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Abstract

Idiosyncratic and covariate shocks have considerable impacts on household food security and welfare. While impacts of covariate and idiosyncratic shocks have been widely documented, the mitigating role of infrastructure against such events has not been widely assessed due to the complexities in quantifying its accrued economic benefits. Further, traders, who play a significant role in allocating food resources amidst idiosyncratic and covariate shocks, their behaviour, motivations and aspirations that drive market outcomes have not been well addressed in literature from sub-Saharan Africa.

Using Malawi as a case, this study first examines impacts of extreme weather events and idiosyncratic shocks on food security at household level. Using three waves of Malawi's representative panel Integrated Household Surveys (IHS) the study estimates impacts of shocks using triple difference fixed effects regressions. In general, having controlled for household socioeconomic factors, the study finds that weather shocks such as drought and floods during an agricultural season reduce consumption by 9%. Assuming normal weather conditions, infrastructure scarcity in form of roads, electricity, and service based amenities such as banks, savings and credit cooperatives and markets – summarized into an infrastructure index – worsens economic access to food by 7%. Further, the joint impact of extreme weather events and lack of infrastructure is 17% food security reduction.

Considering that social capital can affect market outcomes in the presence of market and government failure, the study assessed the performance and organization of maize trading by paying attention to the role of social capita and business formality in Malawi. Benefiting from combining both qualitative and quantitative data sources, we used Bayes Model Averaging techniques, instrumental variable and control function approaches and found that food markets are concentrated and highly informal. While there is evidence that social capital is positively associated with business profitability, results do not strongly support the hypothesis that other measures of social capital such as tribal and religious affiliation have an effect on traders' business resilience.

Zusammenfassung

Idiosynkratische und kovariate Schocks haben erhebliche Auswirkungen auf die Ernährungssicherheit und das Wohlergehen von Haushalten. Darüber hinaus hat die Häufigkeit kovariater Schocks, wie beispielsweise extreme Wetterereignisse, in den meisten Teilen Afrikas südlich der Sahara dramatisch zugenommen. Solche Vorkommnisse haben den Zugang zu und die Nutzung von Nahrungsmitteln erheblich beeinträchtigt. Während die Auswirkungen kovariater und idiosynkratischer Schocks umfassend dokumentiert sind, wurde die Bedeutung der Infrastruktur bei der Bewältigung solcher Ereignisse aufgrund der Komplexität der Quantifizierung des daraus erwachsenden Nutzens nicht umfassend bewertet. Darüber hinaus wurde die Rolle der Nahrungsmittelhändler, die bei der Zuteilung von Nahrungsmitteln inmitten von idiosynkratischen und kovariaten Schocks eine bedeutende Rolle spielen, ihr Verhalten, ihre Motivationen und Bestrebungen, die die Marktergebnisse bestimmen, in der Literatur für Afrika südlich der Sahara wenig beachtet.

Anhand des Fallbeispiels Malawi untersucht diese Studie zunächst die Auswirkungen extremer Wetterereignisse und idiosynkratischer Schocks auf die Ernährungssicherheit von Haushalten. Unter Nutzung dreier Befragungswellen der Malawi Integrated Household Surveys (IHS), einer repräsentativen Panelbefragng, schätzt die Studie die Auswirkungen von Schocks im Rahmen einer Regression mit dreifacher Differenzbildung sowie mit Haushalts-fixed Effekten. Unter Berücksichtigung der sozioökonomischen Faktoren der befragten Haushalte kommt die Studie zu dem Ergebnis, dass Wetterschocks, wie Dürre und Überschwemmungen während einer landwirtschaftlichen Saison, den Konsum im Allgemeinen um 9% reduzieren. Demgegenüber steht, dass eine schlechte Infrastruktur in Form von Straßen, Strom und der Verfügbarkeit von dienstleistungsorientierten Einrichtungen, wie Banken, Spar- und Kreditgenossenschaften und Märkten, zusammengefasst in einem Infrastrukturindex, bei normalen Wetterbedingungen den wirtschaftlichen Zugang zu Nahrungsmitteln um 7% verringert. Die Kombination von extremen Wetterereignissen und mangelnder Infrastruktur führt zu einer Verschlechterung der Ernährungssicherheit um 17%.

In Anbetracht der Tatsache, dass Sozialkapital bei Markt- und Staatsversagen

die Marktergebnisse beeinflussen kann, bewertete die Studie die Funktionsfähigkeit und Organisation des Maishandels unter Berücksichtigung der Rolle des sozialen Kapitals und der Verbreitung formeller Geschäftstätigkeit in Malawi. Wir nutzen eine Kombination qualitativer und quantitativer Datenquellen und verwendeten Bayes-Modell-Mittelwertbildungstechniken, sowie Ansätze für instrumentelle Variablen und Kontrollfunktionen und stellten fest, dass Nahrungsmittelmärkte konzentriert und in hohem Maße informell sind. Es gibt zwar Belege dafür, dass Sozialkapital positiv mit der Rentabilität der Handelsbetriebe verbunden ist, allerdings stützen die Ergebnisse nicht unbedingt die Hypothese, dass andere Indikatoren des Sozialkapitals, wie Stammes- und Religionszugehörigkeit, einen Einfluss auf die wirtschaftliche Widerstandsfähigkeit von Händlern haben.

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List of Abbreviations

ADMARC	**A**gricultural **D**evelopment and **M**arketing **C**orporation
AIDS	**A**cquired **I**mmune **D**eficiency **S**yndrome
BMA	**B**ayes **M**odel **A**veraging
CAADP	**C**omprehensive **A**frica **A**griculture **D**evelopment **P**rogramme
CEM	**C**oersened **E**xact **M**atching
CGE	**C**omputable **G**eneral **E**quilibrium Model
CII	**C**omposite **I**nfrastructure **I**ndex
DDD	**D**ifference-in-**D**ifference-in-**D**ifference
DMSP-OLS	**D**efense-**M**eteorological **S**atellite **P**rogram-**O**ptical **L**ine **S**canner
DODMA	**D**epartment of **D**isaster **M**anagement **A**ffairs
ESR	**E**ndogenous **S**witching **R**egression
FAO	**F**ood **A**griculture **O**rganization
FEWSNET	**F**amine **E**arly **W**arning **S**ystem **N**etwork
FISP	**F**arm **I**nput **S**ubsidy **P**rogram
GDP	**G**ross **D**omestic **P**roduct
GoM	**G**overnment **o**f **M**alawi
HHI	**H**erfindahl **H**irschman **I**ndex
HHID	**H**ousehold **U**nique **I**dentifier
HIV	**H**uman **I**mmunodeficiency **V**irus
IFPRI	**I**nternational **F**ood **P**olicy **R**esearch **I**nstitute
IHS	**I**ntegrated **H**ousehold **S**urvey
IPCC	**I**ntergovernmental **P**anel on **C**limate **C**hange
IPWRA	**I**nverse **P**robability **W**eighted **R**egression **A**djustment
LSMS-ISA	**L**iving **S**tandards **M**easurement **S**urveys - **I**ntegrated **S**urveys on **A**griculture
MCMC	**M**onte **C**arlo **M**arkov **C**hain
MGDS	**M**alawi **G**rowth and **D**evelopment **S**trategy

MWK	**M**alawi **K**wacha
NASA	**N**ational **A**eronautic and **S**pace **A**dmnistration
NGO	**N**on-**G**overnmental **O**rganization
NOAA	**N**ational **O**ceanic and **A**tmospheric **A**dministration
NPC	**N**ominal **P**rotection **C**oefficient
NSO	**N**ational **S**tatistical **O**ffice of **M**alawi
NTL	**N**ight **T**ime **L**ight
PCM	**P**rice **C**ost **M**argin
RBM	**R**eserve **B**ank of **M**alawi
RCT	**R**andomized **C**ontrol **T**rial
SDG	**S**ustainable **D**evelopment **G**oals
SPEI	**S**tandardized **P**recipitation - **E**vapotranspiration **I**ndex
UNDP	**U**nited **N**ations **D**evelopment **P**rogramme
USD	**U**nited **S**tates **D**ollar

Chapter 1

Introduction

1.1 Background

1.1.1 Policy context of the study

On 1st January, 2016 the world saw the commencement of 17 ambitious Sustainable Development Goals (SDGs) to make the world a better place by 2030. First among the goals are to "end poverty in all its forms everywhere" and to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture". Highly connected to these two fore-running goals is another goal to "ensure sustainable consumption and production patterns" (United Nations Development Programme, 2016; FAO, 2018). Although quite challenging, these goals call for efficient allocation of resources in order for them to be attainable.

Operationalizing these goals requires changing the status quo of doing development activities. Developing countries, especially those south of the Sahara, where there is extreme poverty and hunger have been putting together efforts and commitment to achieve these goals. Most often, poverty alleviation policies have been criticized for lacking clear implementation plans in order to achieve their strategic goals (United Nations, 2003).

This study takes Malawi, a land locked developing economy in southeast Africa, as a case on how different circumstances have affected its aspirations towards attainment of the SDGs and other goals that have preceded them. Ranked among the world's least developed countries, at purchasing power parity, Malawi's GDP is $22.42 billion. It translates to $1200 per capita of its population of 18 million, of which 7 million comprise its labour force. Slightly over half of its population

lives on less than $1.90 per day and inequality is at 0.46 using the Gini index (Central Intelligence Agency, 2019). The country faces constraints to economic growth such as policy inconsistency, poor infrastructure, corruption, poor health and low education attainment (Central Intelligence Agency, 2019). Agriculture is the mainstay of Malawi's economy with smallholder farming comprising 80% of agricultural GDP. Agriculture employs 77% of the labour force and contributed 28% to GDP for six consecutive quarters since 2017. Agriculture has strong forward and backward linkages evidenced by active commodity markets, wholesaling and general trading which contribute 15% to GDP since 2017 (Reserve Bank of Malawi (RBM), 2019).

During the second and third quarter of 2018 and the first quarter of 2019, inflation stood around 9.1%. During the same time, food inflation increased by one percentage point to 9.5% compared the previous quarters. The mechanism explaining the food price inflation was a decrease in maize production during the 2017/2018 crop production season due to fall armyworms and dry spells in some areas (Reserve Bank of Malawi (RBM), 2019).

From growth strategy point of view, in 1998 the Government of Malawi came up with a long term strategic plan named "Malawi Vision 2020". The long term goal of the vision 2020 was that "By the year 2020, Malawi will be secure, democratically mature, environmentally sustainable, self reliant with equal opportunities for and active participation by all,having social services, vibrant cultural and religious values and being a technologically driven middle-income economy" (Government of Malawi, 1998). In its attempt to operationalize this long term vision, the Government of Malawi came up with a number of strategic options to spur economic growth which comprised developing the following key sectors 1) agriculture; 2) manufacturing industry, 3) Mining, 4) Tourism and re-orienting Malawi to be a predominantly exporting country (Government of Malawi, 1998).

As further commitment to economic growth and agricultural development, the Malawi Government adopted the Comprehensive Africa Agriculture Development Programme (CAADP) which aimed at increasing the Gross Domestic Product (GDP) by 6% per year by allocating 10% of its public expenditure in the agricultural sector (United Nations, 2003). An International Food Policy Research Institute (IFPRI) commissioned study assessed different investment options to achieve agricultural

growth and reduce poverty. The study found that Malawi could not manage to halve poverty by 2015 by investing 10% in agriculture only. However, it found that the investment option was worthwhile since historically, agricultural spending as a share of public spending was much lower (Benin et al., 2008).

The years post-2000 saw increased government commitment to agricultural growth through introduction of the Farm Input Subsidy Program (FISP) in 2005. In 2006, the Malawi Government came up with a five throng strategy to move Malawi out of poverty called the Malawi Growth and Development Strategy (MGDS). As part of the long term strategy of ending poverty by 2020, the MGDS had five pillars namely 1) agriculture and food security; 2) irrigation and water development; 3) Infrastructure development; 4) energy 5)integrated rural development and 6) prevention and management of nutrition disorders and HIV and AIDS (Government of Malawi, 2006). In its long term food security goal, the MGDS aimed at 1) achieving no food shortages during times of negative economic disruptions such as drought, floods, pests and diseases; and 2) increase exports of staples to neighbouring countries. In its medium term objective on food security, the 2006 – 2011 MGDS aimed at ensuring that high quality nutritious food was available and accessible to everyone in the economy to lead active and healthy lifestyles. Table 1.1 summarizes the MGDS investment priorities as a percentage of the total investment budget.

TABLE 1.1: MGDS 2005 – 2011 thematic areas and their investment shares

Theme	2006/07	2007/08	2008/09	2009/10	2010/11	Total
1: Sustainable Economic Growth	7.0	7.4	6.7	6.3	6.5	6.7
2: Social Protection	5.4	5.5	5.4	5.4	5.5	5.4
3: Social Development	12.1	11.6	12.2	13.1	13.7	12.4
4: Prevention and Management of nutrition disorders, HIV and AIDS	12	13.9	12.6	12.0	12.1	12.4
5: Infrastructure	54.8	57.0	58.6	59.7	58.5	57.3
6: Good Governance	8.8	4.8	4.7	3.6	3.7	5.8
All Themes	100	100	100	100	100	100
Costs in Million MWK	1.31909×10^{11}	1.27533×10^{11}	1.2636×10^{11}	1.2387×10^{11}	1.22424×10^{11}	6.36448×10^{11}

Between 2006 and 2011, in the sustainable economic growth theme, the minimum investment share allocated to agriculture, irrigation and water development was 6.5%. The bulk of the investment budget was allocated to infrastructural development. The MGDS indicated that "by 2011, 71% of the road network will be in good

condition; 18% in fair condition and 11% only in poor condition". On nutrition the MGDS planned to achieve "active healthy life with reduced burden of diet related, illness, deaths and disability among men, women, boys and girls living in Malawi".

Noteworthy, much research in Malawi has mainly focused on agricultural growth and impacts of Farm Input Subsidy Program (FISP). Looking at the investment figures, infrastructural investments and nutritional impact studies should have equally taken a leading role to get a whole picture on how these policies fared in the medium to the long run.

In 2011 the Government of Malawi introduced a second version of the Malawi Growth and Development Strategy (MGDSII) which prioritized entrepreneurship as a strategy to encourage all gender groups to participate fully in economic activities for wealth creation and poverty reduction. The government committed a substantial amount of resources to ensure that its goal of ensuring economic growth by encouraging entrepreneurship and innovation *see* Table 1.2 (Government of Malawi, 2011a).

TABLE 1.2: Government investment allocation to promote entrepreneurship for sustainable economic growth

Priority activity	Amount allocated in 2011 million MWK
Promoting women entrepreneurship and involvement in cooperatives	270
Improving youth access to credit facilities, capital and markets for sustainable entrepreneurship	594
Improving youth technical, vocational, entrepreneurial and business management skills.	20,704
Promoting equal access to appropriate technologies and micro finance schemes.	505

As implementation strategies, the government introduced entrepreneurship in school syllabus at primary, secondary and tertiary levels. It further provided microcredit to the youth and women through a dedicated fund which had straight forward streamlined rules for lending. The government established institutions to encourage innovation such as business incubation centers, village polytechnics, youth networks, youth-led Non-Governmental Organizations (NGOs) and centers (Government of Malawi, 2011a).

The MGDS II completed its five year implementation plan in 2016. However, no

rigorous assessment of the impact of the prioritized strategies was conducted. Therefore, it is against this background that this study would like to assess the impacts of some of the strategies of the MGDS such as food and nutrition security, infrastructure and promotion of entrepreneurship given Malawi market institutions' structure and conduct.

1.1.2 External shocks to the economy

Between 2011 and 2016, the MGDS II time frame, a number of macroeconomic, idiosyncratic and covariate shocks occured. At macroeconomic level, Malawi experienced a sudden shift in its exchange rate from a fixed to a market based flexible regime. Pauw, Dorosh, and Mazunda (2013) documented that the main culprits to the crisis were a rising import bill mainly attributed fertilizer imports to support the FISP, a reduction in tobacco exports which reduced its foreign exchange inflows and withdrawal of budgetary support from the Malawi Governments' main donors. These macroeconomic policy shocks could also reflect on domestic markets especially food markets by altering the structure and conduct of markets and eventually access to international markets. So far, no study has explored the organization of food markets during such tumultuous time period.

A number of floods and droughts due to El Nino weather conditions also affected the economy througout the five year period. Using a forward looking Computable General Equilibrium (CGE) model for Malawi, Pauw et al. (2011) found that income would generally decrease due to extreme weather events but households in the southern parts of the country will be the ones that lose most. So far, a confirmatory or falsifying *ex-post* externally valid study has not been conducted during the time period.

Furthermore, household specific shocks could also have perverse economic impacts on households. It is therefore the purpose of this study to explore, using the lenses of modern microeconomic theory, the impact of idiosyncratic and covariate shock on household food security.

1.2 Problem statement

The challenge of achieving zero hunger calls for a deeper understanding of fundamental drivers of food security. While increasing agricultural production is fundamental, increasing economic access to food could reduce the prevalence of undernourished people (Von Braun, 2017). Improving food security also requires efficiency of markets (Grote, 2014), institutions (Kirsten, 2009) and provision of physical support systems such as public infrastructure (Godfray et al., 2010). Noteworthy, worldwide, agriculture faces vagaries of climatic shocks. While impacts of climate change and other weather related shocks have been widely documented (Parry, 2019; Smit and Skinner, 2002; Adams, 1989), there is a lacuna in literature on how much soft and hard public infrastructure mitigate against impacts of seasonal shocks. Secondly, whether these shocks drive people out of agriculture to start new entrepreneurial ventures or people start new businesses while still in agriculture to cushion themselves against seasonal shocks is also not widely understood. Further, the institutional and behavioural determinants of food market performance and resilience in an African context are not extensively documented.

Using Malawi, a land locked developing economy in southeast Africa, as a case, this study is a collection of four distinct essays that relate to determinants of progress in achieving food security. In the first article, the impacts of seasonal weather and idiosyncratic shocks and the mitigating role of infrastructure are discussed. The second essay assesses the role of social capital in determining performance and resilience of maize trading businesses. The third paper examines the role of business registration on business performance. The fourth discourse analyses the distributional effects of entrepreneurship on food security. It delves into the mechanisms and implications of entry into entrepreneurial activities on food security.

1.3 Main research questions

The thesis asks the following guiding research questions:

1. What are the impacts of idiosyncratic and covariate shocks on food and nutrition security?

2. What is the mitigating role of public physical infrastructure on the the impacts of extreme weather events on household food security?

3. What is the contribution of off-farm entrepreneurship to food and nutrition security?

4. What are the food and nutrition security implications of the staple food market structure and conduct in Malawi? Specifically, what is the role of institutions and social capital in determining the structure and conduct of food markets?

1.4 A review of relevant literature

In what follows next, a review of the literature to reveal the state of the art and gaps for further studies regarding these questions is conducted. Thus, the review follows each question by reviewing closely related literature in order to develop hypotheses. At the end of each subsection, a summary of contributions this study makes is provided. The last subsection, therefore, presents the hypotheses guiding the study.

1.4.1 Impacts of idiosyncratic and covariate shocks on food and nutrition security

Idiosyncratic and covariate shocks could have significant impacts on food and nutrition security. An idiosyncratic shock is an event that a household experiences that other households in the same area are not experiencing with potential of affecting production and consumption possibilities (Pradhan and Mukherjee, 2018; Dercon et al. 2005). For example, death/birth of a family member, debt and sickness in the household. On the other hand, a covariate shock is an event that affects a number of households in an area. For instance, droughts, floods, conflict, pests and diseases (Dercon, Hoddinott, Woldehanna, et al., 2005; Pradhan and Mukherjee, 2018).

