication Index		0.00527	
		(0.00571)	
Index of Breadth Measures			0.116***
			(0.0341)
Index of Depth Measures			0.0135
			(0.0642)
Index of Concentration Measures			-0.108
			(0.0627)
Constant	-1.343***	-1.368***	-1.181***
	(0.0370)	(0.0394)	(0.0856)
Observations	3,335	2,545	2,545
R-squared	0.004	0.008	0.011
Number of villageid	34		
Village FE	Yes	No	No
Cluster SE	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.2: A market sophistication index does have slightly better explanatory power for weight-for-age than village fixed effects, but is statistically insignificant. Breadth measures seem to be most strongly related to weight-for-age.

VARIABLES	(1)	(2)	(3)
	Length/height-for-age z-score (9 months)		
Household Income	-9.38e-09	-2.73e-08	-2.40e-08
	(3.83e-08)	(3.69e-08)	(3.57e-08)
Asset Index	0.0167	0.0245	0.0142
	(0.0551)	(0.0520)	(0.0523)
Housing Index	0.0172	0.0229	0.0371
	(0.0520)	(0.0571)	(0.0555)
Distance to Nearest Market (m)	-1.77e-05	-3.05e-05	-2.82e-05
	(2.69e-05)	(2.75e-05)	(2.24e-05)
Lean Season	0.0132	0.0360	0.0297
	(0.0636)	(0.0788)	(0.0772)
Post-Harvest	0.0482	0.0387	0.0413
	(0.0464)	(0.0521)	(0.0498)
Market Sophistication Index		0.00314	
		(0.00496)	
Index of Breadth Measures			0.0173
			(0.0479)
Index of Depth Measures			0.141
			(0.0810)
Index of Concentration Measures			-0.151*
			(0.0791)
Constant	-1.184***	-1.171***	-1.206***
	(0.0490)	(0.0499)	(0.113)
Observations	3,331	2,541	2,541
R-squared	0.001	0.003	0.006
Number of villageid	34		
Village FE	Yes	No	No
Cluster SE	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.3: Length-for-age is not strongly related to any measured covariates.

VARIABLES	(1)	(2)	(3)
	Weight-for-length/height z-score (9 months)		
Household Income	-2.87e-08	8.37e-09	-7.66e-09
	(4.40e-08)	(4.73e-08)	(4.80e-08)
Asset Index	0.0437	0.0857	0.0943
	(0.0569)	(0.0667)	(0.0659)
Housing Index	-0.00125	-0.0149	-0.0187
	(0.0451)	(0.0477)	(0.0502)
Distance to Nearest Market (m)	-4.83e-05***	-3.75e-05	-2.88e-05*
	(1.48e-05)	(2.29e-05)	(1.61e-05)
Lean Season	-0.0574	-0.0606	-0.0575
	(0.0544)	(0.0609)	(0.0623)
Post-Harvest	0.0912*	0.0263	0.0396
	(0.0501)	(0.0547)	(0.0559)
Market Sophistication Index		0.00492	
		(0.00530)	
Index of Breadth Measures			0.142***
			(0.0258)
Index of Depth Measures			-0.0836*
			(0.0470)
Index of Concentration Measures			-0.0342
			(0.0462)
Constant	-0.902***	-0.952***	-0.679***
	(0.0274)	(0.0410)	(0.0824)
Observations	3,331	2,541	2,541
R-squared	0.005	0.009	0.014
Number of villageid	34		
Village FE	Yes	No	No
Cluster SE	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.4: Market and individual factors have more explanatory power for weight-for-length z-scores, but the relationships are still small.

although the effect is weaker.

3.7.1 Dimensions of Markets

Tables 3.5 - 3.8 present a series of regressions of weight-for-length (the most variable of our nutritional outcomes) on a suite of household-level controls and one measure of the market closest to the child (for measures of open-air markets, only children in villages with open-air markets are included). These measures are roughly grouped into village-level factors and measures of breadth, depth, and concentration. Village-level factors include population in the market catchment area, market location (in relation to paved all-weather roads), and measures of available infrastructure (is there an open-air market, what kind of infrastructure is prevalent in the market, how well-built and organized are shops on average, and how many new products have been introduced in the previous year).

Although the coefficients on each regression are not directly comparable as the measures are neither independent nor measured on similar scales, these tables serve to demonstrate the relative importance of each broad dimension of the market. That is, if many measures of one dimension of market sophistication have a significant relationship with weight-for-length, even after controlling for household-level factors, then that indicates the importance of that dimension for childhood nutrition.

Examining these tables, the first salient point is the low explanatory power across all the models. As discussed previously, market characteristics are far from the primary factors in determining nutritional outcomes, and all of our results should be interpreted with extreme caution. This is further emphasized by the near-zero coefficients on most variables, with very few statistically significant market measures (or indeed individual controls, apart from the household distance from a market center and post-harvest seasonal dummy).

However, when we consider the tables as a whole, we can identify suggestive patterns of the dimensions of markets that seem to matter more for childhood nutrition. In particular, several broad features of the village and/or market are statistically significant for weight-for-length, as can be seen in table 3.5, although often with counter-intuitive signs. These same factors do increase our explanatory power slightly, as seen in the higher R^2 values. Villages further away from paved roads seem to have heavier children (a result we explore further below). Additionally, children living near markets where more products have been introduced in the past year, a measure of dynamism, are slightly heavier for their height. Finally, children in villages where a larger proportion of vendors (both shops and open-air market participants) rely on mobile infrastructure, such as trays or carrying baskets of wares, are heavier for their length. The magnitude on this effect is suspiciously high and perhaps stems from the noisy nature of our data and the many hypotheses we test