In an African setting, idiosyncratic shocks abound and their adverse impacts on food security and welfare are well documented. One widely documented idiosyncratic shock – with myriad implications – is prevalence of sickness at household level (*see* De Waal and Whiteside, 2003; Gillespie and Gillespie, 2006; Conroy et al., 2006).

For example, sickness and death of the household head have led to significant loss of household labour supply, which eventually leads to lower farm productivity, less output and eventually food insecurity. Sicknesses not only affect household food security through the production channel but also through the utilization and availability of nutrients in the body of sick individuals. Individuals' inability to absorb nutrients may lead to malnutrition. Compounded by sicknesses, food unavailability at household level may also lead to mounting debt. Since most households in rural areas have no access to insurance and credit facilities, the debt servicing premiums are usually high and lead to deepening food insecurity and poverty (Conroy et al., 2006).

While idiosyncratic shocks usually have adverse effects on food security, the effects of covariate shocks on household food security vary from household to household and have mostly been misunderstood. For instance, a drought in a community reduces crop production (Holden and Quiggin, 2016). Resultant food supply at market level reduces, which in turn raises prices (Timmer et al., 1983; Timmer, 2000). Households that are net food buyers have to spend more. In worst cases, this could lead to inability to access food leading to famine and starvation (Ravallion, 1987). Devereux (2007) called this an entitlement failure. From this view, covariate shocks could have negative effects on food security. On the other hand, for net food selling households, a drought, ceteris paribus, could lead to more sales revenue which could lead to more profits (Timmer, 2000). Higher profits from food sales could increase household total value added which could open up possibilities for more food consumption and dietary diversity through an income effect. Thus, covariate shocks could have positive effects on food security.

Covariate shocks could have heterogeneous effects on households. It is therefore, important to consider the structure of households when attempting to isolate their causal effects (*see* Azeem, Mugera, and Schilizzi, 2016; Harttgen, Klasen, and Rischke, 2015; Davies, 2010). For example, Foltz et al. (2013) assessed impacts of weather and temperature on welfare using total household consumption and food consumption. Using panel data from 1994 to 2004, the authors showed that rainfall did not have statistically significant effect of household consumption and on food consumption. However, the authors found that longer degree days had positive

effects on both consumption and food security while long dry spells reduced food and total consumption significantly. In most studies such as the aforementioned, one estimate for the effect of shocks on a food security outcome is estimated and conclusions and implications are drawn from such. The problem is that substantive impacts could be heterogeneous. For a complete understanding of impacts of covariate shocks, a disaggregated approach to the assessment of covariate shocks should not be overlooked. This study contributes to the understanding of the impacts of idiosyncratic and covariate shocks by examining different types of households together and separately to tease out the heterogeneity in the impacts. Treating the assessment of impacts from this perspective has the advantage of obtaining tailored policy implications for different households as compared to implications obtained from single coefficient generalized effects.

Some literature separates idiosyncratic and covariate shocks (Azeem, Mugera, and Schilizzi, 2016; Günther and Harttgen, 2009) . However, there is an overlap between idiosyncratic and covariate shocks – i.e. the two are highly correlated. For example, weather shocks in Tanzania – covariate shocks – lead to reduction in household incomes and later induced a 13 % probability of migrating – an idiosyncratic shock – (Miguel, 2005). In addition, Miguel (2005) also found that weather shocks such as droughts lead to increasing murder rates (idiosyncratic) in Tanzania. Kudamatsu, Persson, and Strömberg (2012) also found that droughts increased infant mortality in Africa. Their results indicated that infants were more likely to die if they were exposed to drought in utero and are born during hunger episodes. When a funeral occurs in a household and villagers leave their work to attend, does the is the shock only idiosyncratic or has it become covariate? Such correlations among shocks are usually ignored in literature. This paper attempts to bridge this gap.

1.4.2 Mitigating impacts of climatic shocks: the role of infrastructure

Diao and McMillan (2018) indicate that agricultural productivity growth in Africa will be triggered by deliberate investment. Collier and Dercon (2014) reported that effects of large investments in agriculture, that is predominantly smallholder farmer driven, are still unknown. What is clear though is that smallholder farming fails to be productive because of poor infrastructure which increases transaction costs.

However the study advocates building institutions that eliminate market failures such as insurance before heavily investing in smallholder agriculture. Sonwa et al. (2017) reported that although climate change has had negative impacts on production and consumption, spatially differentiated physical infrastructure plays a key role in mitigating climatic risks. Donaldson and Hornbeck (2016), using railway data from the United States from the 1890s and a general equilibrium theory in reduced econometric form, found that absence of rail roads reduce the value of agricultural land by 60%. In addition, Dorosh et al. (2012) found that although increasing proximity by opening up remote areas with infrastructure such as roads could increase crop production, demand constraints and transport costs may not immediately decrease if the new regions' production volumes and markets are not competitive. The study further advocates for complementing the investments with support institutions such as credit facilities and strong land tenure frameworks. Further, Banerjee, Duflo, and Qian (2012), using data from China found causal effects between sectoral per capita GDP but not on per capita GDP growth. They argue that factor mobility plays an important role in determining economic growth outcomes.

Literature shows that presence of public infrastructure such as roads improves economic productivity. Burgess and Donaldson (2010), for example, assessed the mitigating impact of openness to climatic shocks during the famine period in India's colonial era. Using railway data as an indicator of openness, the study found that openness reduced the effects of the famine. Skoufias, Essama-Nssah, and Katayama (2011) assessed impact of rainfall shocks on welfare in Indonesia using instrumental variable and propensity score matching techniques. While the authors found that rainfall shocks had negative effects on welfare, infrastructural projects had positive contribution to welfare. Noteworthy, Banerjee, Duflo, and Qian (2012), using data from China, assessed the impact of connectivity to economic growth. The authors' findings showed that connectivity had a moderately positive effect on GDP per capita.

As Burgess and Donaldson (2010) contended, openness through presence of infrastructure such as means of transportation can exacerbate effects of shocks. The study observed that a weather shock might affect availability of resources in one area. Through spatial arbitrage, resources may move from the area of abundance to

the area of scarcity. In the end, it may bid up prices in the area that did not experience a shock. Thus, openness through infrastructure provisioning could also increase effects of weather shocks. However, their results did not support the assertion.

Further, Arndt et al. (2012), using an economy wide model and a climate infrastructure model for Mozambique, found that climatic shocks would destroy physical infrastructure thereby reducing welfare. The study showed that the rising temperatures and increased rainfall intensity and flooding could lead to quick deterioration of road stocks. Nevertheless, the authors indicated that "the implications are not so strong as to drastically diminish development prospects." The study emphasized that African countries would continue experiencing increasing marginal productivity of infrastructural investments due to the scarcity of infrastructure.

While numerous studies show impacts of weather shocks and selected studies take it further to include infrastructure, none of the studies have analyzed how food security in form of food consumption expenditure and dietary diversity during shocks conditional on infrastructure provisioning. Thus, our study extends this narrow strand of literature by using novel indicators of infrastructure, weather shocks, food security and dietary diversity.

1.4.3 Idiosyncratic and covariate shocks, off-farm entrepreneurship, food and nutrition security

Covariate and idiosyncratic shocks could have significant implications on occupation choice and labour allocation at household level. Bezu and Holden (2014), conducting a study in Ethiopia, asked whether young people were abandoning agriculture. Their study descriptively showed a large proportion (30%) of youth engaging in some form of self-employment or business. Using a probit regression model, their study showed that when youths lived in areas that frequently experienced rainfall shortages, they were more likely to opt for self-employment or venture into entrepreneurship. The study is corroborated by Bandyopadhyay and Koufias (2012) who used nationally represented data from Bangladesh and concluded that households that live in areas with highly variable rainfall were more likely to diversify out of agriculture into other occupations such as businesses as a form of self-employment. Although the studies clearly showed that productive labour is

moving out of agriculture, they did not address implications the shift may have on food security outcomes. Does the movement result in increased food security and more diversified diets at household level? A more nuanced look at this question has not yet been addressed.

Further, Floro and Swain (2013) found that choice of a business is highly correlated to food security outcomes among vulnerable households in Bolivia. Using money shortage as an indicator of food insecurity, the study found that women were more likely to start a business in the food sector as an adaptation strategy to food insecurity compared to men. In addition, their study found that social networking, measured by years spent living in the city, increased the likelihood of starting a business in the food sector. Although very informative, several problems arise from the study. Firstly, money shortage, which proxies lack of purchasing power, may not be the best indicator of food shortage if the household a farming household. Thus, the relevance of the study in an African setting may be less since most households in Africa combine consumption and production decisions. A household that produces enough food but faces some immediate cash constraints may be reported as a food insecure household when this indicator is used. As a result more direct measures of food security which account for the quantity, quality and variation of food consumed should be accounted for.

Tracing determinants of occupational choice, Blattman, Fiala, and Martinez (2013) examined the effects of credit constraints on young adults in Northern Uganda from starting new businesses. The authors used a randomized control trial which gave participants an unconditional cash transfer. The study then observed whether the transfer payment led to a proliferation of new business ventures. The study showed that high ability individuals, who were patient became entrepreneurs while low skilled individuals remained as labourers. The authors concluded that when given cash transfers, credit constraints were relaxed and entrepreneurial activities increased. In addition, the study also found that women were more credit constrained than men. A similar study by Brudevold-Newman et al. (2017) conducted in Nairobi, Kenya provided bundled interventions to reduce credit constraints and direct transfer payments to induce entrepreneurial activity. Using a randomized control trial, the study found that reducing credit constraints among poor households

improved their income levels but did not induce entrepreneurship in years after the intervention. The study indicated that when women facing savings constraints receive large cash grants, it does not lead to consumption smoothing. Noteworthy, the study showed that cash transfers increased total earnings, wealth and expenditure. However, both studies did not attempt to examine the implications on food and nutrition security among vulnerable households. Noteworthy, the studies did not consider the nature of businesses. Therefore, without concretely and accurately describing the types of businesses involved, by simply indicating that they are in the agricultural/food sector, there remains a wide gap in quantifying and attributing the impacts. Further, the impacts could be heterogeneous. So far none of the recent studies reviewed have attempted to quantify such heterogeneity.

This study, therefore, attempts to extend this literature by examining the distributional impacts of off-farm entrepreneurship on food and nutrition security. The study presents the sources of heterogeneity by showing the types of off-farm business enterprises. Then, presents distributional assessment of the entry into entrepreneurship in different quantiles of income.

1.4.4 Staple food markets, traders, social capital and institutions: Implications for food and nutrition security

In the presence of economic disruptions such as climatic and idiosyncratic shocks, a clear understanding of the food industry structure and institutions that may affect its performance and resilience is required. Numerous studies have assessed the structure-conduct-and performance of food markets from an industrial organization perspective. For example, Beynon, Jones, and Yao (1992) conducted the earliest African review on the structure, conduct and performance of food markets in Eastern and Southern region. The review highlighted that public institutions ought to be reformed to improve performance of food markets. The study found significant market failures in input markets which eventually affected effective input demand. Further, the paper found that there were significant entry barriers for smaller firms into the food industry which undermines performance. In addition, the study observed that remoteness also affected pricing of strategic staple food commodities.

Since then, a number of studies have attempted to bridge the gap in literature on the role of public institutions in liberalizing food markets. For example, Goletti and Babu (1994), found that liberalization had increased market performance in major food markets but cautioned that the integration could be slower. Later, after the international food crisis in 2007, Minot (2010) found that maize prices in Malawi were more volatile than international prices and that the volatility in Malawi started much earlier in 2006. Further, Ochieng et al. (2019) recently found that market integration is still weak in maize markets and responds slowly to long-run equilibrium values.

In addition, several studies have addressed the role of government intervention in food markets in Malawi. Baulch (2018) used daily time series data to assess effects of in-kind food and or cash transfers during a 2017 food crisis in Malawi. Consistent with previous studies, Baulch (2018) found that markets were poorly linked but showed a structural break due to the food/cash transfers. The study found that food/cash transfers during the emergency response did not affect daily maize prices but provided direct entitlement to food despite weak purchasing power of beneficiaries. Further, Edelman and Baulch (2016) assessed impact of trade restrictions on maize and soya beans in Malawi. The study showed that government interventions through export bans led to less competitive markets in the country. Further, by limiting trade to only those with licenses the study found that it creates opportunities for rent seeking behaviour among major traders which could undermine competition.

The aforementioned studies have revealed that although markets were liberalized, food markets in Malawi are still far from efficient. In the absence of efficient support institutions and policies, adverse market outcomes are inevitable. In such environments, producers, consumers and traders often resort to informal institutions. As a case in point, during food crises, households often rely on kinship and social obligations as a source of informal social insurance. Margolies, Aberman, and Gelli (2017) calls this the subsistence ethic. The authors analysed the impacts of market interventions in form of food and cash transfers on food and nutrition security in Malawi. Their results showed that individuals relied much on their social networks in order to obtain resources such as food. While this arrangement is common among households, little is known about the subsistence ethic's influence on maize markets in terms of trader behaviour. In Ethiopia, Eleni (2001) showed significant

interactions between traders and brokers from the same origin. Further, De Weerdt and Fafchamps (2011) found that self-interested individuals are also involved in altruistic and unreciprocated transfers and risk sharing between kins. Thus, there is evidence of partial altruism in support of the subsistence ethic in addition to the self-interested rational economic agents among households. However, what is not known is to what extent households and other economic agent are following either reciprocal or unreciprocated transfers and risk sharing using social norms.

Noteworthy, none of these studies linked the role of social capital on market/trader performance. While there has been mention of the effects that trade restrictions could have on market outcomes, no empirical evidence was given, for instance, on how licensing through business registration could affect firm performance. Thus, there is still a gap in this strand of literature that this study fills by looking at trade and trader behaviour not only through neo-classical lenses but also from an industrial organization, institutional and behavioral economic perspectives to isolate drivers of food instability and pervasive welfare outcomes in the Malawi. This view would address the substantivist anthropological skepticism that most economic models do not fully represent qualitative and behavioural aspects of economic agents (Janvry and Sadoulet, 2005). In fact this study uses some ethnographic ground truthing techniques to substantiate the econometric techniques.

1.5 Hypotheses

In view of the reviewed literature, the following hypotheses have been postulated for the study:

1. There is food consumption, dietary variety, calorie and micro-nutrient intake decline among households after negative idiosyncratic and covariate shocks in Malawi.

2. Public physical infrastructure reduces the impact of agricultural season extreme weather events on food and nutrition security in Malawi.

3. Entrepreneurship has positive distributional effects on food security in Malawi.

4. Staple food markets in Malawi are not perfectly competitive and face significant institutional, physical and social capital constraints.

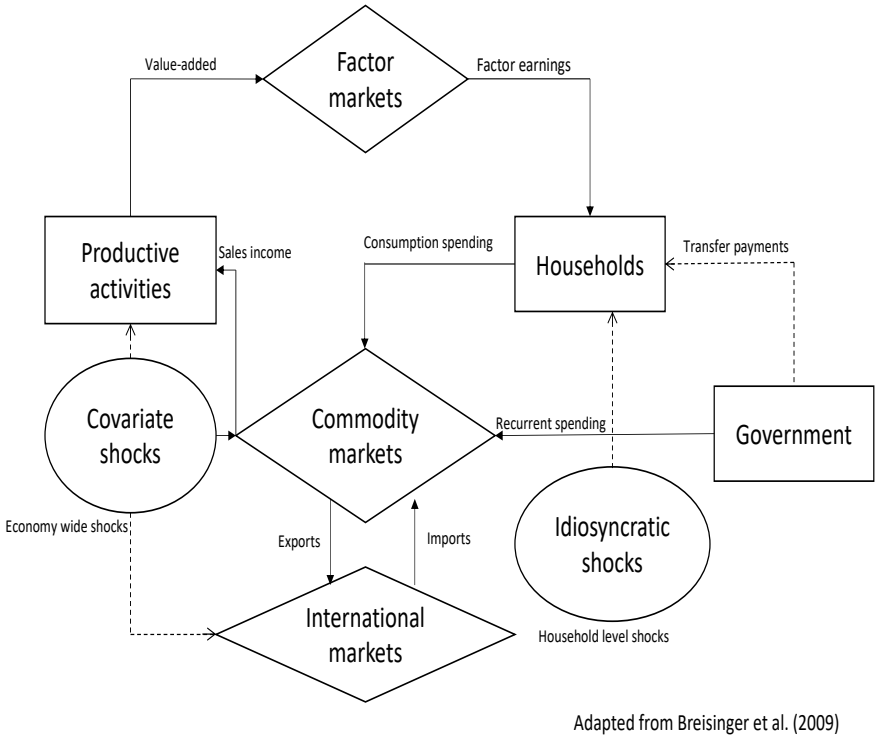
1.6 Organization and concept of the thesis

The thesis uses insights from standard general equilibrium modeling but proceeds with simpler tractable reduced form econometric techniques. Notable literature has followed this approach with profound results *see* (Donaldson and Hornbeck, 2016; Banerjee, Duflo, and Qian, 2012; Heckman, Lochner, and Taber, 1998). Figure 1.1 summarizes the general equilibrium framework showing households, markets, activities, expenditure links and impact pathways of shocks.

Chapter 2 examines economic disruptions, infrastructural investments, food and nutrition linkages in Malawi. It starts with agricultural households – i.e. the households box in figure 1.2 – who engage in production using constant returns to scale technologies. Households use factors of production comprising land, labour, managerial ability or entrepreneurship and capital which takes the form of direct inputs and public physical infrastructure.

We assume that households get factor payments from factor markets (the factor market trapezium in figure 1.2) since they are eventual owners of factors of production. Thus, the arrow from the factor market trapezium indicates transfer of factor earnings to households. Of note, any disruption to the factors of production affects factor earnings. For example a covariate shock (the left circle) such as a drought may affect factor earnings by reducing output from the productive activities rectangle and later household income. Household income is, therefore, a combination of factor earnings albeit with varying factor income shares and transfer payments. The dotted line from the government rectangle indicates transfer payments. Households can then use their income to purchase food in the commodity market (the outward going arrow from the households' rectangle). This simplified circular flow framework guides Chapter II's assessment of impacts of covariate shocks and the role of infrastructure to mitigate these impacts. During the analysis, we explicitly show behavioural equations and consumption functions that are theoretically consistent and econometrically estimable.

FIGURE 1.1: A conceptual framework linking different aspects of the thesis.



Chapter III examines market structure, conduct and traders' performance in Malawi's maize sector. In continuation, households buy and sell food items in the market place but the problem is that there are many farming households, few traders and many consumers. This chapter details the mechanisms affecting the behaviour of the commodity markets' trapezium. If markets behave in a competitive nature, then the market clears. If not, then some form of market power exists and welfare reduces.

Chapter IV is a natural extension of Chapter 3. It examines the role of informality in shaping market behaviour and outcomes. When the market faces many entrants through entrepreneurship, it increases its efficiency and in turn welfare – i.e. it results in an increase in incomes captured in equation (3). Thus, Chapter V examines implications of entry into entrepreneurship on household food security.

During the analysis, several mechanisms drive our results, we control for demographic, community, district, rural-urban location, survey round and various forms of endogeneity. We abstract from explicitly analyzing land and credit markets. This provides room for further research. The last chapter summarizes the thesis and presents policy recommendations.

Chapter 2

Infrastructure, extreme weather events and food security in Malawi

2.1 Introduction

We cannot end hunger if we ignore key complementary investments that enable resilience to economic disruptions. Investment in public infrastructure is significantly correlated with increased agricultural growth and welfare (Dorosh et al., 2012; Diao and Dorosh, 2007; World Bank, 2018). Hirschmann (1958) defined social overhead capital, hereinafter infrastructure, as resources and services which cannot be owned privately for social and institutional reasons. Hirschmann (1958) and Uzawa (1975) expounded that members of society may utilize the resources freely or pay some nominal charges that are regulated by a public entity. Recently, other quasi-public service-based structures also known as soft infrastructure are included as part of social overhead costs (Prud'Home, 2005).

Abundance or scarcity of infrastructure may change allocation of economic resources such as food by altering internal terms of trade and changing the structure of uncertainty regarding production and factor allocation decisions in rural economies (Platteau, 1996; World Bank, 2018). Hirschmann (1958) observed that when infrastructure is scarce, an increase in direct productive activities such as farming may exert pressure on infrastructure thereby calling for an increase in its investment. Christaller's central place theory and Heinrich von Thünen's model of agricultural land use also posit that human settlements would be around places that are adequately endowed with infrastructure. This way, such settlements could minimize

distances to access economic resources and also remove the possibility of making excess profits due to higher transport margins — such excess profits are also known as Thünen rents (Christaller, 1966; Getis and Getis, 1966; Von Thünen, 2009; Fischer, 2011).

In addition, Banerjee, Duflo, and Qian (2012) observed that proximity to infrastructure such as road networks in China had positive causal effects on per capita Gross Domestic Product (GDP). Therefore, absence of infrastructure such as roads or markets increase transaction costs which may limit access to economic resources such as food by increasing prices. Taking this view, absence to infrastructure may be an implicit tax to economically isolated individuals (Renkow, Hallstrom, and Karanja, 2004; Nissanke and Aryeetey, 2017). A household lacking access to infrastructure may need to pay extra costs in time and resources to access markets making it less competitive and more inclined to be autarkic and self-sufficient. When this happens, as earlier reported by Uzawa (1975), it may imply that the marginal productivity of social overhead capital is very high.

Using data from Madagascar, Minten et al. (1999) contended that longer distances to roads were rather associated with lower consumer prices. Minten et al. (1999) argued that longer distances are associated with higher economies of scale – making transportation of bulky commodities cheaper. This line of argument, however, only works when there is considerable connectivity. In most parts of Africa, however, it is not so. Most bulky commodities are still transported on foot, and by head load(Riverson, Carapetis, et al., 1991; Barwell et al., 2019). Given these issues, non-excludable physical infrastructure can, therefore, have positive welfare effects (Tilman, Dixit, and Levin, 2019).

Mechanisms explaining impacts of infrastructure on income distribution and hence food security are complex. Among the complexities, Prud'Homme (2005) observed that infrastructure is often viewed from the capital goods perspective rather than the services and the institutions involved. In fact, earlier policy analysts preferred to deal with physical availability of infrastructure because monetary investments were often not available, and if available, mostly questionable. Prud'Homme (2005) also observed that treating infrastructure by actual observation in this manner was advantageous because it is lumpy e.g. a bridge is only useful once it is complete.

Quantifying effects of infrastructure on economic outcomes is also complicated by the fact that infrastructure is long-lasting. Donaldson and Hornbeck, (2016) observed that railway instalments had lasting impacts such that a counterfactual scenario of removing them reduced the value of agricultural land in the United States of America by 60%. Further, although the Roman road network has been in existence for over two millennia, Garcia-López, Holl, and Viladecans-Marsal (2015) observed that the investments made by the Romans of old still shape economic activity in Europe today. The findings on long lasting effects of infrastructure are also confirmed by studies by (Palei, 2015; Goldsmith, 2014).

Noteworthy, Binswanger, Khandker, and Rosenzweig (1993) and Donaldson (2018) argued that infrastructure is endogenous such that its placement is often influenced by region and micro-climatic specific factors. Prud'Homme (2005) also observed that infrastructure is space specific. As an illustration, an irrigation project may only be restricted to locations that are conducive for such investments making its assignment a function of location.

Market failures, externalities, and government failure also plague infrastructural investments (Prud'Homme, 2005). As an example of the latter, Banerjee, Duflo, and Qian (2012), Guasch, Laffont, and Straub (2007), and Boarnet (1997) reasoned that government administrators might have their own preferences that guide the politics of infrastructure delivery. Such decisions result in winners and losers from infrastructure investments. In African agriculture, politically strategic investments that are critical for increasing agricultural productivity and resilient livelihoods in the long-run such as infrastructure are often not prioritized in favor of meeting immediate consumption needs of some groups in society for political expediency (Raballand et al., 2011). Thus, any attempt to assess distributional and welfare effects of infrastructure must also adequately account for these sources of endogeneity.

2.1.1 The connection between infrastructure and shocks

Arezki and Sy (2016) reported that the African continent faces risky infrastructure deficiencies which make it suffer considerable diseconomies of scale. In the absence of proper infrastructure, effects of extreme events such as weather related shocks and unusual price fluctuations in addition to household specific idiosyncratic shocks can

be deleterious. In fact, the African Development Bank (2014) reported that in Africa, due to lack of connectivity, costs of service delivery range between 50 – 175% higher than anywhere in the world.

Further, Arndt et al. (2012) assessed effects of climate change on economic growth in Mozambique using a computable general equilibrium model. The study showed that in future – 2050 in particular, climate change in form of high precipitation of drought may destroy existing infrastructure thereby increasing maintenance costs. In addition Arndt et al., (2012) also indicated that although the study showed that shocks could reduce economic growth and increase cost of infrastructure investments, such a future should not deter investments. Noteworthy, the study was macroeconomic level focused and did not show microeconomic adaptation and impacts on consumption or income distribution.

Chinowsky et al. (2015) assessed the effects of climate change on road infrastructure in Malawi, Zambia and Mozambique between 2010 and 2050. Using a stressor-response model under different IPCC scenarios to assess impacts of precipitation, floods and temperature on paved and unpaved road infrastructure in Malawi, the authors showed that climatic shocks could raise costs of construction and maintenance by USD21 million discounted 2010 values in Malawi. Chinowsky et al. (2015), however, omitted social economic impacts.

In addition, Asfaw and Maggio (2018) found that weather shocks were severe among female headed households. The authors measured shocks as deviations from the historical average without accurately accounting for crop output responses which directly links to food security outcomes. Such an omission could overestimate the actual impacts. To contribute to that inquiry, we use a more novel long term Standardized Precipitation – Evapotranspiration Index (SPEI) (Vicente-Serrano, Beguería, and López-Moreno, 2010; Kubik and Maurel, 2016) drought index that adjusts for precipitation, potential evapo-transpiration to determine whether an event was truly extreme at different monthly intervals. Kubik and Maurel (2016) have revealed that SPEI performed much better that previous methodologies such as the one used by Asfaw and Maggio.

Malawi has also had a recent history of combined extreme weather and economic shocks, which due to its low infrastructural investment levels, have undermined its

growth prospects (World Bank, 2018). For example, during the 2015/16 agricultural season, floods, due to extreme El Nino weather, displaced farming communities in southern Malawi making them unable to both produce and thereafter earn income for a living (Nation Publication, 2017). According to the Malawi Government's Department of Disaster Management Affairs (DoDMA) and United Nations Office of the Resident Coordinator, about 87000 people were affected by floods in 2019 that were caused by a cylone, named Idai (Government of Malawi (GoM) and United Nations, 2019). The report showed that nearly 90000 people were displaced, infrastructure in form of transport networks, electricity was also destroyed.

This paper, therefore, assesses the impact of household shocks on food security in Malawi conditional on infrastructural investments using food budget shares, Berry and Shannon indexes of dietary variety as key dependent variables. Since some areas are well endowed with infrastructure than others – i.e. the space specificity of infrastructure – and some experienced extreme weather events within the time frame, this presents a natural experiment. Therefore, we use a dose-response kind of difference-in-difference-in-difference approach to identify the effects. That is, we partial out the changes due to extreme weather, infrastructure and eventually time.

In a panel data setting, this adds value to the growing literature, which has mostly relied upon cross-section data (Harttgen, Klasen, and Rischke, 2015), small non-representative samples Harttgen, Klasen, et al., 2012 and computable general equilibrium (CGE) models (Pauw, Dorosh, and Mazunda, 2013), by bringing evidence from three waves of nationally representative surveys with a simple, theoretically consistent and clearly identified methodology.

The study also triangulates the self-reported drought incidence with high-resolution long-term gridded weather data at $0.5^\circ \times 0.5^\circ$ longitude-latitude grid cells. To further triangulate the survey data on access to infrastructure, we use remote sensed Night Time light data at the same grid level as the SPEI data. To the best of our knowledge, this study is the first to combine high-resolution data and micro data to assess the mitigating role of infrastructure on food and nutrition security during crises in Malawi. Combining big data and representative, country level data enhances the precision and accuracy of impacts of shocks – which goes a long way to achieving evidence based policy analysis.

The paper is structured as follows: Section 2 presents the methodology and data. In this section we describe a micro-economic theoretical framework on which our analysis is based. We use the theory to guide our econometric identification and estimation. Then we present sources of data and construction of key variables while getting insights from literature. In section 3 we present key results of impacts of seasonal shocks on household food security and impacts of community infrastructure on food security. In Section 4 we present a discussion of key results while in section 5 we provide a summary and conclusion.

2.2 Methodology

2.2.1 Theoretical framework

Public infrastructure could help cushion the household from the impacts of economic shocks by smoothing consumption. Following notation from Sadoulet and De Janvry (1995), Jacoby (2000), and Liu and Henningsen (2016) with modifications, we assume that households maximize their utility

$$u = u(X, C, Z, M^h) \tag{2.1}$$

where $X = \{x_1, \ldots, x_n\}$ is a set of home produced crops, $C = \{c_1, \ldots, c_k\}$ is a set of imported commodities; and $Z = \{z_1, \ldots, z_m\}$ is a set of other non-imported commodities and $M^h = \{m_1, \ldots, m_k\}$ is a set of household specific characteristics.

Households engage in production of crops $Y = \{y_1, \ldots, y_n\}$ using a well behaved multi-input multi-output production technology that constrains utility. Thus, for a unit of output y_i the production function is

$$y_i = f(a_i, l_i, q_i, M^p) \tag{2.2}$$

where a_i is land; l_i is labour; $q_i = \{q_1, \ldots, q_m\}$ is a vector of inputs such as fertilizer; and $M^p = \{m_1, \ldots, m_k\}$ is a set of farm specific conditions including weather conditions represented by SPEI.

We define crop prices that the households in location τ face as $P^x = \{p_1^x, \ldots, p_n^x\}$. Due to differences in infrastructure provisioning, e.g. some communities could have better roads, markets, electricity, among others, prices carry along transaction costs. For instance, let $\tilde{p_i}^x = p_i^x - bh$ be the price the net producer household faces in the market after considering the cost b of traveling h hours to the market. Another consideration might be the case when the household faces electricity power shortages to process their farm output for the market. Thus, if a household is a net buyer it will face a price of $\tilde{p_i}^x = p_i^x + bh$. Further, input costs are also obtained with transaction costs, $\tilde{v} = v + bh$, where $v = \{v_1, \ldots, v_m\}$ is a set of input prices; $\tilde{w} = w + bh$ is the wage and $\tilde{r} = r + bh$ is the land rent (Jacoby, 2000). Thus, a farm household facing infrastructure constraints will seek to maximize returns to its productive activities as follows

$$\rho(\tilde{p_i}^x, \tilde{w}, \tilde{v}, \tilde{r}) = \tilde{p}^x \cdot Y - \tilde{v} \cdot q_i - \tilde{w} \cdot (l - T) - \tilde{r} \cdot a_i \tag{2.3}$$

which leads to a household budget constraint of the form

$$P^x \cdot X + P^c \cdot C + Z \leq \tilde{p}^x \cdot Y - \tilde{v} \cdot q_i - \tilde{w} \cdot (l - T) - \tilde{r} \cdot a_i + E_i \tag{2.4}$$

where the price of commodity Z has been normalized to 1 and E_i is any exogenous income such as transfer payments or other income from off-farm businesses. Given first order conditions, we get a set of demand equations $X^* = \{x_1^*, ..., x_n^*\}$; $C^* = \{c_1^*, ..., c_m^*\}$ and $Z^* = \{z_1^*, ..., z_n^*\}$ which are functions of prices $\tilde{p_i}^x, \tilde{p_i}^c, \rho(\tilde{p_i}^x, \tilde{w}, \tilde{v}, \tilde{r})$ and E (Sadoulet and De Janvry, 1995). These demand equation give rise to the indirect utility function

$$\Psi\left(\tilde{p_i}^{x*}, \tilde{p_i}^{c*}, \rho(\tilde{p_i}^{x*}, \tilde{w}, \tilde{v}, \tilde{r})\right). \tag{2.5}$$

Define Ω as a piece of infrastructure such as a road or market, among others[1]. Constructing a good road reduces economic isolation by reducing transaction costs. Let $\sigma^h(\Omega, h) = \rho^h(\tilde{p_i}^x, \tilde{w}, \tilde{v}, \tilde{r})$ be the income situation of the household after the

[1]While the use of a road infrastructure seems reductionist and overtly simplistic, it serves to make the model didactic and readable. In practice, infrastructure services that were not captured in earlier studies such as information, credit, banks, cooperatives, insurance trailing the social overhead capital are included in the composite infrastructure index. Thus, the simple theoretical model could easily be extended to other examples of infrastructure. Hirschmann (1958) observed that using roads and power alone could account for all the other soft and hard infrastructure. During the construction of the composite index we will test this hypothesis.

infrastructure project in location $\tau = 1$. Thus, due to changes in transaction costs, profits, incomes and therefore demand for food commodity bundles may change while in a location without infrastructure $\tau = 0$ the may not (Jacoby, 2000; Jacoby and Minten, 2008).

In addition, we define $G(h, a)$ as the joint cumulative probability distribution function for distance from the market and the land endowments, we can define the social welfare function as

$$W(\Omega, h) = \int_a \int_0^{\bar{h}} \Psi \left(\tilde{p}_i{}^{x*}, \tilde{p}_i{}^{c*}, \rho^h(\tilde{p}_i{}^{x*}, \tilde{w}, \tilde{v}, \tilde{r}) \right) dG(h, a). \tag{2.6}$$

Differentiating the welfare function with respect to Ω gets

$$W_\Omega = \int_a \int_0^{h*} \Psi' \left(\tilde{p}_i{}^{x*}, \tilde{p}_i{}^{c*}, \rho^{h'}_\Omega(\tilde{p}_i{}^{x*}, \tilde{w}, \tilde{v}, \tilde{r}) \right) dG(h, a). \tag{2.7}$$

In this case, W_Ω measures the change in welfare with respect to the infrastructural endowment. On the other hand, if we differentiate the equation 2.7 with the M^p variable i.e.

$$W_{\Omega, M^p} = \int_a \int_0^{h*} \Psi''_{M^p} \left(\tilde{p}_i{}^{x*}, \tilde{p}_i{}^{c*}, \rho^{h''}_{\Omega M^p}(\tilde{p}_i{}^{x*}, \tilde{w}, \tilde{v}, \tilde{r}) \right) dG(h, a) \gtrless 0 \tag{2.8}$$

is the unknown mitigating role of infrastructure on impact of extreme weather events.

2.2.2 Estimation

Anand and Harris (1994) and Deaton (2019) reported that food consumption indicators can be used to measure welfare changes. Thus, without losing much details, we assume that the indirect utility function can be adequately represented by food consumption behaviour at household level. We can econometrically estimate the food consumption behaviour (*see* Deaton (2019, Chapt. 4)) for household i in community

j at time period t as

$$
\begin{aligned}
W_{ijt} = {} & \beta_0 + \beta_1 \times T_{2013} + \beta_2 \times T_{2016} \\
& + \beta_3 \times \text{SPEI}_{ijt} \\
& + \beta_4 \times \text{CII}_{ijt} \\
& + \beta_5 \times 2013 \times \text{SPEI}_{ijt} \\
& + \beta_6 \times 2016 \times \text{SPEI}_{ijt} \\
& + \beta_7 \times 2013 \times \text{CII}_{ijt} \\
& + \beta_8 \times 2016 \times \text{CII}_{ijt} \\
& + \beta_9 \times \text{SPEI}_{ijt} \times \text{CII}_{ijt} \\
& + \beta_{10} \times 2013 \times \text{CII}_{ijt} \times \text{SPEI}_{ijt} \\
& + \beta_{11} \times 2016 \times \text{CII}_{ijt} \times \text{SPEI}_{ijt} \\
& + \beta_{12} \times X_{ijt} + \tau_j + e_{ijt}. \qquad (2.9)
\end{aligned}
$$

where $\ln W_{ijt}$ is the food budget share; food expenditure, dietary variety or a proxy index of consumption per person per day in year $t \in T$. The time is represented by time dummies; X_{ijt} is a vector of household level characteristics; β_i are unknown parameters to be estimated; τ_j are community fixed effects; SPEI_{jt} is a 3-month interval SPEI; CII_{jt} is a composite infrastructure index; e_{ijt} is an independent and identically distributed error term. We also assume that $E(e_{ijt}|X_{ijt}, \tau_i) = 0, \quad Var(e_{ijt}|X_{ijt}) = \sigma_e^2, \quad \forall t \in T$ and $Cov(e_{ijt}, \tau_j|M) = 0$ (Woodridge, 2009). In addition to the assumptions advanced in equation 2.9, one requirement for identifying causal effects is that the explanatory variable of interest i.e. infrastructure should not be correlated with the error term. That is, $cov(CII_{jt}, e = 0)$.

The parameters β_5 to β_8 represent time varying impacts of SPEI and CII on food security, respectively. The interaction represented by β_9 represent the average joint effect of SPEI and CII over time. The parameter β_{10} is the intermediate joint impact of CII and SPEI on food security during the second wave. Our parameter of interest is β_{11} which measures the joint impact of extreme weather events and infrastructure i.e. the difference - in - difference - in difference estimate. Because of the continuous nature of the infrastructure index and the drought index, the set up in equation 2.9

is a time-varying, continuous treatment triple differencing technique. Such a set up has been examined by Angrist and Pischke (2008), Dettmann, Giebler, and Weyh (2019), and Lins, Servaes, and Tamayo (2017, pp.138). The framework maintains the parallel trend assumption – that is, without investments in infrastructure during 2010 till 2016, the changes in food security outcomes of households with access to infrastructure and those without would be the same among comparable explanatory variables. That is, taking $t = 1, 2, 3$, and for comparison assuming minimum infrastructure access for one group and maximum access for the other and dropping the subscripts for readability, it should hold that

$$E[W_0(3)|X, CII_{max,spei}] = E[W(1)|X, CII_{max} + E[\Delta W(3)|X, CII_{min,spei}. \tag{2.10}$$

Given this condition, the average treatment effect on the treated can be given as

$$ATT = E[\Delta W(3)|X, CII_{max,spei}] - E[\Delta W(3)|X, CII_{min,spei}. \tag{2.11}$$

To ensure that this holds in our data while following Dettmann, Giebler, and Weyh (2019), Fong, Hazlett, Imai, et al. (2018), Ho et al. (2011), and Hirano and Imbens (2004) we balanced the covariates in the baseline using coersened matching. Coarsened Exact Matching (CEM) coerces each of the explanatory variables to some limits within which matching can easily take place. For example, given a continuous variable such as distance to markets or age of the household head, an analyst can coerse the variable by recoding it into categories such as $0 < 20$, $20 - 30$ and so on. Doing so gives the analyst more discretion on how to deal with each variable, reduces model dependence, and reduces bias as an improvement in balance in one variable due to coersion does not affect other variables' balancing outcomes. Further, it prevents the problem of losing data due to model dependence (Iacus, King, and Porro, 2012). King and Nielsen (2019) likens the discretion in CEM to the one in creating bins for histograms. The outcome of the CEM exercise is driven by prior knowledge of the relative importance of the variables and when the matching approximates a fully randomized block design.