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Weight-for-length/height z-score (9 months)						
Individual Controls							
Household Income	-1.9e-08	-2.6e-08	-2.3e-08	-2.0e-08	-2.2e-08	-1.7e-08	-1.7e-08
	(4.3e-08)	(4.5e-08)	(4.4e-08)	(4.4e-08)	(4.5e-08)	(4.3e-08)	(4.4e-08)
Asset Index	0.080	0.082	0.086	0.084	0.081	0.087	0.071
	(0.053)	(0.053)	(0.052)	(0.053)	(0.052)	(0.053)	(0.051)
Housing Index	-0.021	-0.014	-0.020	-0.021	-0.024	-0.022	-0.014
	(0.039)	(0.038)	(0.039)	(0.038)	(0.040)	(0.039)	(0.037)
Distance to	-0.000021	-0.000020	-0.000024	-0.000036	-0.000020	-0.000026**	-0.000014
Nearest Market (m)	(0.000015)	(0.000014)	(0.000014)	(0.000022)	(0.000013)	(0.000012)	(0.000014)
Lean Season	-0.054	-0.059	-0.053	-0.049	-0.050	-0.049	-0.060
	(0.053)	(0.055)	(0.054)	(0.054)	(0.053)	(0.053)	(0.055)
Post-Harvest	0.079	0.088*	0.083*	0.083*	0.083*	0.082*	0.087*
	(0.049)	(0.050)	(0.049)	(0.048)	(0.049)	(0.048)	(0.050)
Village-Level Factors							
2012 Population	5.8e-07						
	(6.7e-06)						
Distance to		0.0061**					
Paved Road (km)		(0.0026)					
On Paved Road			-0.030				
			(0.048)				
Has Open-Air Market				-0.069			
				(0.100)			
Average Number of New					0.0029***		
Products Introduced					(0.00064)		
Average Shop Score						-0.097	
						(0.060)	
Percent of Vendors with							5.21**
Mobile Infrastructure							(2.20)
Constant	-0.95***	-0.98***	-0.93***	-0.87***	-0.98***	-0.63***	-1.01***
	(0.058)	(0.042)	(0.051)	(0.11)	(0.038)	(0.21)	(0.049)
Observations	3,313	3,331	3,331	3,331	3,331	3,331	3,331
R-squared	0.006	0.009	0.007	0.007	0.008	0.009	0.009
Cluster SE	Village	Village	Village	Village	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.5: Weight-for-Length, Village Factors

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Weight-for-length/height z-score (9 months)					
Individual Controls						
Household Income	7.4e-09	-1.8e-08	-1.8e-08	-1.8e-08	-1.8e-08	-1.8e-08
	(4.8e-08)	(4.3e-08)	(4.4e-08)	(4.4e-08)	(4.4e-08)	(4.4e-08)
Asset Index	0.078	0.078	0.077	0.077	0.080	0.079
	(0.064)	(0.054)	(0.053)	(0.053)	(0.053)	(0.054)
Housing Index	-0.013	-0.020	-0.020	-0.023	-0.020	-0.020
	(0.048)	(0.039)	(0.039)	(0.040)	(0.039)	(0.039)
Distance to	-0.000040*	-0.000021	-7.5e-06	-0.000013	-0.000020	-0.000021
Nearest Market (m)	(0.000020)	(0.000014)	(0.000018)	(0.000014)	(0.000015)	(0.000014)
Lean Season	-0.062	-0.054	-0.057	-0.056	-0.054	-0.054
	(0.062)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
Post-Harvest	0.030	0.082	0.084*	0.084	0.082	0.082
	(0.057)	(0.049)	(0.049)	(0.050)	(0.049)	(0.049)
Measures of Breadth						
Number of Open-Air	0.00017					
Market Sellers	(0.00013)					
Number of Shops		0.00030				
		(0.00057)				
Total Categories			0.011			
Available			(0.0092)			
Number of Categories				0.013		
Available from Shops				(0.0083)		
Number of Distinct Products					0.0016	
Offered by All Shops					(0.0040)	
Number of Total Products						0.000032
Offered by All Shops						(0.000081)
Constant	-1.01***	-0.96***	-1.13***	-1.11***	-0.99***	-0.96***
	(0.055)	(0.052)	(0.15)	(0.11)	(0.11)	(0.054)
Observations	2,541	3,331	3,331	3,331	3,331	3,331
R-squared	0.010	0.007	0.008	0.008	0.007	0.007
Cluster SE	Village	Village	Village	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.6: Weight-for-Length, Breadth Measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Weight-for-length/height z-score (9 months)								
Individual Controls									
Household Income	-1.4e-08	-1.9e-08	-1.8e-08	-1.8e-08	-1.9e-08	-1.4e-08	-2.1e-08	-1.9e-08	-1.5e-08
	(4.3e-08)	(4.4e-08)	(4.4e-08)	(4.4e-08)	(4.4e-08)	(4.4e-08)	(4.4e-08)	(4.5e-08)	(4.3e-08)
Asset Index	0.071	0.082	0.078	0.079	0.083	0.085	0.082	0.081	0.072
	(0.054)	(0.054)	(0.054)	(0.054)	(0.053)	(0.053)	(0.053)	(0.053)	(0.051)
Housing Index	-0.022	-0.020	-0.021	-0.020	-0.020	-0.025	-0.019	-0.020	-0.016
	(0.038)	(0.039)	(0.039)	(0.039)	(0.039)	(0.037)	(0.038)	(0.039)	(0.038)
Distance to	-2.0e-5*	-2.0e-5	-2.0e-5	-2.1e-5	-2.5e-5*	-3.8e-5**	-2.5e-5*	-2.4e-5*	-2.0e-5
Nearest Market (m)	(1.2e-5)	(1.5e-5)	(1.4e-5)	(1.4e-5)	(1.3e-5)	(1.5e-5)	(1.4e-5)	(1.4e-5)	(1.4e-5)
Lean Season	-0.056	-0.052	-0.055	-0.054	-0.053	-0.049	-0.052	-0.052	-0.056
	(0.052)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.054)
Post-Harvest	0.079	0.082	0.080	0.082	0.084*	0.082	0.082	0.082	0.084*
	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.048)	(0.049)	(0.049)	(0.049)
Measures of Depth									
Shops per 100	0.14**								
Population	(0.057)								
Number of Distinct		-7.3e-5							
Milk Products		(0.0065)							
Number of Total			0.0002						
Milk Products			(0.0005)						
Number of Shops				0.0008					
with Milk Products				(0.0017)					
Percent of Shops					-0.16				
with Milk Shops					(0.12)				
Percent of Retailers						-0.39			
with Fruits & Veg						(0.23)			
Percent of Shops							0.10		
with Food							(0.14)		
Percent of shops								-0.13	
with Medicine								(0.54)	
Percent of Shops									-0.26**
with Food & Medicine									(0.10)
Constant	-1.06***	-0.95***	-0.96***	-0.96***	-0.83***	-0.84***	-1.00***	-0.94***	-0.92***
	(0.062)	(0.062)	(0.052)	(0.054)	(0.088)	(0.078)	(0.081)	(0.046)	(0.038)
Observations	3,313	3,331	3,312	3,331	3,331	3,331	3,331	3,331	3,331
R-squared	0.009	0.007	0.006	0.007	0.008	0.008	0.007	0.007	0.009
Cluster SE	Village	Village	Village	Village	Village	Village	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.7: Weight-for-Length, Depth Measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Weight-for-length/height z-score (9 months)							
Individual Controls								
Household Income	-1.7e-08	-1.4e-08	-1.9e-08	-1.7e-08	-1.8e-08	-1.8e-08	-1.9e-08	-1.8e-08
	(4.3e-08)	(4.1e-08)	(4.4e-08)	(4.3e-08)	(4.4e-08)	(4.4e-08)	(4.5e-08)	(4.4e-08)
Asset Index	0.077	0.077	0.081	0.078	0.079	0.078	0.068	0.074
	(0.053)	(0.052)	(0.054)	(0.053)	(0.053)	(0.053)	(0.051)	(0.051)
Housing Index	-0.018	-0.020	-0.020	-0.022	-0.021	-0.020	-0.016	-0.022
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.038)	(0.039)
Distance to	-0.00001	-0.00002	-0.00002	-0.00002	-0.00002	-0.00002	-0.00002	-0.00002
Nearest Market (m)	(0.00002)	(0.00001)	(0.00002)	(0.00002)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Lean Season	-0.056	-0.054	-0.053	-0.056	-0.054	-0.054	-0.054	-0.066
	(0.054)	(0.053)	(0.053)	(0.052)	(0.053)	(0.053)	(0.054)	(0.053)
Post-Harvest	0.083	0.083*	0.083*	0.081	0.082	0.082	0.084*	0.088*
	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.050)	(0.050)
Measures of Concentration								
Percent of Retailers	0.14							
with One Category	(0.17)							
Average Number of		-0.028						
Categories per Shop		(0.029)						
Num of Distinct Products			0.0021					
in Largest 10 Shops			(0.0082)					
Num of Total Products				0.00027				
in Largest 10 Shops				(0.00027)				
Perc of Distinct Products					-0.10			
in Largest 10 Shops					(0.16)			
Perc of Total Products						-0.049		
in Largest 10 Shops						(0.098)		
Perc of Shops Carrying							0.19**	
80% of Distinct Products							(0.088)	
Perc of Shops Carrying								-0.52**
80% of Total Products								(0.22)
Constant	-1.05***	-0.86***	-0.99***	-1.01***	-0.86***	-0.91***	-1.04***	-0.63***
	(0.13)	(0.098)	(0.17)	(0.071)	(0.12)	(0.077)	(0.062)	(0.13)
Observations	3,331	3,331	3,331	3,331	3,331	3,331	3,331	3,331
R-squared	0.007	0.007	0.007	0.007	0.007	0.007	0.009	0.011
Cluster SE	Village	Village	Village	Village	Village	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.8: Weight-for-Length, Concentration Measures