Data balancing is achieved by first creating bins for all numerical variables. After that, a multivariate cross-tabulation of the binned variables is created. Finally, Iacus, King, and Porro (2012) uses the L_1 statistic to analyze the covariate imbalance as follows

$$L_1(f,g) = \frac{1}{2} \sum_{l_1,\ldots,l_k} |f_{l_1,\ldots,l_k} - g_{l_1,\ldots,l_k}| \tag{2.12}$$

where f and g are the empirical distributions of treated and control groups [2] while $l_1,\ldots,l_k$ are the respective multivariate cell location coordinates. The difference is not only measured at the mean only but also at different quartiles. We triangulate the CEM matching with full optimal matching in which we allow one treated observation to one or more control observations (Hansen, 2004).

We implemented the CEM technique using the `CEM` (Iacus, King, and Porro, 2012) and `MatchIt` R package (Ho et al., 2011) in RStudio (RStudio Team, 2019). Matched observations were then used for further analysis while the observations that did not find any matches after CEM were discarded.

2.2.3 Data and descriptive statistics

Data used in this study came from three waves of Integrated Household Surveys (IHS3, IHSP and IHS4) of the National Statistics of Malawi (NSO). The surveys were conducted in 2010, 2013, and 2016 with support from the World Bank's Living Standards Measurement Survey and Integrated Surveys for Agriculture (LSMS-ISA) project. A stratified two-stage sample design was used for the IHS panel surveys and a sample size of 2,508 households was collected. The NSO reported that the surveys are representative at national level, rural/urban, regional and district-level.

Dependent variables considered

Food budget share: Using the consumption module of the IHS questionnaire, we computed quantities of food consumed per day per capita. The IHS questionnaire

[2] For purposes of balancing the data, a dummy variable equal to 1 was created for households with access to infrastructure and 0 otherwise. Access to infrastructure is presented by a standardized index introduced later.

groups foods in categories of cereals, vegetables, meat etc. In each group, we calculated specific quantities of food consumed and how much the food costed. Assuming that the marginal cost of consuming food that was home produced was its market price, we converted the quantity of the food consumed at home by the median market price to get the value of food consumed. We then transformed the value of the food consumed by adjusting it for adult equivalence scales. For ease of interpretation, food consumption expenditure was transformed into food budget shares by dividing the food expenditure by the total household expenditure. Figure 1 summarizes results of the food budget. Although results are not significantly different across the regions (North, Center and South), results show a significant increase in the cost of food over the past six years. Generally, results show a two-third rise for a period of six years.

Berry index of dietary variety: After calculating the quantities of food consumed, we also assessed dietary diversity by counting the total number of food commodities a household consumed in the last seven days. This roughly gives the household dietary diversity score. Then we calculated the share of each food item in the value of food consumed. We calculated the Berry-Index of dietary variety as $BI = 1 - \sum_i s_i^2$ where s_i is the share of the food consumed. A larger index means that the individual consumes a wide variety of foods (Drescher, Thiele, and Mensink, 2007). Across all regions and years are quite low (less than 0.5). This shows that dietary diversity is very low across the country.

Shannon Entropy Index: To corroborate the Berry Index, we also computed the Shannon Entropy Index of dietary diversity. The Shannon Entropy Index is defined as $E = \sum_i^n s_i \log \frac{1}{s_i}$ where s_i is as defined above. Lower values of the entropy index imply lower dietary diversity while higher values reflect highly diversified diets(Liu, Shively, and Binkley, 2014)

A typology of self-reported household shocks

Table 2 summarizes 20 self-reported shocks in the study. We obtained the shocks from the household questionnaire and cross-checked them with the community questionnaire of the IHS. Results indicate varying occurrences of shocks during the baseline. Of note, Table 3 summarizes measures of association between shocks. The

specific names of the shocks have been shortened to the first three letters of the names presented in Table 3 to save space. We corrected the relationships with a Bonferroni adjustment – a correction applied when multiple null hypotheses are being tested to reduce the probability of incorrectly rejecting the null hypothesis, due to a rare event, when in fact the null hypothesis is true. As shown some shocks show statistically significant correlations that have economic meanings at $p = 0.05$. For instance, high incidence of flooding is associated with a 22% increase in crop pests. Pests and diseases have a mutually reinforcing association with a magnitude of 35% while high agricultural input costs are associated with 16% and 15% increase in incidences of pests and diseases, respectively. Incidences of floods, pests and high input costs are associated with food price increases of 12%, 13% and 27%, respectively. Occurrence of death of the household head is associated with a halt in earnings from salaried employment with a magnitude of 13%. Considering the large number of shocks reported in the study and how closely related some of the shocks are, we have a dimensionality problem. In order to reduce the number of highly related variables, we used Principal Component Analysis (PCA). PCA results (details not presented), using a minimum factor loading of 0.3, identified three key groups of shocks namely price related shocks labelled (a); extreme weather events (b); livestock and diseases (c) and household mixed distress events in Table 2. Thus, the analysis proceeds in assessing impacts of these four categories of shocks.

TABLE 2.1: Shocks used in the study

	Distress events (Shocks)	Percent
1	Drought/Irregular Rains	55.57[b]
2	Floods/Landslides	5.52[b]
3	Earthquakes	4.57
4	Unusually High Level of Crop Pests or Diseases	8.85 [c]
5	Unusually High Level of Livestock Diseases	8.18[c]
6	Unusually Low Prices for Agricultural Output	34.45[a]
7	Unusually High Costs of Agricultural Inputs	71.08[a]
8	Unusually High Prices for Food	85.60[a]
9	End of Regular Assistance/Aid/ Remittances	13.30
10	Reduction in the Earnings from Household	9.77[a]
11	Household (Non-Agricultural) Business Failure	7.39[d]
12	Reduction in the Earnings of Currently head	3.41[d]
13	Loss of Employment of Previously Salaried employment	1.14[d]
14	Serious Illness or Accident of Household	18.74[d]
15	Birth in the Household	4.00[d]
16	Death of Income Earner(s)	1.90
17	Death of Other Household Member(s)	7.14[d]
18	Break-Up of Household	9.13[d]
19	Theft of Money/Valuables/Assets/Agricultural output	5.61[d]
20	Conflict/Violence	5.61

NOTE: Letters a,b,c and d refer to groups selected by Principal Component Analysis using varimax rotation.

FIGURE 2.1: Descriptive statistics of variables used in the study. Results are disaggregated by variable type, survey period and geographic region. This panel summarizes continuous variables beginning with dependent variables and explanatory variables used in later regression models. Age of the household head and food budget are in halved logarithms while all distances are in log transformed kilometers.A dot represents a mean of the variable X and the lines to the left and right of the dot represent the lower and upper 95% confidence intervals, respectively.

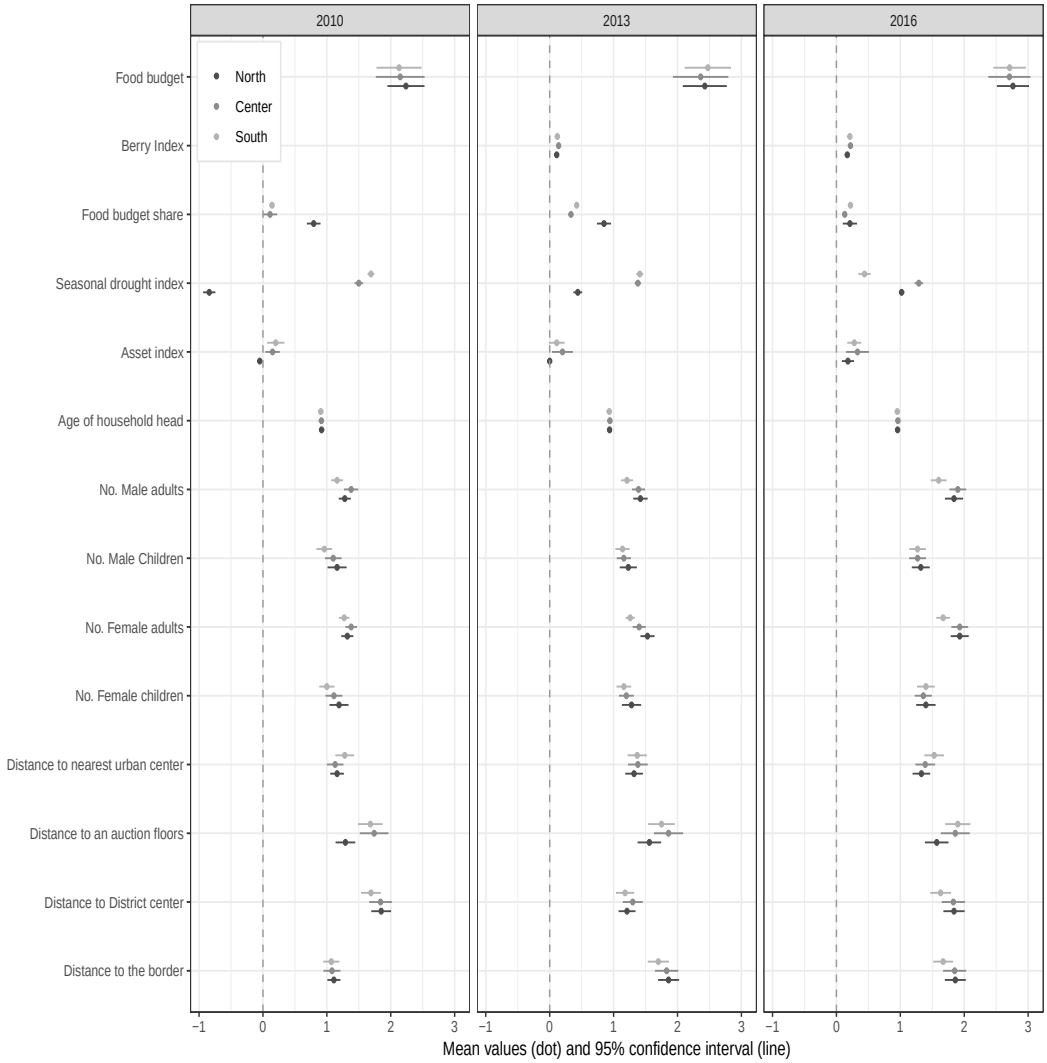


FIGURE 2.2: Summarizes categorical variables which are presented in proportions. A dot represents a proportion of the dummy variable $X = 1$ otherwise $X = 0$ while the lines to the left and right of the dot represent the lower and upper 95% confidence intervals, respectively. A full detailed table is provided in Table 4.

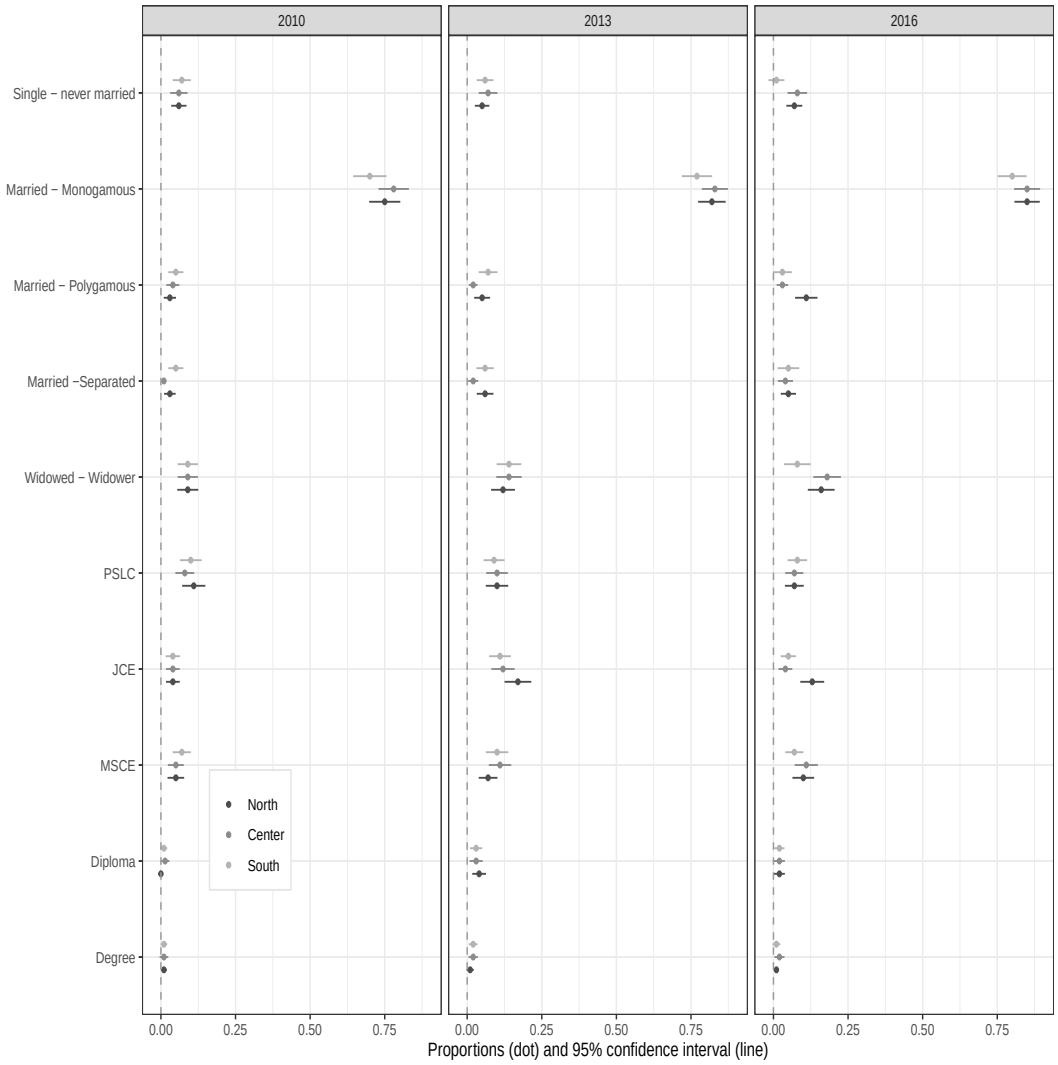


TABLE 2.2: Pearson correlation coefficients between household shocks.

	DRO	FLO	EAR	PES	DIS	COS	FOO	AID	EAR	BUS	SAL	EMP	ILL	BIR	DEA	DEO	THE	CON
DRO	1																	
FLO	.074	1																
EAR	.021	.107	1															
PES	.063	.218*	.044	1														
DIS	.057	.110	.068	.347*	1													
COS	-.046	.073	-.006	.164*	.154*	1												
FOO	-.081	.121*	-.048	.130*	.082	.273*	1											
AID	-.055	.015	-.035	.058	.042	.062	.078	1										
EAR	-.057	.052	-.024	.083	.057	.024	.068	.027	1									
BUS	-.109	.006	-.039	.003	.048	-.050	.033	.007	.127	1								
SAL	-.064	.025	-.031	.027	-.018	-.002	.099	.065	.071	.014	1							
EMP	-.030	-.026	-.024	.030	.033	.025	.046	.041	.022	-.019	-.015	1						
ILL	-.042	.023	-.047	-.021	-.019	-.062	-.017	.018	-.029	.014	-.016	-.052	1					
BIR	-.013	-.007	.002	.005	.010	-.003	.001	-.032	.005	.020	.006	-.022	-.036	1				
DEA	-.002	.027	.003	.079	-.016	-.011	-.008	.067	.074	.056	.129*	-.015	.022	-.028	1			
DEO	-.094	.046	-.043	.031	-.015	-.069	-.064	.027	.014	-.006	.066	.005	.009	-.019	.097	1		
THE	-.115*	-.004	-.069	-.052	-.046	-.049	-.056	-.008	-.034	.021	.002	-.003	-.008	-.014	-.020	-.024	1	
CON	-.048	.013	-.014	.040	.033	-.025	-.011	.068	.010	.029	-.005	.013	.010	-.008	.057	.013	.009	1

NOTE: Pearson correlation coefficients after Bonferroni adjustment
*Significantly different from zero at 95 percent confidence
DRO =Drought/dry spells; FLO= Floods/Landslides; EAR= Earthquakes; PES=Crop Pests or Diseases; DIS = Livestock Diseases
COS= Costs of Agricultural Inputs; FOO=High Prices for Food; AID=End of Aid/ Remittances; EAR=Reduction in the Earnings;
BUS= Business Failure; SAL= Reduced earnings of head; EMP= Loss of Employment;ILL= Serious Illness; BIR= Birth in family
DEA=Death of head in family; DEO= Death of other family member; THE= Theft; CON= Conflict.

Seasonal drought and floods

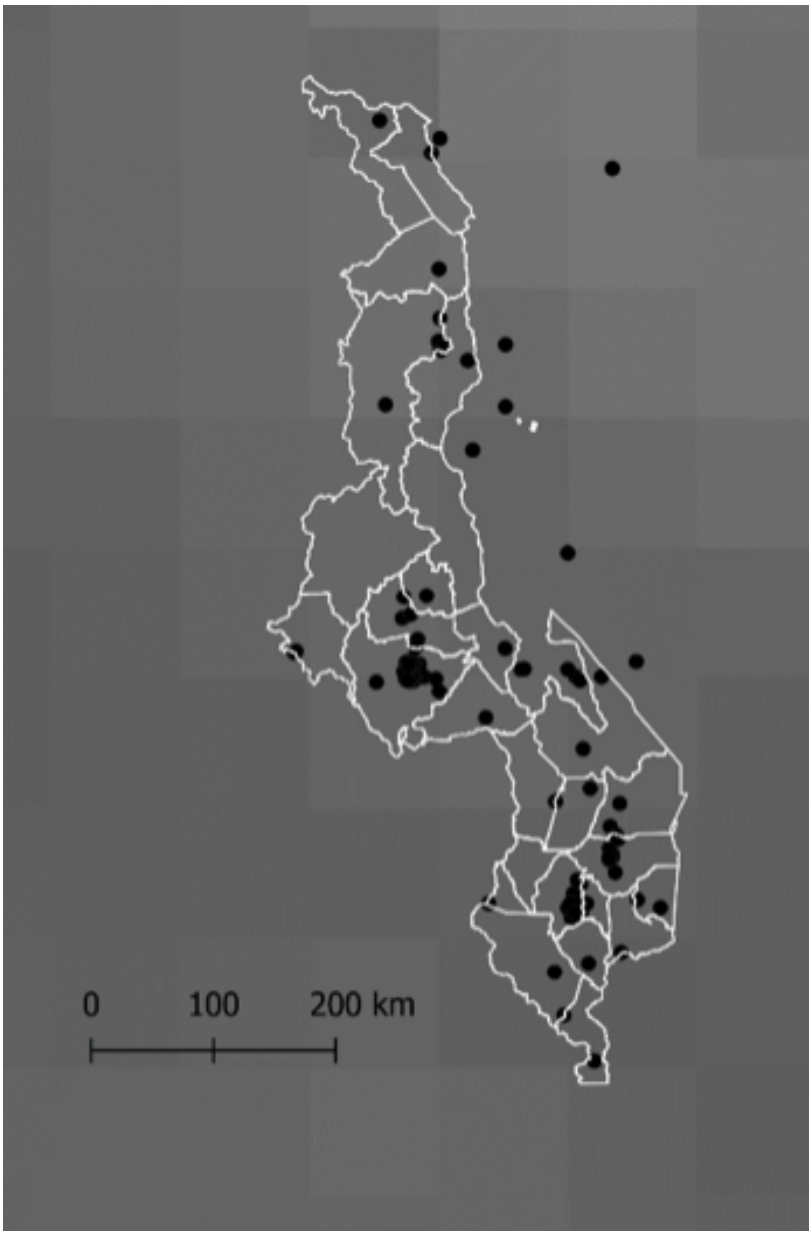
The IHS data is geo-referenced. We therefore use the GPS coordinates from the survey and map them on a global Standardized Precipitation-Evapotranspiration Index, which provides near real-time data on drought conditions with a $0.5^\circ \times 0.5^\circ$, longitude by latitude spatial resolution and a monthly resolution of up to 48 months. The SPEI index uses Vicente-Serrano et al. (2010) method of calculating deviations from the mean water balance. Thus, the SPEI calculates drought condition by taking precipitation subtracting potential evapotranspiration. This method is better than other methods because it accounts for two important aspects of drought conditions namely rainfall and temperature conditions which are essential for crop production. Since the data collection covers the entire year, we use the December to March period as a measure of the rain season. Since the historical SPEI is standardized, with mean zero and standard deviation of one, positive values will refer to high precipitation while negative values will mean dry spells. In general, Malawi covers 16 full $0.5^\circ \times 0.5^\circ$ longitude by latitude spatial resolution (figure 3) which also cover its 8 agro-ecological zones which contain 21 meteorological Stations.