here, and therefore should not be over-interpreted.

Interestingly, we see many fewer relationships between market characteristics and weight-for-length z-scores when we consider measures of market breadth (table 3.6) and concentration (table 3.8), despite the significance of the breadth index in table 3.4. In fact, none of the market measures we include in table 3.6 has a statistically significant relationship, indicating these dimensions are perhaps less important for nutritional outcomes. There are significant correlations with two measures of market concentration – the percentage of shops required to visit to find 80% of the distinct and total products available in the market – but the opposing signs are difficult to reconcile.

Finally, when we consider measures of market depth (table 3.7), there are a few factors that seem to be related to weight-for-length. In particular, the density of shops in the market (per population) is positively related to weight-for-length. This result is somewhat expected: children in bigger, more dense markets likely have more exposure to food. It is also likely that markets with more shops per capita are more dynamic, which could indicate better health care, sanitation, or economic opportunities that could also contribute to the observed nutritional outcomes. Looking more specifically at the depth of the hypothesized relevant markets (such as those for dairy or childhood nutritional supplements), we can see that these patterns continue. In market environments where dairy and nutritional supplements are more widely available (as measured by the number of shops that carry these products), children have higher weight-for-length z-scores. As the percentage of shops in a market that carry both food and medicine products increases, the average z-score seems to decrease. This is perhaps due to the fact that in sparse markets, more shops are likely to pull 'double-duty' in their product offerings, while shops become more specialized as markets deepen. Therefore, deeper markets would be associated with lower values for this measure, and the deeper markets are again correlated with higher weight-for-length z-scores.

Broadly, we show that market features do appear to have a (weak) relationship with nutritional outcomes. Depth in particular seems to be important, while breadth and market concentration are less significant.

3.7.2 Lasso-selected variables

If we are instead interested in isolating particular features of the market, this approach of running many individual regressions is problematic. This is because estimating many regressions makes us more likely to find spurious effects given multiple hypothesis testing.[8] Therefore, in order to compare the relative impacts of multiple measures in the same model, we turn to a principled variable-selection technique. As described in the methodology, we use Lasso, a form of penalized regression, to select the most important orthogonal

[8]Indeed, only the average number of new products introduced in the past year by shops survives as statistically significant after Bonferonni correction of the p-values.

covariates. This allows us to find the strongest predictive features of the market to a given nutritional outcome. We then include these simultaneously in a regression framework to examine their marginal effects.

Table 3.9 presents the results of regressing weight-for-length z-scores on the individual-level and market-level variables selected by the Lasso. These included covariates were chosen from a list of candidate variables including individual controls (household income, asset index, housing index, and distance from the nearest market), market characteristics (distance from a paved road, number of shops per 100 population, 2012 population served by the market, existence of an open-air market, average shop score, and average number of new products introduced in the market), market breadth (total number of categories available), market depth (percentage of shops with food, number of distinct and total milk products available, and number and percentage of shops that carry dairy products), and market concentration measures (average number of categories available per shop, and percentage of shops with one category). The results presented are from an OLS regression using the variables selected by the Lasso with standard errors clustered at the village level. Lasso introduces some bias in the coefficients and does not determine statistical significance; therefore, for the sake of interpretation, we follow Belloni et al. (2011) and re-run OLS for unbiased estimates of both coefficients and standard errors.

In table 3.9, the outcome variable is the baseline weight-for-length z-scores (the most short-term and responsive anthropometric measure). The Lasso selected 7 variables, four of which are statistically significantly different from zero at the 10% level. Unexpectedly, the sign on one of these variables, distance from the road, is the opposite from what we might anticipate: being further from the paved road is associated with higher weight-for-length at 9 months old. (We explore this finding in more detail below as it was also evident in individual regressions.) More predictably, children of wealthier households (as measured by an asset index) are heavier, as are children in larger markets that have more shops per person[9] and more dynamic markets, as measured by the average number of new products introduced by shops over the past 12 months. This suggests that encouraging the market to grow, whether through creating infrastructure or through microcredit programs that encourage entrepreneurship, could be an effective (if not efficient) way of improving nutritional outcomes.

3.7.3 Distance from Paved Roads

We next explore the strange finding that villages further from the road have healthier children along all three anthropometric measures. We focus our analysis on weight-for-length because, as we have seen, this measure has the strongest relationship with the market characteristics we measure, offering us the most statistical

[9]The magnitude of this effect is relatively large: an additional shop per 100 people in the village is associated with a one-fifth of a standard deviation larger children as measured by weight-for-length.

VARIABLES	(1) Weight-for-length/height z-score (9 months)
Asset Index	0.0494*
	(0.0250)
Distance to Nearest Market (m)	-1.60e-05
	(9.96e-06)
Distance to Paved Road (km)	0.00881***
	(0.00289)
Shops per 100 Population	0.204***
	(0.0482)
Percentage of Shops with Food	0.163
	(0.113)
Average Shop Score	-0.0765
	(0.0517)
Average Number of New Products	0.00401***
	(0.000704)
Lean Season	-0.0619
	(0.0531)
Post-Harvest	0.0859*
	(0.0487)
Constant	-1.032***
	(0.226)
Observations	3,335
R-squared	0.016

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.9: Lasso-selected covariates for Weight-for-Length

power.

Theoretically, we would expect markets closer to the paved road to be more sophisticated, as they are more closely linked to local and global supply chains. We also expect that families living in villages closer to the paved road have better access to health care (in time traveled if not physical distance) which should improve children's health. There is a burgeoning literature that examines the (positive) effect of road construction on children's health, and this intuitive result seems to be widely assumed (Gu et al., 2016).

However, our contrary finding is not entirely novel. Prudhomme O'Meara et al. (2013) find a statistically significant positive coefficient for the distance from a paved road on the probability of going to hospital for antenatal care in some districts in Kenya, despite having hypothesized the opposite relationship. They do not convincingly explain this result, instead suggesting that it could be an artifact of constructing distance as a continuous variable rather than using thresholds or travel time. They argue that it is consistent with other studies that find no effect of distance/travel time on hospital attendance.

Nevertheless, we delve into this result in tables 3.10 and 3.11 to see if we can uncover what is driving it. In table 3.10, we begin in column (1) by rerunning the detailed regression from table 3.9, column (3). We then split the sample into those villages located on the paved road (within one kilometer) and those further afield. We separately estimate the same regression on each sub-sample in columns (2) and (3), and we find that the effect is still positive and significant for those off the road. This indicates that it is likely not a structural break between two different kinds of villages: even for those off the road, being further from the road is associated with higher z-scores on average. However, including the squared distance of the village to the paved road makes both terms statistically insignificant. The negative coefficient on the squared term means that despite higher weight-for-length z-scores in villages further from the road, this effect diminishes as villages become more remote.

It may be, however, that a single outlier village could be driving our results. To see if this is the case, in table 3.11 we sequentially exclude the villages furthest from and closest to the paved road (of those in the "off-road" sample) to see if any of these omissions makes a substantial difference. Column (1) again shows the coefficient for the full off-road sample, and each subsequent column repeats the regression for a sub-sample excluding the village located at the distance indicated from the paved road. No individual village seems to be driving the observed results.

VARIABLES	(1)	(2)	(3)	(4)
	Weight-for-length/height z-score (9 months)			
Distance to Nearest Market (m)	-1.60e-05	-9.07e-06	2.58e-06	-1.58e-05
	(9.96e-06)	(1.64e-05)	(1.63e-05)	(1.00e-05)
Distance to Paved Road (km)	0.00881***	-0.139	0.0140***	0.0137
	(0.00289)	(0.146)	(0.00430)	(0.00893)
Squared Distance to Paved Road				-0.000211
				(0.000324)
Constant	-1.032***	-1.162**	-1.025***	-1.054***
	(0.226)	(0.389)	(0.247)	(0.232)
Observations	3,335	1,897	1,438	3,335
R-squared	0.016	0.013	0.029	0.016
Sample	Full	On-Road	Off-Road	Full

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Controls as in table 3.9 included but suppressed.

Table 3.10: Weight-for-Length and Distance from Road

VARIABLES	(1)	(2)	(3)	(4)	(5)
	Weight-for-length/height z-score (9 months)				
Distance to Paved Road (km)	0.00881***	0.0107***	0.00580***	0.00924***	0.00878***
	(0.00289)	(0.00346)	(0.00201)	(0.00283)	(0.00295)
Constant	-1.032***	-1.050***	-1.020***	-1.047***	-1.029***
	(0.226)	(0.227)	(0.227)	(0.230)	(0.225)
Observations	3,335	3,249	3,176	3,261	3,276
R-squared	0.016	0.016	0.015	0.016	0.016
Sample	Full	excl (29km)	excl (21km)	excl (1.05km)	excl (1.47km)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.11: Weight-for-Length and Distance from Road, Sequential Exclusion

3.8 Discussion

3.8.1 Distributions and Markets

We have seen evidence of a relationship, albeit a weak one, between the quality of the market environment and the nutritional status of children living near that market. It is crucial to bear in mind that we are dealing with distributions of children in the village, and the means (which are, in essence, captured by these regressions) may not tell the whole story. The following three figures plot a histogram of the distribution of each of the three nutritional outcomes for each village, with the distributions stacked according to the village score on the market sophistication index. This data visualization allows us to simultaneously see changes in the entire distribution as the market becomes more sophisticated. The line plotted represents the trend line of a simple regression of the mean nutritional outcome on the final index. As can be seen, the positive relationship identified in the regression analysis is represented with a positive slope. However, it is also clear that the left tail of the distribution does not follow the same slope: the least healthy children in each village are not healthier in better markets.