With the exception of the northern region in IHS3, results presented in Figure 1 indicate that, as a country, Malawi experiences a sufficiently wetter agricultural season. This is evidenced by all mean seasonal drought index values lying to the right of the zero dotted line across all years. Few districts in the North experienced some dry spells during the 2010 and 2013 growing season. Importantly, results indicate that seasonal drought incidence varied widely across the country and over the three survey periods. F-test comparison of means (represented by an asterisk in Figure 1) shows that seasonal drought conditions were significantly different across the survey periods ($p < 0.01$) and also across the regions ($p < 0.01$).

Infrastructure availability

We obtained infrastructure data from the IHS surveys and US National Oceanic and Atmospheric Administration. We used the Defense-Meteorological Satellite Program-Optical Line Scanner (DMSP-OLS) Night Time Light (NTL) data gathered by NOAA and NASA's polar orbiting satellites that take pictures which cover the

FIGURE 2.3: Map of Malawi showing the $0.5^\circ \times 0.5^\circ$, longitude by latitude spatial resolution grid. Noteworthy, every 4 grid cells approximately correspond to the country's agro-ecological zones. The dots are sampled geographical points.



entire earth twice per day. The data is presented in form of raster images. The data presents points illuminated by electricity across the planet in form of near infra-red radiance. The data is presented in two spatial resolution modes namely full resolution and smoothed data. We used the smoothed data which was constructed using a nominal spatial resolution of 2.7 km at 30 arc-seconds, covering $180°W$ to $180°E$ longitude and $75°N$ to $65°S$ latitude.

Using QGIS 3.6, we extracted a portion of the data corresponding to latitude $-13°15'4.38''S$ and longitude $34°18'5.50''E$ which is the location of Malawi. We extracted raster values to points corresponding to our survey coordinates at a given time using QGIS's processing toolbox. We standardized the radiance such that negative standard deviations would imply very low lights and positive standard deviations implying availability of light. Radiance greater than or equal to zero meant that the sample geographic point had electric light and if it was below zero, it did not.

Community leaders, through the community questionnaire, and respondents at household level (household questionnaire) reported on the existence of different types and quality of infrastructure. Further, the enumerators also measured geographic distances a household was from infrastructural resources such as roads, markets etc.

Following Christaller's Central Place theory (Christaller, 1966; Getis and Getis, 1966; Von Thünen, 2009), we measure access to infrastructure as the geographic distance in kilometers from the center of the district, market, clinic, bank, safe water amenities and savings and credit cooperation.

Factor analysis based on maximum likelihood was used to extract a composite infrastructure index using the `factanal` package in R statistical package. The factor analysis created a linear combination of the factors in order to identify variables that explain the underlying structure behind the data. Table shows the three factors that were extracted from the factor analysis. The factors are independent from each other. That is, a varimax rotation, which gets orthogonal factors, was used as opposed to promax, which provides correlated factors. Factor 1, which is the main factor, generally shows positive correlations with increasing distances to key hard and soft infrastructure and is negatively associated with presence of night time lights.

Thus, in interpretation we can state that it measures infrastructure inaccessibility or remoteness to key infrastructure. Since this first factor accounted for most of the variation in the data (> 0.6), we used it as an indicator of access to infrastructure. To ease interpretation, we scaled the factor scores to range between 0 and 1 where 0 means that a household had full access to infrastructure and 1 means it is further away from infrastructure[3]

Figure 2.5 presents a visual graphic of the factors. Factor 1 is shown on the x-axis while factor 2 is shown in the y-axis of panel A while factor 3 is shown on the y-axis of panel B. The results show only factors with significant factor loadings with correlations of greater than 0.1. Generally, variables namely electricity, distance to a savings and credit cooperation, ADMARC and the auction floors have high loadings. Consistent with our guiding theoretical framework, the composite infrastructure index (factor 1) shows that remoteness to a main road is associated with no access to electricity, input, commodity, and financial markets. Also consistent with Hirschman's hypothesis these results demonstrate that a road is a precursor for electricity and soft infrastructure. Thus, our theoretical model's focus on road infrastructure as a didactic working model for overall infrastructure is justified. Factor 2 just features remoteness to central locations, as demonstrated by distances from the center, which is consistent with Christaller's central place theory. Factor 3 summarizes access to financial markets since roads, and all financial market indicators have high factor loadings.

Household characteristics

Figure 1, panel A presents household and community characteristics. A general pattern shows that both household and community characteristics did not change much across the regions and also over the subsequent surveys.

Asset index: We calculated an asset index using principle component analysis by examining the availability at household level (Harttgen and Vollmer, 2013). Using

[3]Composite Infrastructure Index (CII) was scaled as follows to ease interpretation i.e. $0 \leq CII \leq 1$. Thus,

$$CII = \frac{X_i - MinX_i}{MaxX_i - MinX_i}.$$

FIGURE 2.4: Map of the earth showing smoothed NTL data which was constructed using a nominal spatial resolution of 2.7 km at 30 arc-seconds, covering $180°W$ to $180°E$ longitude and $75°N$ to $65°S$ latitude

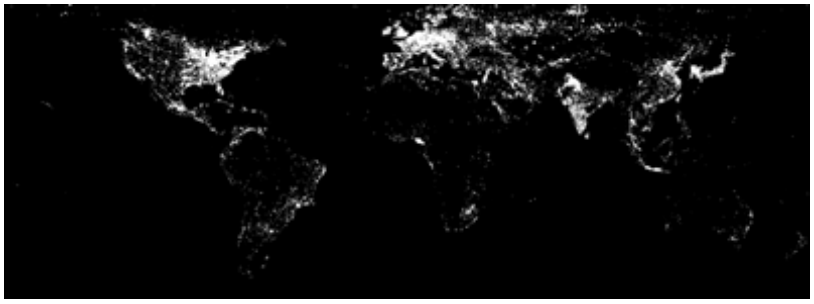
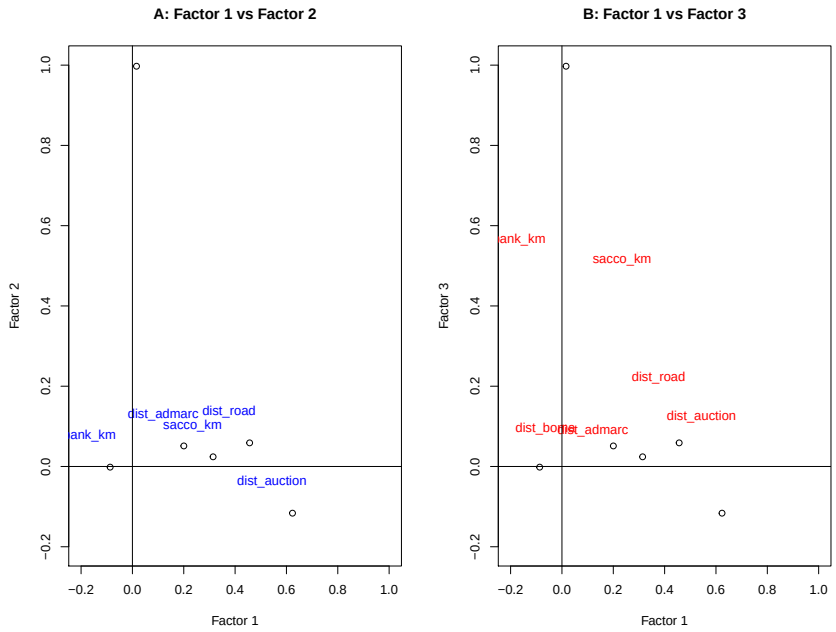


TABLE 2.3: Results of factor analysis to identify underlying access to infrastructure patterns.

Infrastructure access variable	Factor1	Factor2	Factor3
Distance to the road	0.457		0.142
Distance to the district center		0.997	
Distance to credit and savings cooperation	0.314		0.436
Distance to the nearest bank			0.487
Night time lights	-0.685		0.147
Distance to ADMARC	0.2		
Distance to auction floors	0.624	-0.116	
SS loadings	1.401	1.030	0.964
Proportion Var	0.200	0.147	0.138

FIGURE 2.5: Results of factor analysis showing factor 1 to factor 3.



a varimax rotation procedure, we used the component that explained a lot of variation in the data. Results show no significant changes in the asset index the number of households with access to irrigation schemes (17%) between 2010 and 2013 but show a 21-percentage point increase in 2016. However, we notice regional variations within surveys across regions.

Age of the household head: The average age of the household head in the 2016 survey was 46. Although we find statistically significant ($p < 0.01$) results for equality of means, substantively, the ages do not differ much across the regions. Table 2 supplements Figure 1 and shows that, indeed, the age of the household head does not change much.

Number of male and female adults and children: Food security is a function of household composition and gender dynamics. Kennedy and Peters (1992) presents the oldest reference to gender food security linkage. The study argues that that households in which women have more discretionary power over expenditure decisions had better child and overall household nutrition outcomes. Kassie, Ndiritu, and Stage (2014) however found that female headed households had less food security outcomes. From a resource needs perspective, a household having more children requires a more nutritionally diverse food consumption bundle that a household that only has adults. Further, from an econometric perspective, an interaction of time variant and invariant characteristics makes evaluation of the gender inequality gap much easier to track. Results show that the distribution of the sexes is between one and two. A simple count shows that an average household has between two and five individuals regardless of sex.

Marital status: Panel B of figure 1 summarizes the marital status of the household. Continuing with the argument from Kennedy and Peters (1992) and Kassie, Ndiritu, and Stage (2014), the need to account for marital status follows naturally. Households for single individuals who have never married could have much lower food security requirements compared to households with married and more diverse compositions. Results summarized in figure 1 show that the majority of households were married and monogamous, accounting for about 75% of the sample observations in 2010. The number proportion increased to 83% in both 2013 and 2016 but with much variation across the regions. In a similar manner results for the other

marital status categories also show similar patterns.

TABLE 2.4: Descriptive statistics of variables used in the study.

	2010/11 IHS 3 data			2013 IHSP data			2016/17 IHS4 data		
	North	Center	South	North	Center	South	North	Center	South
Food budget	8.95	8.59	8.52	9.71	9.45	9.90	11.05	10.83	10.84
Berry Index	0.04	0.05	0.05	0.11	0.14	0.12	0.17	0.22	0.21
Child stunting	-0.79	-1.11	-1.14	-0.85	-0.91	-1.33	-1.26	-1.21	-1.09
No. Days without food	0.20	0.28	0.40	0.43	0.50	0.63	0.84	1.10	1.26
Seasonal drought index	-0.84	1.50	1.69	0.44	1.38	1.41	1.02	1.29	0.44
Night time light index	0.10	0.60	0.33	-0.12	0.37	0.17	0.09	0.59	0.28
Composite infrastructure index	0.23	0.22	0.14	0.25	0.22	0.14	0.25	0.22	0.14
Asset index	-0.05	0.15	0.20	0.00	0.20	0.11	0.18	0.33	0.28
Age of household head	3.67	3.66	3.62	3.75	3.77	3.73	3.83	3.85	3.81
No. Male adults	1.28	1.38	1.16	1.42	1.39	1.21	1.84	1.90	1.60
No. Male Children	1.16	1.10	0.96	1.23	1.16	1.14	1.32	1.27	1.27
No. Female adults	1.32	1.38	1.27	1.53	1.40	1.26	1.93	1.93	1.67
No. Female children	1.19	1.11	1.00	1.28	1.20	1.16	1.40	1.36	1.40
Pests & disease incidence	0.33	0.50	0.17	0.86	0.83	0.78	0.77	0.82	0.68
Single - never married	0.75	0.78	0.70	0.82	0.83	0.77	0.85	0.85	0.80
Married - Monogamous	0.06	0.06	0.07	0.05	0.07	0.06	0.07	0.08	0.01
Married - Polygamous	0.03	0.04	0.05	0.05	0.02	0.07	0.11	0.03	0.03
Married -Separated	0.03	0.01	0.05	0.06	0.02	0.06	0.05	0.04	0.05
Widowed - Widower	0.09	0.09	0.09	0.12	0.14	0.14	0.16	0.18	0.08
Distance to main road	0.60	0.41	0.58	0.71	0.54	0.83	0.73	0.57	0.92
Distance to nearest urban center	1.16	1.13	1.28	1.32	1.38	1.37	1.33	1.39	1.41
Distance to an auction floors	1.29	1.74	1.68	1.56	1.86	1.75	1.57	1.86	1.79
Distance to District center	1.85	1.84	1.69	1.21	1.30	1.18	1.84	1.83	1.72
Distance to the border	1.11	1.08	1.07	1.86	1.83	1.70	1.86	1.85	1.71

2.3 Results

2.3.1 Proximate impacts of seasonal shocks on food security

In order to assess impacts of household shocks on food security, we implement a difference-in-difference-in-difference (DDD) fixed effects regression (Angrist and Pischke, 2008, pp.138). In Table 2.5, we estimate the DDD. As part of robustness checks, the Berry index of dietary diversity, and Shannon Entropy Index were used. Across the table, we present four models of the impact of seasonal shocks on food and nutrition security. Column 4 presents results of the fixed effects on natural logarithm of household food expenditure adjusted for adult equivalence units. Other shocks were highly collinear with the SPEI indicator such that we deem the measures of associations presented earlier to suffice.

In general, results show that infrastructure mitigates impacts of extreme weather events on food security. Our variable of interest is the interaction effect between

TABLE 2.5: Impact of extreme weather events on food security conditional on infrastructure

VARIABLES	(1) Food Share	(2) Berry	(3) Entropy	(4) Food Exp.
2013 × SPEI × CII	0.093*	0.022	0.125	-0.048
	(0.055)	(0.065)	(0.122)	(0.241)
2016 × SPEI × CII	0.172***	-0.097	-0.079	-0.109
	(0.063)	(0.072)	(0.127)	(0.449)
Constant	0.636***	0.634***	1.664***	9.489***
	(0.091)	(0.125)	(0.246)	(0.393)
Fixed effects				
Year dummies	YES	YES	YES	YES
SPEI, CII, respectively	YES	YES	YES	YES
SPEI × CII	YES	YES	YES	YES
Year × CII, and Year × SPEI	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Observations	4,060	4,205	4,205	4,061
R-squared	0.306	0.046	0.076	0.558
Number of HHID	1,554	1,556	1,556	1,554

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

the standardized Precipitation – Evapotranspiration Index (SPEI) and the Composite Infrastructure Index (CII) in 2016. It measures the change in food security jointly caused by SPEI and CII. The coefficient for the interacted variables in the fixed effects regression model shows an impact of $17 \pm 6\%$ increase in budget shares ($p < 0.01$). The interaction term shows that the joint impact of seasonal weather shocks and absence of infrastructure increases the food budget shares. When we consider the middle survey period of 2013, we find that the the joint impacts were 9%. Considering the three time periods, we can indicate that the effects of extreme weather events and lack of infrastructure accessibility worsen i.e. an 8 percentage point increase in budget shares.

To understand the effects, we split the SPEI variable to indicate floods i.e. SPEI greater than 1 or less than -0.5 for drought (Aadhar and Mishra, 2017). When this is done, we find that the joint impact of flooding and CII is a $17 \pm 6\%$ increase in the budget shares ($p < 0.1$) (table 2.6). The results for the 2013 survey also show a $9 \pm 5\%$ increase in budget shares. Thus, results show that effects of floods given lack of infrastructure are worsening over the six year period. However, results in table

TABLE 2.6: Impacts of floods on food security conditional on infrastructure

VARIABLES	(1) Food Share	(2) Berry	(3) Entropy	(4) Food Exp.
2013 × Flood × CII	0.091*	-0.035	0.072	-0.226
	(0.049)	(0.057)	(0.107)	(0.225)
2016 × Flood × CII	0.168***	-0.081	-0.117	-0.074
	(0.064)	(0.079)	(0.141)	(0.495)
Constant	0.637***	0.628***	1.634***	9.486***
	(0.091)	(0.125)	(0.244)	(0.397)
Fixed effects				
Year dummies	YES	YES	YES	YES
SPEI × CII	YES	YES	YES	YES
Year × CII, and Year × SPEI	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Observations	4,060	4,205	4,205	4,061
R-squared	0.301	0.045	0.075	0.554
Number of HHID	1,554	1,556	1,556	1,554

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

2.8 show that droughts have had no significant impacts of food security across the time periods. Thus, we can conclude that the results in Table 2.5 are mainly driven by increasing flooding conditions.