From a normative perspective, while we are concerned with the health and nutrition of all of these children (for almost all are below WHO "normal" anthropometric measures), we know that the health effects of improvements in z-scores are highly nonlinear. This is the rationale for the use of stunting and wasting measures, which essentially impose a discontinuity in the outcome at a z-score of -2. However, this cutoff is somewhat arbitrary and has been subject to criticism. Indeed, until recently, many studies used different cut-points, as there is not a clear rationale for a particular cut-point representing the non-linearities of the underlying nutritional processes. Furthermore, using a cutoff and transforming the data into a binary variable (indicating whether a child is 'stunted' or not) loses some of the information contained within the actual score (Fenske et al., 2011).

Fenske et al. (2011) instead suggest using quantile methods to look at the lower tail of the distribution in a more nuanced way, although those authors acknowledge that methods for doing so are as yet relatively undeveloped. Their context and proposed methods address our question almost perfectly: they use Boosting Additive Quantile Regression to simultaneously determine the factors influencing stunting (model selection) and estimate their effects on children in the extreme left tail of the distribution in India using state-of-the-art machine learning techniques. However, they focus primarily on individual-level factors, such as socioeconomic status indicators, duration of breastfeeding, and mother's education. These (in some cases highly predictive) factors give them an effective sample size of over 37,000 children, which is sufficient for their data-intensive methods. We, however, only have 3,088 children, and our effective sample size is further restricted because our variables of interest are only measured at the market level. We thus cannot replicate

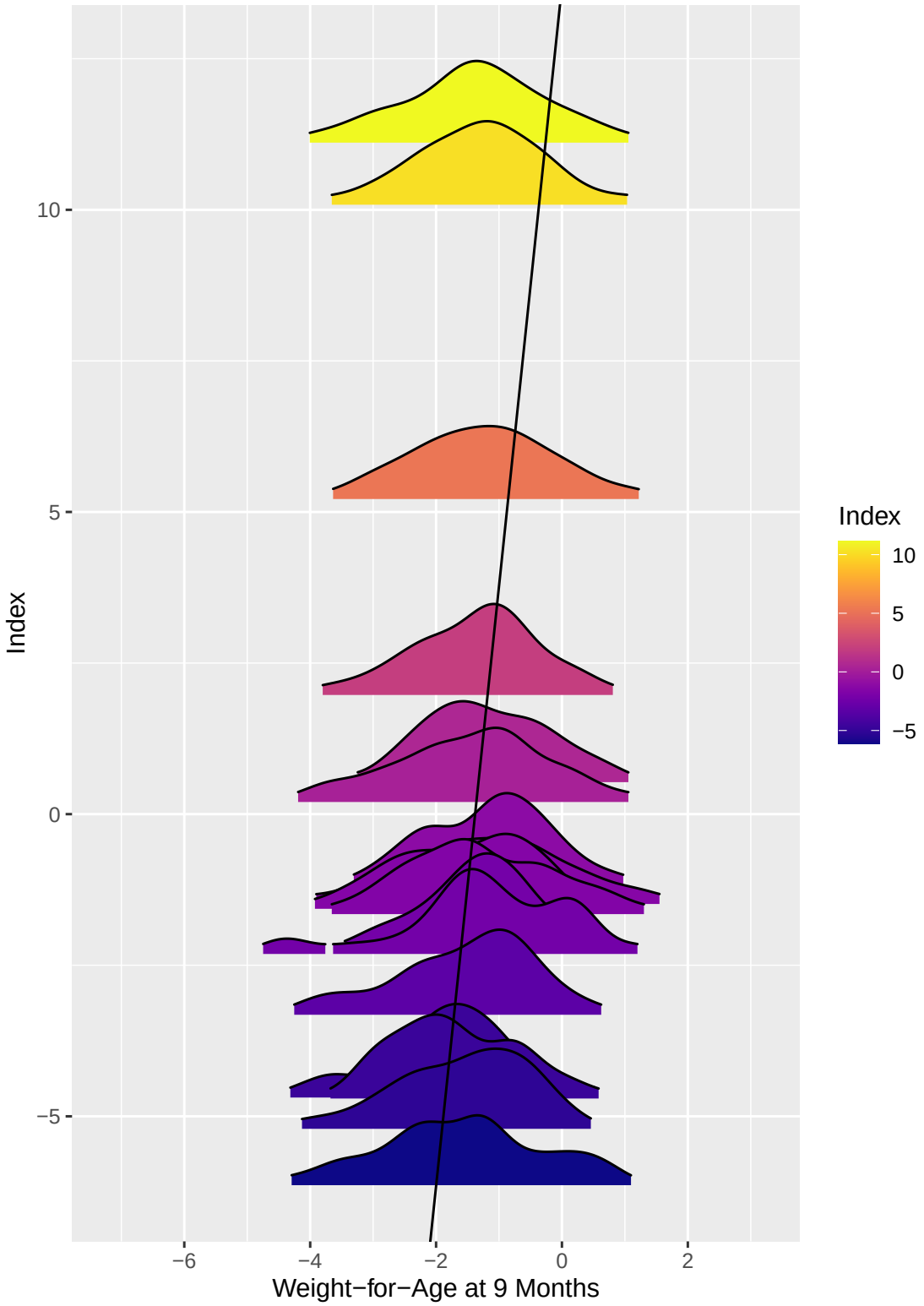


Figure 3.3: Distribution of Weight-for-Age Z-scores in Markets, Sorted by Market Sophistication Index

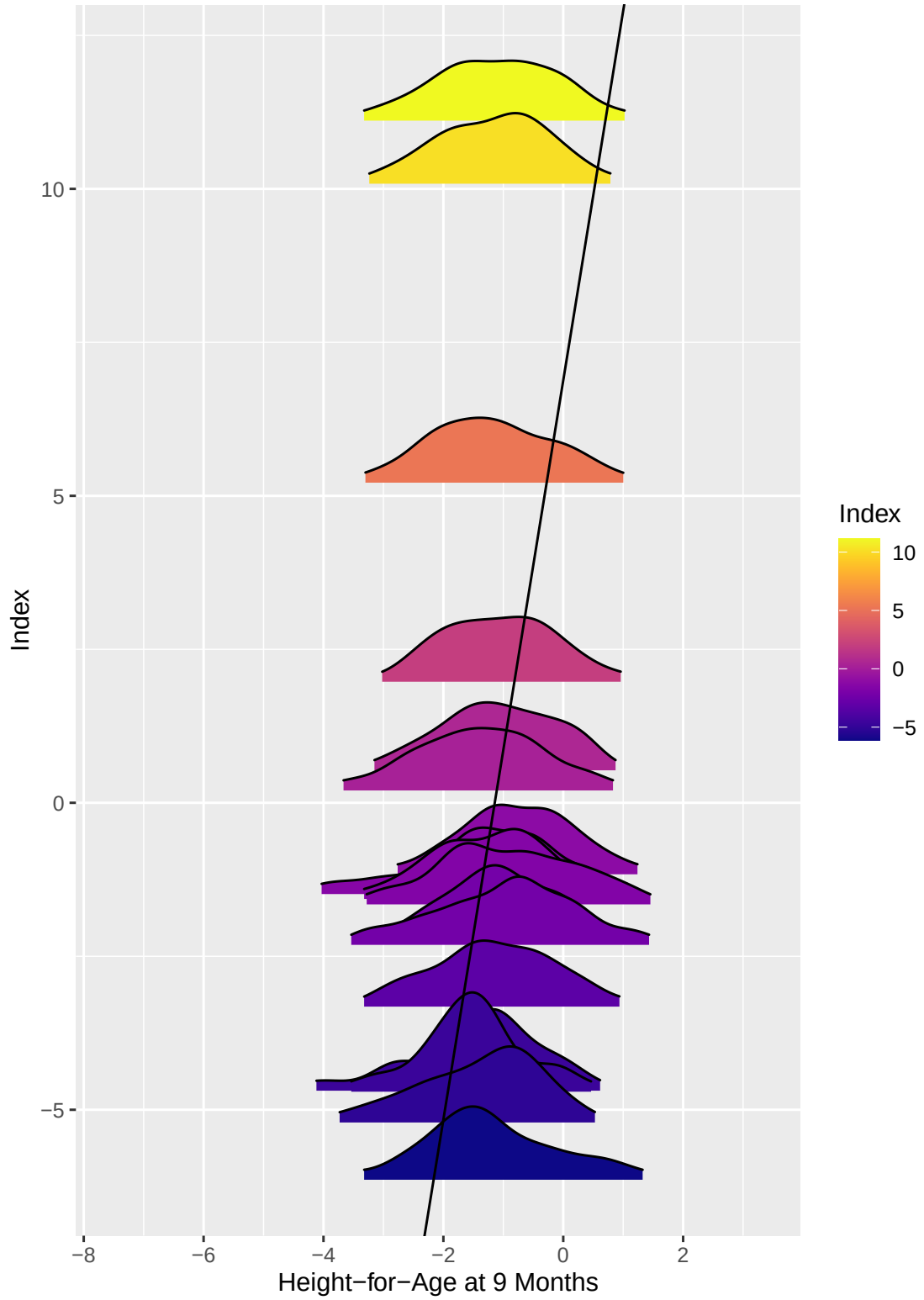


Figure 3.4: Distribution of Height-for-Age Z-scores in Markets, Sorted by Market Sophistication Index

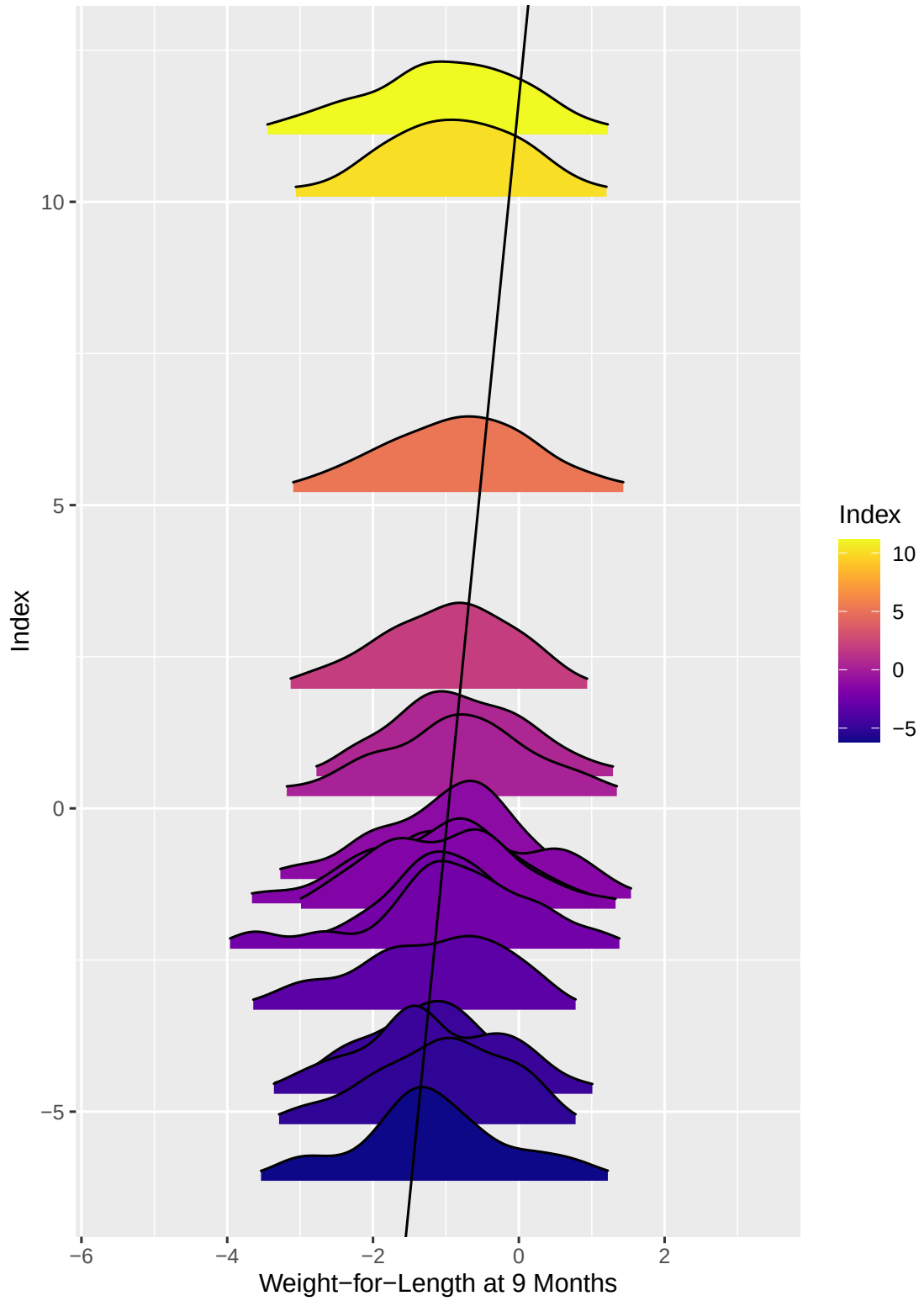


Figure 3.5: Distribution of Weight-for-Length/Height Z-scores in Markets, Sorted by Market Sophistication Index

their quantile methods, which represent a frontier in statistical analysis of stunting and determining the contributing factors.