2.3.2 Household dietary diversity and nutrition

Do seasonal extreme weather events influence household dietary diversity patterns? To answer that question, we present results of the Berry and the Shannon Entropy indexes of dietary diversity models in tables 2.5 to 2.7, respectively. The Berry index ranges from 0 to 1 where zero means that the household is not dietary diversified – meaning that they only consume one food group – and 1 means that the household is fully dietary diversified. Lower values of the Shannon Entropy index mean that the household has less varied diets – signifying lower economic access or lower production and exchange entitlement to nutritious food – while higher values imply more varied diets. Dietary variety is linked to higher nutrient intake (Drescher, Thiele, and Mensink, 2007; Kennedy et al., 2007). The descriptive results indicate that dietary diversity is lower – Malawian households consume a low variety of

TABLE 2.7: Impacts of drought on food security conditional on infrastructure

VARIABLES	(1) FoodShare	(2) Berry	(3) Entropy	(4) Food Exp.
2013 × Drought × CII	-0.576	0.611	1.188	0.327
	(0.421)	(0.758)	(1.157)	(6.259)
2016 × Drought × CII	0.478	-0.461	-0.970**	-2.683
	(0.308)	(0.298)	(0.488)	(1.992)
Constant	0.589***	0.605***	1.623***	9.096***
	(0.092)	(0.126)	(0.243)	(0.392)
Fixed effects				
Year dummies	YES	YES	YES	YES
SPEI, CII, respectively	YES	YES	YES	YES
SPEI × CII	YES	YES	YES	YES
Year × CII, and Year × SPEI	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Observations	4,060	4,205	4,205	4,061
R-squared	0.296	0.048	0.077	0.560
Number of HHID	1,554	1,556	1,556	1,554

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

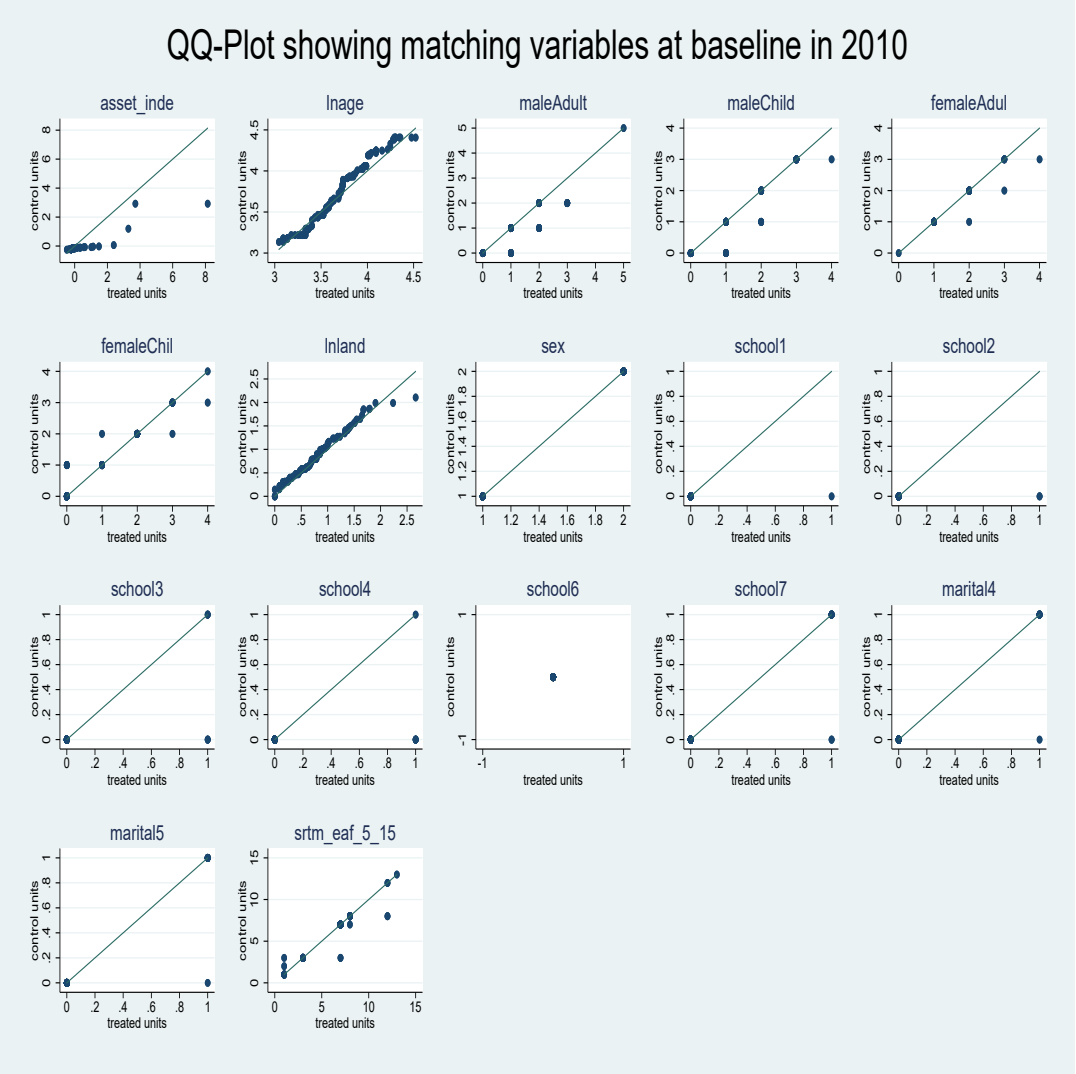
food commodities. Resultant, effects of extreme weather events on dietary diversity conditional on infrastructure availability are also negative but very low and in most cases statistically not significant. Results suggest that households generally do not diversity regardless of circumstances.

2.3.3 Potential mechanisms

Given the theoretical framework, several mechanisms can drive our results. Thus, the innovation in household utility from food consumption may not only be driven by seasonal extreme weather or infrastructure placement but also other miscellaneous shocks, household and community characteristics. In figures 2.7, 2.8 and 2.9 we present other factors that may drive our results. We divide our results by the household's level of commercialization namely subsistence farming (Figure 2.8) and commercially oriented farming [4]. We consistently find that effects of extreme

[4]Following Von Braun, Kennedy, et al. (1994) and Carletto, Corral, and Guelfi (2017), we compute a measure of commercialization as a ratio of the value of agricultural sales in markets to the value of agricultural production. Lower ratios imply subsistence while higher ratios commercial agricultural production. Households below the median are subsistence.

FIGURE 2.6: Baseline matching outcomes of key explanatory variables used in the analysis. Of note, except for household assets, the variables were not statistically significant during the matching. A simple transformation of CII into a dummy variable equal to 1 when the CII ≤ 0.



weather events are much higher on subsistence farming households than commercially oriented households.

Consistent with what we observed in literature and also from our guiding theoretical model, we find that asset holding is positively associated with food consumption ($p < 0.01$). Our results are consistent with Janzen and Carter (2018) and Giesbert and Schindler (2012) who reported that poor people who sell their assets after extreme weather conditions such as drought consistently ended up with poor food security outcomes.

FIGURE 2.7: Summarizes mechanisms controlled for during the analysis. The dependent variable is the share of expenditure allocated to food per day. A pooled and within effects model is considered. A dot represents the marginal effect while the lines to the left and right of the dot represent the lower and upper 95% confidence intervals. The interaction is for the last period.

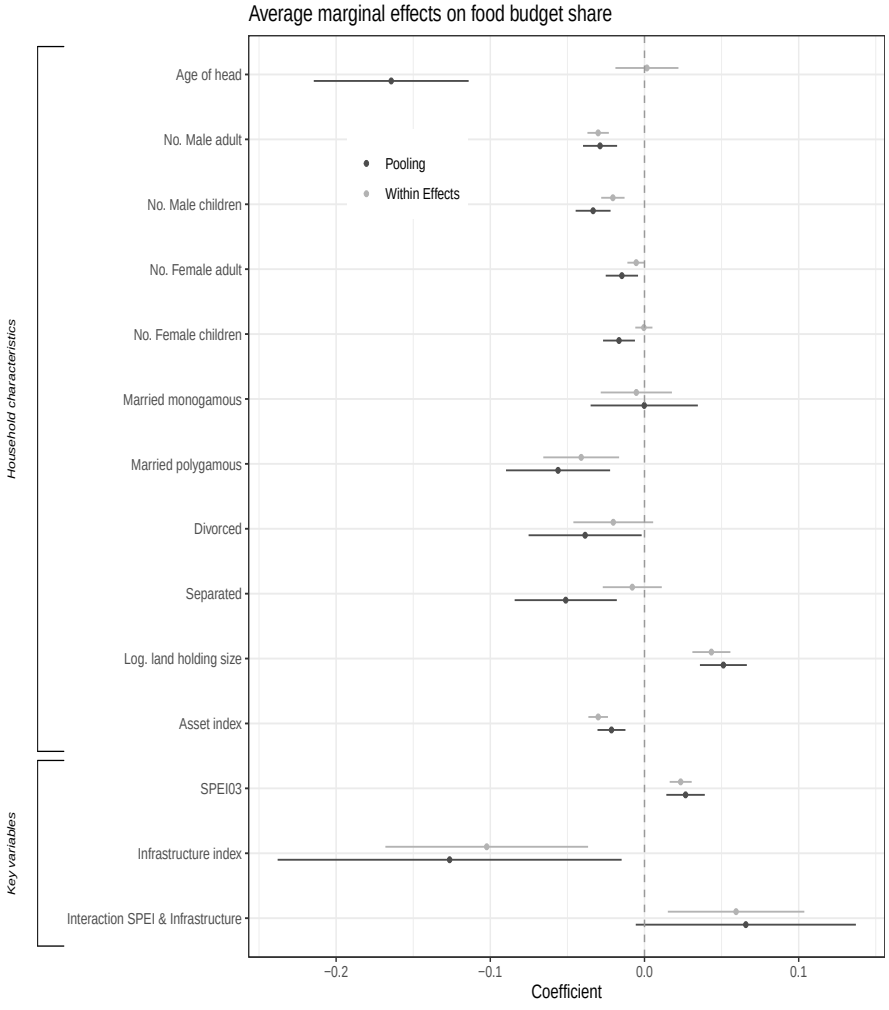


FIGURE 2.8: Summarizes mechanisms controlled for during the analysis. The dependent variable is the share of expenditure allocated to food per day adjusted for net food buying households. A pooled and within effects model is considered. A dot represents the marginal effect while the lines to the left and right of the dot represent the lower and upper 95% confidence intervals. The interaction is for the last period.

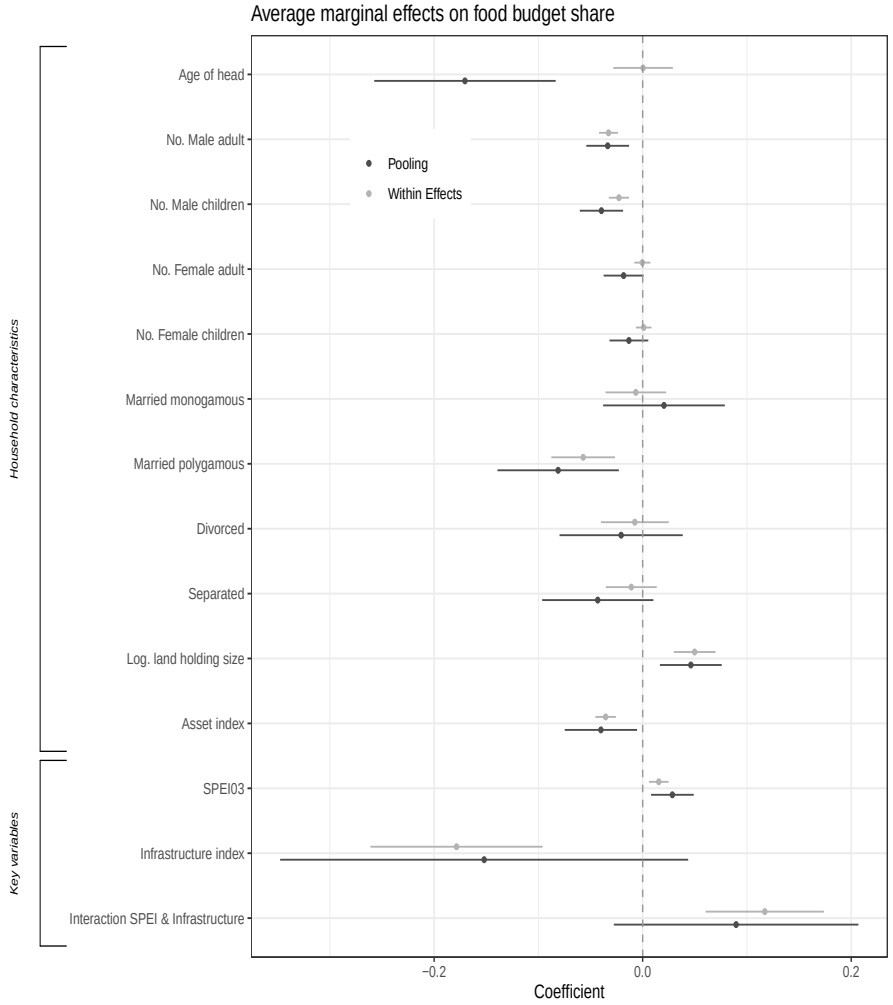
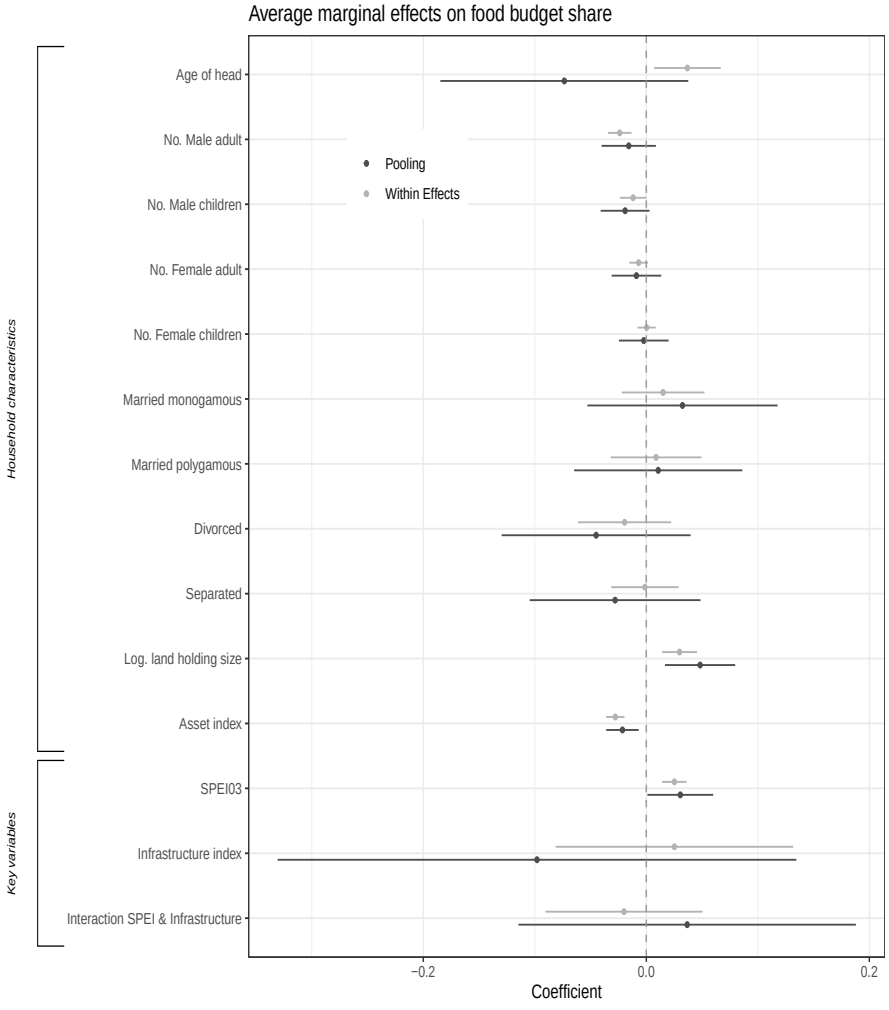


FIGURE 2.9: Summarizes mechanisms controlled for during the analysis. The dependent variable is the share of expenditure allocated to food per day. A pooled and within effects DDD model is considered. A dot represents the marginal effect while the lines to the right and left represent the lower and upper 95% confidence intervals. The interaction is for the last period.



Household dynamics, in terms of gender composition, were positively associated with household consumption expenditure. Although both presence of both male and female adults was positively correlated with food consumption expenditure shares ($p < 0.01$). An additional male child was also associated with more food consumption expenditure. In addition, Kassie, Ndiritu, and Stage (2014), Little, Ilbery, and Watts (2009) found that gender plays a significant role in home food preparation and consumption decisions. Thus, in addition to the gender disparity in consumption expenditure, household composition may also influence dietary diversity outcomes. We find that households with more males have lower dietary diversity compared to households with more females. Further, we also find that households that were in any form of a civil union had more consumption expenditures compared to household heads who had never married before. This also has to do with household size and food consumption needs.

2.4 Discussion

Economic disruptions have important implications for welfare and development policy. A clear identification of the shocks and households that are affected is critical in order to trace direct causal effects at household and community level. Throughout the analysis in this study we have addressed both issues and get two consistent results. First, that seasonal shocks have negatively impacted household food consumption given household characteristics. Second, in the presence of shocks, public infrastructure plays a pivotal role in smoothing consumption.

The first result – that effects of extreme weather events have deleterious effects on household consumption expenditure – are consistent with theoretical predictions of our economic model. Any shock that affects the total household value added results in reduced indirect utility. Our results show that a supply side shock that affects earnings – results in significant decrease in consumption per capita. Further, a supply side shock such as floods (SPEI values in excess of 1) bid up food prices thereby making households pay more for the same bundle of food items. Of note, these results were triangulated with the use of the total household expenditure but to reduce endogeneity, a household asset index was used as a proxy. Due to seasonal

shocks, food production may fail thereby reducing household earning capabilities which in turn may affect food consumption possibilities. Devereux (2007) refers to this as an entitlement failure.

Accounting for community level infrastructure has clear advantages for welfare. Our results throughout all the models suggest that infrastructure is associated positively associated with food security. This observation comes from our theoretical framework that infrastructure can have positive consumption effect by reducing transaction costs.

Our results are consistent with findings by Donaldson (2018) who, while assessing effects of road infrastructure in India, found that infrastructure placement decreased transaction costs, also further deflated prices, increased trade and raised income levels. Thus, from a policy planning perspective and owing to the representativeness of our data, it is important that at household and community level, capital infrastructure be given priority. At community level, it can fairly be assumed that returns to infrastructure, being mostly non-excludable, accrue to households and can therefore be used for current consumption and smoothen future consumption possibilities. Our observation is consistent with Banerjee, Duflo, and Qian (2012) who, while assessing impacts of infrastructure on economic growth in China, found a moderate positive effect on economic growth and income growth.

Although several studies have addressed effects of some of these shocks in isolation (Ellis and Maliro, 2013, Ellis and Manda, 2012, Harttgen et al., 2012, 2015, Pauw et al., 2013), our study is the first to exploit the combined impact of several shocks and in a panel data framework combined with triangulated station based and remote sensed data. Thus, not only are our results internally consistent but can also be generalized at national level considering the representative nature of our dataset. This is a great advantage considering that other studies which had small sample sizes, were single cross-sectional surveys or forward-looking simulations.

2.5 Conclusion

This study assessed impacts of shocks on household food security in Malawi using three indicators namely: food consumption expenditure shares, Berry Index of

dietary diversity, and the Shannon Entropy Index of dietary diversity. The study used fixed effects regression techniques to assess the impact of seasonal weather shocks on food security. Second, the study assessed the impact of community infrastructure on household food security using fixed effects regression techniques. Three waves of nationally representative integrated household panel surveys obtained from the Malawi National Statistical Office were used. To triangulate the self-reported shocks conditions in the survey, long term station weather data was used to come up with the Standardized Precipitation – Evapotranspiration Index from the Climatic Research Unit of the University of East Anglia. To triangulate infrastructure conditions, remote sensed Night Time Light data from US National Oceanic and Atmospheric Administration (NOOA) and National Aeronautics and Space Administration (NASA) was used. The study finds that extreme weather events result in increase in food consumption expenditure shares. Second, investment in complementary infrastructure enable households smoothen their consumption. Therefore, in attempting to address impacts of shocks on household welfare, it is important to also account for community level assets and infrastructure.

Chapter 3

Social capital and market performance: Implications for food security

3.1 Introduction

Industry structure can alter competitiveness and growth prospects of most sectors in an economy [1]. Emergence of highly concentrated industries may deter new entrants and may lead to inefficient allocation of resources in the market (Poulton, Kydd, and Dorward, 2006; Porto, Chauvin, Olarreaga, et al., 2011; Sexton and Xia, 2018). Highly concentrated markets might not be particularly good for food commodities especially when commodities are heavily consumed by the poor. Concentration can drive out small firms, scare potential investors and exacerbate avoidable crises (Sexton and Xia, 2018).

Few studies have been conducted to document and assess the complex relationship between industry structure, firm productivity, performance, resilience and the role of institutions and social capital in the staple food sector markets of developing economies. For example, Sitko et al., 2018 found no evidence of market concentration by entry of large firms into smallholder grain markets but rather found

[1] This chapter was published as: Kankwamba, H., and Kornher, L. (2019). Performance, behaviour and organization of maize trading in Malawi. Agricultural and Food Economics, 7(1), 14. https://doi.org/10.1186/s40100-019-0136-6

that the retail prices of grain declined due to improved market efficiency. For instance, Gabre-Madhin (2001), using a new institutional economics perspective, assessed market institutions, transaction costs, and social capital in the Ethiopian grain market and found that social capital enhances firm productivity. Further, Fafchamps and Minten (2001), using survey data from traders in Madagascar, found high large social capital effects on firm productivity.

We define social capital as "the structure of informal social relationships conducive to developing cooperation among economic actors aimed at increasing social product, which is expected to accrue to the group of people embedded in those social relationships" (Hayami, 2009). Social capital among traders may help reduce transaction costs if traders interact more with their fellow traders for longer periods of time (Fafchamps and Minten, 2001). However, such interactions may affect efficiency outcomes as markets may become dominated by small groups of traders that are well acquainted.

Using structural, relational and cognitive indicators for social capital, most literature from developed countries suggest a positive association between social capital and business performance (*see* Islam, Habes, and Alam, 2018; Liu and Li, 2018; García-Villaverde et al., 2018; Miao et al., 2017). To illustrate, Islam, Habes, and Alam (2018) found that a managing director's cognitive ability, education, experience and a number of connections had a positive influence on a cooperative's performance. Further, Miao et al. (2017) assessed the effect of social capital and business performance and found that the link between social capital and performance is mediated by human capital – education and skills of employees and entrepreneurial orientation – the strategic, philosophical and behaviours in decision making – of the trader. In a similar manner, Asiaei and Jusoh (2015) indicated that relational and social capital improve business perfomance.

Further, other literature asserts that productivity may be reduced if traders trade and interact with close relatives. For example, Levine et al. (2014) reported that ethnic proximity of traders may promote price bubbles and thereby bring about undesirable market outcomes such as market inefficiency. In addition, Atmadja, Su, and Sharma (2016) found that firms that are run by ethnically cohesive individuals tend to poorly perform on a indicators such as profitability and survivability – i.e. time

in years a business stays profitable before closure. However, Oliveira and Nisbett (2018) argue that there may not be much differences in outcomes from ethnically diverse groups than homogenous groups. In addition, Portes (2014) argued that social capital might drive marginalism in that individuals without social capital may be ostracized, face significant barriers to growth and eventually be left out of economic systems. This becomes particularly difficult when the individuals are poor traders in developing countries. To a greater extent, the link between business performance and behavioural aspects of traders such as social capital and informal arrangements such as trust relationships provide mixed evidence (Van Rijn, Bulte, and Adekunle, 2012). Interestingly, in Africa, where most businesses and, therefore the transactions therein, are informal do not feature much in the debate on social capital versus performance. As such, it is important to explore on the role of social capital in economic outcomes.

The main objective of this study is to assess the effect of industry structure and social capital on maize traders' behaviour, business resilience and profitability in Malawi. We use a randomly sampled, market level representative data set involving small to medium scale maize traders where we ask about trade volumes, value of stock, proportion of costs, prices, pricing behaviour and whether the enterprise exports or not to ascertain the structure, conduct and performance of the firm. We also ask questions about the nature of the traders' relationship with fellow traders, brokers, lenders and family relations to get information regarding the structure of social networks which might have a bearing on the nature of transaction costs. Further, the study also uses key informant interviews, focused observations and group discussions with industry representatives, grain traders' associations and farmer associations. We hypothesize that traders who interact more with other traders, brokers and lenders will have more resilient and profitable businesses. To test our hypothesis, we econometrically analysed the data using Bayes Model Averaging (BMA) regression techniques. BMA analysis reduces model uncertainty by taking advantage of the posterior probability distributions of all competing model parameters conditional on the observed data and some prior knowledge (*see* Hoeting et al., 1999; Genell et al., 2010; Laffineur et al., 2017). In this study, we are able to use the sample data together with prior knowledge gathered from key informants and available literature

to draw inferences about the organization of maize markets and the behaviour of maize traders.

The study contributes to literature on understanding drivers of business resilience, food policy design and industrial organization by bringing recent evidence from a developing country's staple food industry and also complementing and triangulating results from methodologically different viewpoints namely qualitative and Bayesian regression analysis. This would make our interpretation of results particularly rich and highly informative.

We find two consistent results that social capital enhances business resilience and that not all forms of social capital make maize trading profitable but when traders are very close, even to family ties, profits increase.

The rest of the paper is structured as follows. Section two presents materials and methods used in the paper such as the study area, sampling procedure, theoretical framework and estimation. Section three presents results where we first present descriptive and later inferential statistics. Section four presents discussion while section five presents a summary and conclusion.

3.2 Materials and methods

3.2.1 Study area

The study was carried out in the central region of Malawi. The central region has nine administrative Districts which have a comparative advantage for producing maize, the country's staple food (Chirwa, 2007). In as much as the whole country trades in maize, the majority of maize traders are situated in the central region (Messina, Peter, and Snapp, 2017). In order to understand the structure, conduct and performance of maize markets, the study area is ideal. Second, the region is logistically cost effective since it contains most of the traders and other stakeholders.

3.2.2 Sampling, data and variables

We assume that the population of traders (N) is sufficiently large but we do not know the variability among traders' performance (p). Following Cochran (2007), we assume maximum variability of ($p = 0.5$). We further assumed a desired confidence

level of 95% - corresponding to a z-value = 1.96. Further, we used $\pm$ 10% level of precision (e). Our sample size is then $n = (Z^2 p(1-p))/e^2 = 96$. To account for uncertainties due to logistics, we adjusted the sample size upwards by 50% to 144. At the end of the survey, we had interviewed 172 traders, i.e. 28 more traders.

Before drawing the sample we obtained a list of markets that are followed by the Ministry of Agriculture and Food Security's Agricultural Statistical Bulletin. From that list, we picked historical central markets – i.e. markets that had consistent price and commodity series. We obtained a list of traders in a given market from market authorities and listed them in ascending order. In the case where the market did not have a list of traders, we conducted a linear listing of the traders – usually traders selling maize are arranged in a line and obtaining a list was simply done by obtaining their names and assigning numbers to them. Using the lists, the first trader in the survey was picked using simple random sampling while the second to the nth trader was picked using systematic random sampling by counting the next 3 traders – where the number three was chosen arbitrarily. For each of the markets $j = 1, \ldots, k$ containing $i = 1, \ldots, n$ traders, we draw a systematic sample without replacement and calculate a market mean, of say profit or resilience – survivability, as $\bar{y}_{sys} = \sum y_{ij}/n_j$ such that our systematic sampling mean is $\bar{Y} = \frac{1}{k}\sum_{j=1}^{k} \bar{y}_{sys}$. The systematic sampling variance is then calculated as $s^2 = \frac{1}{k(n-1)} \sum_{i=1}^{n} \sum_{j=1}^{k} (y_{ij} - \bar{y}_j)^2$ Cochran (2007).

The key sources of expert and secondary information were the Ministry of Agriculture and Food Security's (MoAFS) Department of Agricultural Planning Services (DAPS), where we obtained information on historical prices using their Agricultural Statistical Bulletin. We also obtained information on gross margins and average prices from the Department of Agricultural Extension Services (DAES). The second prior data source was the Malawi Strategy Support Program (MASSP) of the International Food Policy Institute (IFPRI) where we interviewed the IFPRI team of experts. The IFPRI team provided monthly prices summarized in form of policy briefs (MASSP, 2018) and indicated their availability for clarifications. We also interviewed other players in the maize marketing industry. Results of the sampled markets and their respective sample sizes are summarized in Table 3.1.

During the study, we also used simple ethnographic data collection techniques

TABLE 3.1: Distribution of sampled observations across markets and districts

District	Kasungu	Dowa	Lilongwe	Mchinji	Dedza	Total
Kasungu	15	0	0	0	0	15
Chamama	14	0	0	0	0	14
Mtunthama	3	0	0	0	0	3
Chatoloma	2	0	0	0	0	2
Dowa	0	12	0	0	0	12
Mponela	0	11	0	0	0	11
Madisi	0	12	0	0	0	12
Kasiya	0	0	10	0	0	10
Lilongwe	0	0	21	0	0	21
Mitundu	0	0	17	0	0	17
Nkhoma	0	0	8	0	2	10
Mchinji	0	0	0	10	0	10
Kapiri	0	0	0	14	0	14
Chimbiya	0	0	0	0	10	10
Bembeke	0	0	0	0	10	10
Total	33	37	56	24	22	172

namely: participant observation (Junker, 1960), where we went to the market and observed market transactions to clarify questions and get accustomed to different market environments. The study also used key informant interviews (Adler and Adler, 2003) with industry experts where we asked questions about the structure and conduct of the market. This way, we obtained qualitative and quantitative prior information. For instance, we asked different experts about average prices, quantities and by how much the averages might deviate. The information is summarized in Table 2.

3.2.3 Theoretical framework

Traders in our study act strategically. As such, we treat them from a game theoretic perspective (Reny and Perry, 2006). To simplify, a trader interacts with other neighboring traders in a Cournot strategic game (Abbink, Jayne, and Moller, 2011). We denote the immediate two traders as (1) and (2), respectively. All traders trade in a homogeneous commodity i.e. maize. We assume that trader (i) produces output q_i while trader (j) produces output qj. Thus, for all markets in the sample (see Table 3.1), there exists total market output $Q = q_1 + \ldots + q_n$ for all traders where $q_i = a - bp_i$ are trader i's linear demand curves.

We further assume that each trader maximizes their profits. For example, firm (i) maximizes its profits as

$$max_{q_1}\pi_i = p(Q)q_i - c_i(q_i). \tag{3.1}$$

Thus, for trader (1), profitability is clearly dependent on trader (2) 's output on the market. Thus, assuming an interior optimum for each trader the Cournot Nash equilibrium must satisfy the following first order necessary conditions

$$D_{q_1}\pi_i = p(Q) + p'(Q)q_i - c_i'(q_i) = 0 \tag{3.2}$$

The second order conditions are

$$D_{q_i}^2 = 2p'(Q) + p''(Q)q_i - c''(q_i) \leq 0 \quad \forall i = 1, \ldots n. \tag{3.3}$$

Okuguchi (1993) provided axioms namely $p^{'} + p^{''}q_i < 0$ and $p^{'} < C_i^{''}$ to ensure that the second order sufficient conditions are less than zero. In order to determine how trader (j) might react we should differentiate the first order conditions with respect to q_j . Thus,

$$f_1'(q_j) = \frac{D^2\pi_1 / D_{q_i,q_j}}{D^2\pi_1 / D_{q_i}^2} \tag{3.4}$$

Traders do not play one-off stage games. The interact repeatedly. In a repeated game, the output of choice for trader i in time t is given by $q_i^t = f_i(q_j)^{t-1}$and profits will be $p_it = \delta^t pi_{it}$ where δ is a discount factor to measure the patience of the trader. The Nash reversion folk theorem states that given a strategy profile in an infinitely repeatedly game, where the end game reverts to a Nash equilibrium as is the one-off stage game, then each player's strategy is to play a consistent outcome until someone finally defects (see (Mas-Colell, Whinston, Green, et al., 1995). That is, with learning effects, market out comes can improve since traders will learn the others' reaction functions and play consistent strategies.

Proposition 1 *Social capital is a parameter that is associated with the trader's profit function. Thus, accumulation of social capital will affect profitability.*

Proof: Considering a the traders' first order conditions and ω, a social capital parameter, we can present the stationarity conditions as

$$D_{q_i}[q_i(\omega), q_j(\omega)] = 0 \tag{3.5}$$

In order to examine the impact of social capital, we take the derivative with respect to ω. That is,

$$\begin{pmatrix} D^2_{q_i} & D^2_{q_i,q_j}\pi_i \\ D^2_{q_j,q_i}\pi_2 & D^2_{q_i} \end{pmatrix} \begin{pmatrix} D_\omega q_i \\ D_\omega q_j \end{pmatrix} = \begin{pmatrix} D^2_{q_i,\omega}\pi_i \\ 0 \end{pmatrix}.$$

So using Crammer's rule, the impact of social capital on a firm's profitability can be quantified as

$$D_{\omega_1} q_1 = \frac{\begin{vmatrix} D^2_{q_1,\omega}\pi_1 & D^2_{q_1,q_2}\pi_1 \\ 0 & D_{q_2}\pi_2 \end{vmatrix}}{\begin{vmatrix} D_{q_1}\pi_1 & D^2\pi_1 \\ D_{q_1,q_2}\pi_2 & D^2_{q_2^2}\pi_2 \end{vmatrix}} \tag{3.6}$$

quantifies the effect of a change in social capital on firm's quantity supplied on the market – a direct measure of industry share which is a function of arguments from profits, from firm 1 and 2 and their respective reaction functions.

We learn two things from this quantity. First, if the traders only met once, then it would make sense for them to use defective strategies, making the $D^2_{q1,\omega}\pi_1$ quantity negative as it would make one firm take advantage to maximize its own profit at the expense of the other. Resultant, the other firm would also play a similar move. Second, if traders would repeatedly interact in the market, and the equilibrium is mutually beneficial (Dal Bó and Fréchette, 2011), there could be an evolution of cooperation which could foster learning effects and eventually firm and market performance would increase. It would be optimal for players to play cooperate and it would be punishable to play defective strategies. This follows the Nash reversion theorem.

However, as traders keep interacting and learning from each other, it is expected that they would adopt strategies that work in improving their businesses and abandon the strategies that are do not work. Nowak (2006) call a strategy that achieves this and ultimately dominates an Evolutionary Stable Strategy (ESS). In this study, traders that tend to play sub-optimal strategies will be left out by the process of

evolution and they will go bankrupt. Further, Hamilton (1964) suggested that natural selection would most certainly favour cooperation and altruistic behaviour in more genetically related individuals. So on in our context we assume that businesses would perform much better among related individuals and friends. That is if a closely related individuals business is falling apart, a relative or a friend they interact with could bail them out in form of a loan or a mere handout. However, we also take note of Levine et al. (2014) observation that ethnic diversity could also lead to better market outcomes. We thus, use different indicators of cooperation in traders interactions namely, 1) kin selection, where individual traders interact more with genetically related individuals; 2) group selection, where individuals would interact more among friends doing similar kind of trade and; 3) direct reciprocity where at first, we observe how firms run as sole trading entities perform and survive. We also group the traders in ethnicity terms to observe how one ethnic group operates against another in direct reciprocity (Trivers, 1971).

3.2.4 Estimation

Considering that we used two sources of data namely trader survey and key informant interviews, it is ideal to bring the two data sets together in the process of drawing inference about the population parameters. For a start, our key informants i.e. key industry experts, few handpicked traders and government personnel informed us about the distribution of the parameters. We use this prior knowledge to complement the survey data in the estimation process of the posterior distribution of parameters and their 95% credible intervals. We thus use Bayesian normal regression techniques to assess the effects of social capital, on firm profitability and resilience. Our basic regression framework is presented as

$$Y_{ijd} = \beta_{ijd} X + \gamma_j + \delta_d + \lambda_t + \epsilon_{ijd}. \tag{3.7}$$

where Y is the $n \times 1$ vector of natural logarithm of profits of trader or firm i in market j and district d. The variable X_{ijd} is an $n \times m$ vector of independent variables that explain the variation in Y_{ijd}. The quantity β_{ijd} is an $m \times 1$vector of unknown

parameters of the explanatory variables,γ_j is an unknown market specific fixed effect while δ_d and λ are a district and seasonal specific fixed effect.

During data collection period, we obtained prior information on the historical estimates, behaviour and structure of the market. This prior information can be useful in estimating the model parameters and reducing uncertainty. To further reduce the level of uncertainty, we use Bayes Model Averaging (BMA) estimator (Hoeting et al., 1999) with market and district specific fixed effects. Considering the lack of extensive literature on small businesses in Malawi, building an accurate model of business profitability in the context of geographic, social institutional and physical capital could be challenging. Thus, given the context, there are many, i.e. the model space is $M = 2^m = 2^{30} = 2.684 \times 10^{08}$ where $m \in M$, competing models that can be estimated from the given variables. Therefore, fitting one Ordinary Least Squares regression model could result in high measurement and specification errors when expert knowledge is limited and sample sizes are small (Genell et al., 2010). BMA fits a regression of the form

$$Y_{ijd} = \beta_{ijd}(X - \bar{X}) + \gamma_j + \delta_d + \lambda_t + \epsilon_{ijd} \tag{3.8}$$

where the unconditional BMA results' β_{ijd} are weighted average parameters conditional on each of the competing models in the model space, i.e. $m \in M$ (Hoeting et al., 1999; Laffineur et al., 2017). Thus,

$$\hat{\beta_{ijd}} = E(\beta_{ijd}|Y_{ijd}) = \sum_{m=1}^{M} \omega_m \hat{\beta_m}. \tag{3.9}$$

Using Bayes' theorem, we estimate the posterior probability distribution as

$$\omega_m = p(M|Data) = \frac{P(M_m) \times p(Data|M_m)}{\int_{m=1}^{2^m} P(M_m) \times p(Data|M_m)} \tag{3.10}$$

such that $p(M_m)$ is the prior probability distribution of model m while $p(Data|M_m)$ is the marginal likelihood distribution of the data given the model M_m where the model space is M such that $m \in M$ (Madigan and Raftery, 1994; Laffineur et al., 2017). We use R statistical package BAS (Bayesian Variable Selection

and Model Averaging using Adaptive Sampling) – which samples the models without replacement and outperforms Markov Chain Monte Carlo frameworks – (Clyde, Ghosh, and Littman, 2011) to estimate the final posterior parameters.

3.2.5 Industry structure

Descriptive statistics

Table 2 summarizes variable descriptions and results of the prior expert information elicited through the qualitative data collection techniques. The data obtained complements the survey data estimates and are later used in the Bayesian estimation. In general, results closely match the data such that we can safely deduce that the prior has similar distributions.

We used the Herfindahl-Hirshmann Index (HHI) to assess market concentration. The HHI assesses the structure of the market through the lenses of market competitiveness by measuring the size of the firm relative to the size of the industry. Using two indicators namely value of operating capital and volume of commodities that the firm handles per month, we computed the HHI as

$$HHI = \sum_{i=1}^{n} s_i^2 \quad \text{where} \quad s_i = 1/N, \tag{3.11}$$

where N is the total number of the firms in the industry. When the HHI is 0.01 or less, then the market is competitive; when HHI is 0.15 it is unconcentrated; when HHI is between 0.15 and 0.25, the market is moderately concentrated while an HHI of 0.25 and above signifies a concentrated industry. We estimate market, district and regional HHI indicators. However, in the regression estimation we use the log of the share as an indicator of industry size.

As a qualitative measure of industry size, we used a count of traders in the market. A larger number of traders was considered to be a competitive market while when there are very few traders, then the market is less competitive.

3.3 Results

3.3.1 Descriptive statistics

Table summarizes variable descriptions and results of the prior expert information elicited through the qualitative data collection techniques. The data obtained complements the survey data estimates and are later used in the Bayesian estimation. In general, results closely match the data such that we can safely deduce that the prior has similar distributions.

Table 3.2 summarises results of the descriptive statistics of key variables that are used in the study. The study's dependent variables are business profitability and business resilience. The average profit of the maize business was MK30 per kilogram. Results show that 91% of the traders were male aging between 20 and 71 years old. We found that 92% of the traders in the sample were male. In addition, when asked about whether they set prices, 39% of traders reported that they discuss with about 10 colleagues setting market prices. Traders also indicated that it took 14 minutes to get to the market from their home. Results also indicate that 9% have an export license. Further, traders reported that the market contained between 7 and 54 maize traders.