Our somewhat unusual data structure, though, does allow us to create figures 3.3 - 3.5. These figures permit us to use 'optical econometrics' to see the whole distribution of z-scores in a village and how they change across different markets. By laying out these distributions along the axis of market sophistication we created, it becomes clear that even if the mean shifts rightward as the index increases, the left tail, which represents extremely small children, does not respond much.

3.8.2 Robustness Checks

Tables 3.12 and 3.13 present a series of robustness checks for tables 3.3 and 3.4. Instead of using the z-scores of individual children, we create a binary measure of stunting and wasting (z-scores less than or equal to -2), and regress these on village fixed effects as well as our index of market sophistication. Whether using a linear probability model or a logit model (which each make different assumptions about the distribution of the error terms), we find that none of our individual factors nor our index are statistically significant. Our analysis therefore appears to be robust to this transformation of the data.

3.9 Conclusion

What, then, does all of this analysis imply for action? We have seen that on average, children in better markets are healthier than their counterparts in less well-served markets. However, we are unable to make causal claims about what happens to childhood nutrition as a market develops. The impact pathway in figure 3.1 only lays out a few of the possible complexities. There are many mediating factors in how markets impact nutrition, and there are a plethora of other factors that could be simultaneously causing better markets and healthier children. Furthermore, our analysis has extremely weak explanatory power (as predicted from the complexity of the impact pathway), so any causal links are tertiary at best. Improving markets is unlikely to be the most effective – or efficient – way of improving childhood nutrition.

By using the Lasso method, we are able to isolate some individual dimensions of these 'better' markets that seem to have a stronger relationship with our measures of nutrition. Broadly, having more shops per person in a village, as well as more specialized shops, seems to be an important indicator. It also seems (unsurprisingly) that a wider availability of products known to be important complementary foods, such as milk or other children's supplements, is linked to healthier children in the village. However, this could easily be a demand-side story where parents who are more concerned with their children's health are more likely to demand these products and take their children to health centers more often.

VARIABLES	(1) Stunted	(2) Stunted	(3) Stunted	(4) Stunted
Household Income	4.96e-10	9.79e-10	1.44e-07	3.09e-07
	(1.58e-09)	(1.68e-09)	(6.55e-07)	(5.35e-07)
Asset Index	0.000219	0.000929	0.143	0.188
	(0.00106)	(0.00133)	(0.674)	(0.411)
Housing Index	-0.00223	-0.00292	-0.946	-0.962**
	(0.00209)	(0.00227)	(0.609)	(0.385)
Distance to Nearest Market (m)	7.58e-07	3.07e-07	0.000179	0.000519***
	(1.15e-06)	(2.46e-07)	(0.000409)	(0.000147)
Lean Season	0.000106	4.76e-05	0.0566	-0.0361
	(0.00278)	(0.00268)	(0.860)	(0.994)
Post-Harvest	-0.000168	-0.000982	0.0182	-0.343
	(0.00246)	(0.00237)	(0.647)	(0.688)
Market Sophistication Index		-0.000244		-0.103
		(0.000180)		(0.0739)
Constant	0.996***	0.998***		6.504***
	(0.00210)	(0.00146)		(0.722)
Observations	3,335	3,317	1,005	3,317
R-squared	0.002	0.004		
Village FE	Yes	No	Yes	No
Model	LPM	LPM	Logit	Logit
Cluster SE	Village	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.12: Binary Outcomes (Stunting): Linear Probability Model and Logit

VARIABLES	(1) Wasted	(2) Wasted	(3) Wasted	(4) Wasted
Household Income	8.82e-10	9.79e-10	3.28e-06	6.30e-06
	(7.00e-10)	(8.60e-10)	(5.00e-06)	(6.67e-06)
Asset Index	4.25e-05	-6.45e-05	-0.512	0.0396
	(0.000376)	(0.000440)	(1.784)	(0.640)
Housing Index	-0.000860	-0.000624	-1.168	-1.218***
	(0.000621)	(0.000478)	(2.078)	(0.258)
Distance to Nearest Market (m)	-1.48e-06	1.84e-08	-0.00278	8.24e-05
	(1.13e-06)	(1.19e-07)	(0.00204)	(0.000158)
season = 1, Lean Season	0.000432	0.000364	0.946	
	(0.000405)	(0.000405)	(43.92)	
season = 2, Post-Harvest	-0.00111	-0.00122	-1.809	-1.621
	(0.00180)	(0.00173)	(3.943)	(1.149)
Market Sophistication Index		0.000116		0.353
		(8.83e-05)		(0.241)
season = 1, omitted				-
Constant	1.002***	0.999***		6.715***
	(0.00191)	(0.00106)		(1.322)
Observations	3,335	3,317	198	2,934
R-squared	0.003	0.002		
Village FE	Yes	No	Yes	No
Model	LPM	LPM	Logit	Logit
Cluster SE	Village	Village	Village	Village

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.13: Binary Outcomes (Wasting): Linear Probability Model and Logit

Our findings suggest that interventions designed to improve these dimensions of markets could count better nutrition outcomes among their myriad benefits. This accounting should be appropriately discounted due to the weakness of the relationship found, and such health benefits may not be a sufficient program justification on their own. Nevertheless, it would be interesting to measure potential nutritional improvements from plausibly exogenous changes in markets, and we suggest this as an avenue for further research.

We find that improving markets is extremely unlikely to affect all children equally, and children in the very tail (and thus the most deprived children) are the least likely to benefit from better markets. We cannot therefore rely on economic growth and market development alone to improve the health of future generations in developing countries. There is a strong rationale for public health investments explicitly designed to reach the whole population, as well as some targeted interventions for those individuals left behind by the market.

3.10 References

J. E. Arsenault, L. Nikiema, P. Allemand, K. A. Ayassou, H. Lanou, M. Moursi, F. F. De Moura, and Y. Martin-Prevel. Seasonal differences in food and nutrient intakes among young children and their mothers in rural Burkina Faso. *Journal of Nutritional Science*, 3:e55, 2014.

C. B. Barrett. Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy*, 33(4):299–317, 2007.

C. B. Barrett, L. Christiaensen, M. Sheahan, A. Shimeles, and C. H. Dyson. On the structural transformation of rural Africa. *Journal of African Economies*, 26(1):11–35, 2017.

J. R. Behrman, J. Hoddinott, J. a. Maluccio, and R. Martorell. Brains versus brawn: Labor market returns to intellectual and health human capital in a poor developing country. 2009.

A. Belloni, V. Chernozhukov, and C. Hansen. Inference for high-dimensional sparse econometric models. *Advances in Economics and Econometrics*, (June 2010):1–41, 2011.

M. Bitler and S. J. Haider. An economic view of food deserts in the United States. In *National Poverty Center/USDA-ERS conference: "Understanding the Economic Concepts and Characteristics of Food Access"*, 2009.

A. de Brauw, M. Van den berg, I. D. Brouwer, H. Snoek, R. Vignola, M. Melesse, G. Lochetti, C. Van Wagenberg, M. Lundy, E. Maitre d'Hotel, and R. Ruben. Food system innovations for healthier diets in low and middle-income countries. (March), 2019.

K. G. Dewey and Arim. Lipid-based nutrient supplements: How can they combat child malnutrition? *PLoS Medicine*, 9(9):1–2, 2012.

N. Fenske, T. Kneib, and T. Hothorn. Identifying risk factors for severe childhood malnutrition by boosting additive quantile regression. *Journal of the American Statistical Association*, 106(494):494–510, 2011.

Global Panel. Improving nutrition through enhanced food environments. *Policy Brief No. 7*, (7):1–24, 2017.

Y. Gu, A. Moradi, S. Poelhekke, and R. Tol. The value of roads: distance to market and the impact of rainfall on children's health in West Africa. 2016.

J. Hemsworth, C. Kumwenda, M. Arimond, K. Maleta, J. Phuka, A. M. Rehman, S. A. Vosti, U. Ashorn, S. Filteau, K. G. Dewey, P. Ashorn, and E. L. Ferguson. Lipid-based nutrient supplements increase energy and macronutrient intakes from complementary food among Malawian infants. *Journal of Nutrition*, 146(2):326–334, 2016.

S. Y. Hess, S. Abbeddou, E. Y. Jimenez, J. W. Somé, S. A. Vosti, Z. P. Ouédraogo, R. M. Guissou, J. B. Ouédraogo, and K. H. Brown. Small-quantity lipid-based nutrient supplements, regardless of their zinc content, increase growth and reduce the prevalence of stunting and wasting in young Burkinabe children: A cluster-randomized trial. *PLoS ONE*, 10(3):1–19, 2015.

J. Hoddinott, H. Alderman, J. R. Behrman, L. Haddad, and S. Horton. The economic rationale for investing in stunting reduction. *Maternal and Child Nutrition*, 9(S2):69–82, 2013.

B. R. Kar, S. L. Rao, and B. A. Chandramouli. Cognitive development in children with chronic protein energy malnutrition. *Behavioral and Brain Functions*, 4(1):31, 2008.

C. K. Lutter, J. P. Peña-Rosas, and R. Pérez-Escamilla. Maternal and child nutrition. *The Lancet*, 382 (9904):1550–1551, 2013.

T. J. Lybbert, S. A. Vosti, K. P. Adams, and R. Guissou. Household demand for child micronutrient supplementation in Burkina Faso. 2016.

J. McDermott and A. de Brauw. National food systems: Inclusive transformation for healthier diets. pages 54–65, 2020.

L. Meinzen-Dick, S. A. Vosti, and J. James. Measuring market sophistication in rural Burkina Faso. 2017.

Ministere de la Sante, Secretariat Generale, and Direction Generale de la Sante et de la Famille. Enquete Nutritionnelle Nationale 2012. Technical report, 2012.

C. Poulton, J. Kydd, and A. Dorward. Overcoming market constraints on pro-poor agricultural growth in Sub-Saharan Africa. *Development Policy Review*, 24(November 2004):243–277, 2006.

C. Prahalad. *The Fortune at the Bottom of the Pyramid: Eradicating Poverty through Profits*. Dorling Kindersley Pvt Ltd, London, 2004.

V. R. Preedy, editor. *Handbook of Anthropometry*. Springer-Verlag New York, 2012.

W. Prudhomme O'Meara, A. Platt, V. Naanyu, D. Cole, and S. Ndege. Spatial autocorrelation in uptake of antenatal care and relationship to individual, household and village-level factors: results from a community-based survey of pregnant women in six districts in western Kenya. *International Journal of Health Geographics*, 12(1):55, 2013.

T. Reardon. The hidden middle: The quiet revolution in the midstream of agrifood value chains in developing countries. *Oxford Review of Economic Policy*, 31(1):45–63, 2015.

T. P. Schultz. Wage rentals for reproducible human capital: Evidence from Ghana and the Ivory Coast. *Economics and Human Biology*, 1(3):331–366, 2003.

L. C. Smith and L. Haddad. How potent is economic growth in reducing undernutrition? What are the pathways of impact? New cross-country evidence. *Economic Development and Cultural Change*, 51(1): 55–76, 2002.

A. D. Stein, M. Wang, R. Martorell, S. A. Norris, L. Adair, I. Bas, H. S. Sachdev, S. K. Bhargava, C. Fall, D. P. Gigante, and C. G. Victora. Growth patterns in early childhood and final attained stature: Data from five birth cohorts from low-and middle-income countries. *American Journal of Human Biology*, 22 (3):353–359, 2010.

R. Tibshirani. Regression shrinkage and selection via the Lasso. *Journal of the Royal Statistical Society, Series B (Methodological)*, 58(1):267–288, 1996.

UNCTAD. The Least Developed Countries Report 2015: Transforming Rural Economies. Technical report, 2015.

USDA Economic Research Service. Food spending as a share of income declines as income rises. Technical report, 2019.

C. G. Victora, L. Adair, C. Fall, P. C. Hallal, R. Martorell, L. Richter, and H. S. Sachdev. Maternal and child undernutrition: consequences for adult health and human capital. *The Lancet*, 371(9609):340–357, 2008.

WHO. Training Course on Child Growth Assessment. *World Health Organization. Training Course on Child Growth Assessment. Geneva*, WS 103:1–116, 2008.