Variable	Description	Prior Source	Mean (SD)
Maize prices	Prevailing price of maize (MK/kg)	MoAFS, IFPRI, ADMARC	35 (25)
Profit	Price Cost Margin (PCM) (MK/kg)	MoAFS, IFPRI, Market Chairperson	25 (12)
Trader is male	Proportion of traders who are male	Observation	.75 (.20)
Registered business	Whether business was registered	MRA, Market Chairperson, MCCCI	.20 (.10)
Export license	Whether the business has an export licence	MCCCI, Market Chairperson	.05 (.03)
No. Trader	Number of traders in the market	District council, Observation	28 (17)
Asset replacement	Frequency of asset replacement	-	flat
Search time	Time spent searching for market information (minutes)		120 (60)
No. family	Number of family members in maize business	-	flat
Business age	Age of the business	MCCCI, Trader	5 (10)
Coverage	Geographical coverage of the business	Trader, Market Chairperson	15 (8)
No. Friends	Number of friends in maize business	-	flat
No. Regional Traders	Number of regional traders interacted with	Market Chairperson	5 (3)
No. District Traders	Number of district traders interacted with	Market Chairperson	12 (5)
Experience Broker	Experience interacting with brokers (years)	Market Chairperson, Brokers	5 (6)
Religion	Religious affiliation of the trader	Market Chairperson	
Christian Catholic			25 (10)
Christian Protestant			35 (10)
Islam			10 (5)
African religion	African religion and others		5 (2)
Trader tribe	Tribe and mother tongue of the traders	Traders, Market Chairperson	
Chichewa			.74 (.12)
Chiyao			.15 (.05)
Chilomwe			.10 (.05)
Chisena			.01 (.01)

TABLE 3.2: Descriptive statistics of key variables used in the study

Variable	Obs.	Mean	SD.	Min	Max
Log of profit	172	4.9	2.178	.613	7.133
Age of business	172	7.263	5.706	1	28
Age of trader	172	34.127	9.043	20	71
Trader is male	172	.919	.274	0	1
Trader dictates prices	172	.39	.488	0	1
Trader interaction (count)	172	9.906	9.544	1	90
Distance to nearest market (log mins)	172	2.674	1.112	0	4.787
Trader has an export license	172	.093	.291	0	1
Industry size (log)	172	2.187	.98	2	4.605
Measures of social capital					
Religion of trader					
Roman Catholic	172	.152	.781	0	1
Christian Protestant	172	.651	.477	0	1
Islam	172	.14	.347	0	1
African Traditional Religion	172	.006	.076	0	1
None	172	.041	.198	0	1
Other religions	172	.012	.107	0	1
Trader's mother tongue					
Chiyawo	172	.041	.198	0	1
Chilomwe	172	.035	.184	0	1
Chisena	172	.006	.076	0	1
No. family members in business	172	1.285	1.446	1	8
No. close friends in business	172	5.622	6.373	0	40
Contacts with regional traders	172	12.32	12.15	0	100
Contacts with distant traders	172	8.564	9.066	0	60
Experience (years) with brokers	172	4.378	2.452	1	15
Business was registered	172	.244	.43	0	1

Considering the three dimensions of social capital namely (1) closeness with family members and ethnically similar individuals; (2) closeness with traders in the vicinity and (3) interaction with distant traders. On similarity between individuals, we used tribe and religion as indicators closeness. Results indicate that 15% of the traders were Roman Catholic; 65% were Protestant; 14% Muslim and 5% either had no religion or practised other religions. Results further show that 92% of traders are of the Chewa tribe while 4% are Yao and 4% are Lomwe. Less than 1% of the traders are of the Sena tribe. On average, one member of the family, usually (self) participated in the maize trade with a range of 7 members. The average trader reported that they had 6 close friends who they interacted closely with in the maize trading business. Results indicate that trader interacted

most with 12 traders within the region and 9 distant traders. Results also indicate that a trader interacted with 4 brokers in the market.

Whether the business was registered or not is of fundamental importance in determining performance and resilience. Results indicate that 78% of the business were not registered. The mean age for registered businesses was 9.32 years with a standard error of 0.89 years while for unregistered businesses was 6.58 years with a standard error of 0.41 years. Though the samples are unequal, a t-test ($t = 3$) indicates that registered businesses tend to stay 3 years longer than unregistered businesses. These results are statistically significant at 1% significance level.

Industry structure

Table 3.3 summarizes results of the HHI.Of note the value of the HHI decreases as we move from a market level concentration to district and eventually regional level measure of concentration. Results indicate that at market level the HHI is 0.468, that is, the level of market concentration is 47%. This HHI value is greater than 25% which indicates that at market level, maize markets do not operate in perfect competition. Thus, in order to analyze the data at market level, a model that accounts for strategic interactions among traders is necessary. Similarly, the district level HHI is 28%, computed by accounting for all markets in the district in question, is also larger than the 28% value – indicating that the maize market is also concentrated at district level.

Noteworthy, Kapiri market in Mchinji District and Bembeke market in Dedza District had the lowest HHI equal to0.205 and 0.208, respectively. The *HHI* values fall within the range of 0.15 and 0.25 which indicates that these markets were moderately concentrated – the small firms in the market were altogether operating in oligopolistic competition. Thus, the Cournot theoretical framework is appropriate for analyzing strategic behaviour of the firms. Market level *HHIs* for the rest of the markets are above 0.25 and are unambiguously concentrated. Importantly, markets that had lower concentration levels lead to much lower concentration values at district level. Of note, Lilongwe District markets had higher levels of concentration at market level, but when the industry was moved to district level, the industry became

moderately concentrated. At regional level i.e. the full sample, the data industry is in perfect competition.

TABLE 3.3: Measures of market concentration using the Herfindahl Index

District	Market	N	Market	District	PCM	ϵ
Kasungu	Kasungu	15	.370	.285	.059	.070
	Chamama	14	.843	.285	.280	.424
	Nkhamenya	3	.557	.285	.147	.002
	Chatoloma	2	.966	.285	.150	.331
Dowa	Dowa	12	.452	.372	.230	.055
	Mponela	11	.761	.372	.050	.248
	Madisi	12	.259	.372	.235	.265
Lilongwe	Kasiya	10	.430	.215	.265	.049
	Lilongwe	21	.505	.215	.180	.262
	Mitundu	17	.619	.215	.190	.224
	Nkhoma	10	.451	.215	.328	.128
Mchinji	Mchinji	10	.419	.327	.205	.525
	Kapiri	14	.205	.327	.285	.753
Dedza	Chimbiya	10	.258	.192	.310	.059
	Bembeke	10	.208	.192	.165	.014
Market HHI		10	-	.468		
District HHI		30	-	-	.280	
Regional average		172	-	.112	.191	.159

PCM $= [(\text{Sales revenue} - \text{Variable costs})/\text{Sales revenue}]$
$s_i =$ market share calculated as cumulative maize quantity supplied.
$\epsilon = PCM_i/s_i$ is the price elasticity of demand (Aiginger, 1996).

Results in Table 3.3 also present price cost margins (PCM) – a ratio of the difference between sales and variable costs by sales (Aiginger, 1996). Results indicate that traders located in larger trading centers have lower PCM. For instance, Kasungu town market had PCM of 6% while Mponela township had 5%. Nkhoma market, a trading center just outside Lilongwe city, had the highest PCM of 33%. Overall, the average industry PCM was 19%.

Generally, the price elasticity of demand for maize across the markets was inelastic i.e. 1% change in the price of maize would result in a less than unitary change in the quantity of maize demanded holding other factors constant. Specifically, in accordance to literature on staple food (Timmer et al., 1983; Levin and Vimefall, 2015), are less than 5% except for Mchinji and Kapiri markets in Mchinji District which had 53% and 75%, respectively.

3.3.2 The role of social capital in determining business performance

Table 3.4 summarizes results of the Bayesian regression analysis of the effect of social capital on business profitability. The table presents three models. First, a Bayesian model with informative prior where we report posterior means, standard deviations and the probability that the posterior mean is not equal to zero i.e. $p\beta \neq 0$). The model is presented in columns 1 to 3. Second, we present a Bayesian model with reference priors in columns 4 to 6. This model uses information from the sample to compute posterior probabilities. In the event that our informative priors are misleading, this model acts as an objective robustness check. Third, we used an Ordinary Least Squares regression model with bootstrapped standard errors replicated 1000 times in columns 7 to 9. Using a frequentist approach with highly conservative standard errors compared to those produced by normal OLS ensures that the precision of our estimates is based on actual variation in the information from the sample and not just chance. The bootstrapped model also shows the level of bias associated with the resampling. In the informative prior model, we used a normally distributed prior with mean 12.65 and the model variance from the sample to estimate the posterior distribution of parameters using 20000 Monte-Carlo Markov Chain (MCMC) simulations. Figure 3.1 summarizes results of the BMA procedure showing 18 best fitted models.

FIGURE 3.1: Results of Bayes Model Averaging showing the competing top 18 best fitting models using 20000 Monte-Carlo Markov Chain (MCMC) simulations. The dependent variable is natural logarithm of profit. The y-axis shows variables included. The bottom x-axis shows log Posterior odds – a higher figure indicates the best fitting model. The top x-axis shows the rank of the models where 1 is the best fitting model and 18 is the worst possible model. A red colour means that the variable should be included while a black colour means that the variable should be excluded. R-squares for the top 5 competing models are as follows 0.546, 0.543, 0.543, 0.540, 0.543 which justifies use of BMA. Variable names follow Table 3.4.

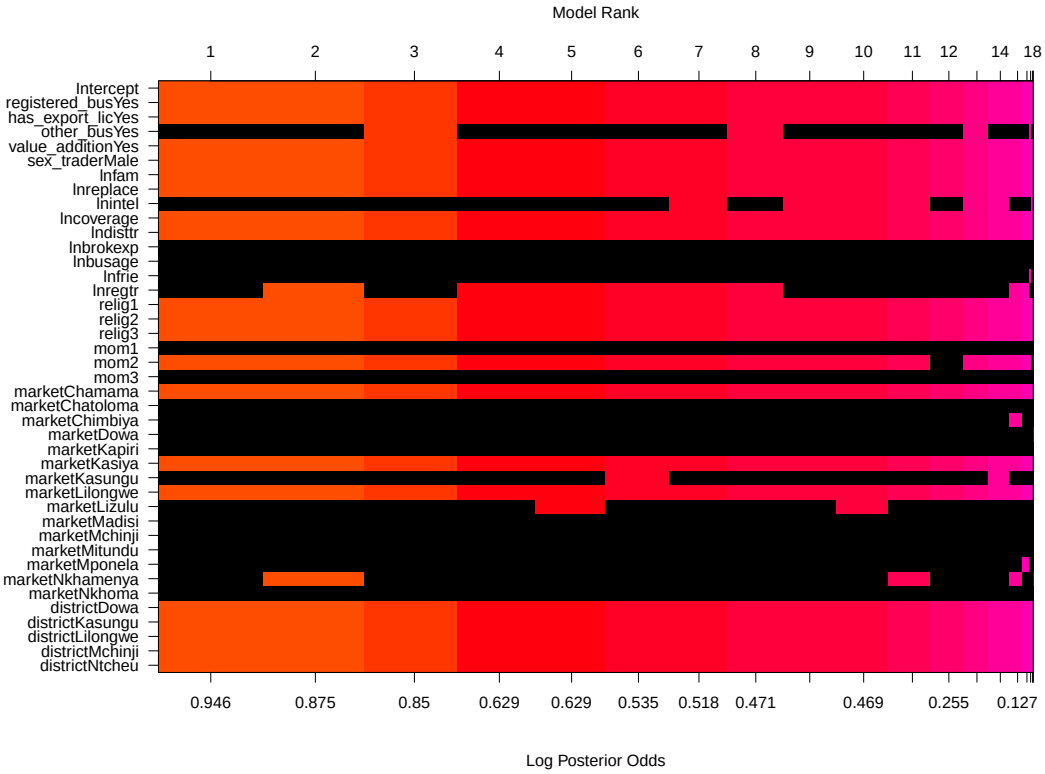


TABLE 3.4: Correlates of business performance in Malawi

	Posterior with informative prior			Posterior with reference prior			OLS with bootstrapping		
Variables	Mean	SD	p($\beta \neq 0$)	Mean	SD	p($\beta \neq 0$)	Coef.	Std. Err.	Bias
Registered business (Yes=1)	0,829	0,254	0,997	0,826	0,272	0,988	0,653*	0,369	0,001
Has export licence (Yes=1)	1,475	0,323	1,000	1,515	0,332	1,000	1,611***	0,433	-0,009
Runs other businesses (Yes=1)	0,047	0,122	0,256	0,050	0,126	0,275	0,222	0,191	-0,014
Multiple market function (Yes=1)	-1,336	0,279	1,000	-1,354	0,286	1,000	-1,297***	0,285	0,016
Trader is male (Yes=1)	1,060	0,334	0,997	1,086	0,345	0,992	1,156***	0,287	-0,011
log No. family members	0,391	0,156	0,981	0,389	0,170	0,951	0,421***	0,164	0,001
log asset replacement record	2,756	0,736	0,999	2,783	0,757	0,998	2,688***	1,011	0,001
log time searching market info	-0,037	0,082	0,296	-0,042	0,088	0,327	-0,194*	0,120	-0,013
log Business age (years)	-0,001	0,051	0,115	-0,003	0,066	0,182	-0,287	0,211	-0,027
log Geographical coverage (km)	0,371	0,094	1,000	0,379	0,097	0,999	0,439***	0,113	0,005
log No. friends running business	-0,063	0,105	0,404	-0,066	0,108	0,411	-0,287***	0,103	-0,003
log No. Traders from region	0,033	0,085	0,249	0,040	0,094	0,291	0,232*	0,141	0,011
log No. distant traders	0,644	0,118	1,000	0,648	0,120	1,000	0,722***	0,124	0,008
log Experience with broker (yrs)	0,079	0,163	0,327	0,094	0,179	0,352	0,392	0,266	0,013
Christian Catholic	-1,121	0,415	0,989	-0,110	0,468	0,956	-1,310***	0,516	0,002
Christian Protestant	-1,200	0,376	0,997	-0,119	0,424	0,985	-1,410***	0,475	0,011
Moslem	-1,676	0,447	1,000	-0,164	0,484	0,997	-2,172***	0,585	0,006
Chichewa	-0,015	0,157	0,140	-0,015	0,160	0,141	0,116	0,548	0,062
Chiyao	0,108	0,313	0,229	0,107	0,314	0,224	0,702	0,665	0,065
Chilomwe	-0,027	0,191	0,139	-0,029	0,197	0,143			
Market FE	YES			YES			YES		
District FE	YES			YES			YES		
Seasonal FE	YES			YES			YES		
No. Traders	172			172			172		

Note: *p<0.1; **p<0.05; ***p<0.01

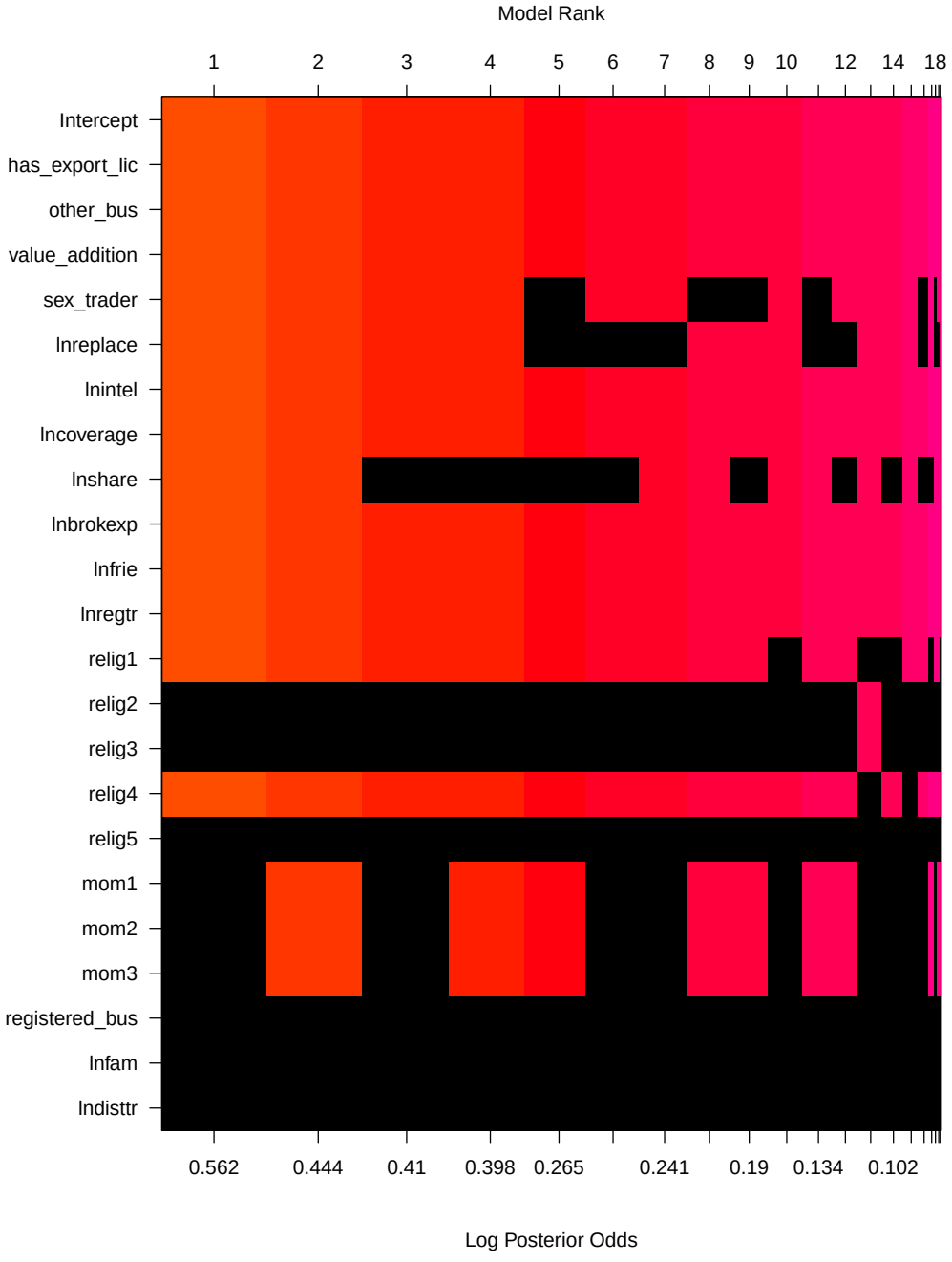
Results indicate that registered businesses were 83% more profitable than unregistered ones. Further, traders that possessed export licences were twice more profitable. If a trader ran other businesses apart from the current grain trading, it resulted in 4% more profits in the maize grain trading business. Results further show that traders who participated in many marketing functions had profits, which were lower by a factor of 1.3 than traders who consistently performed one marketing function. Traders that were combining multiple functions were mostly small and itinerant with capacity and credit constraints. We also find that male traders were twice more profitable than female run businesses. Number of close family relatives is associated with 40% more profits. We found that traders who were innovative in changing assets and trying new technologies during trading realized 37% profitable businesses. Results indicate that the larger the geographical coverage of the business, the more profitable the business i.e. 1% increase in geographical coverage resulted is 36% increase in profits. As far as social capital is concerned, we found that the more the trader interacts with traders within the same district but from other distant markets, the more profitable the business is – 1% increase in interactions resulted in 63% increase in profits. We found higher posterior probabilities that the other measures of social capital such as religion, and tribe of the trader have significant effects on profitability.

3.3.3 The role of social capital in business resilience

Taking age of the business as an indicator of business survivability and resilience (Atmadja, Su, and Sharma, 2016) , In Table 3.5 we estimated a model of key success factors of business resilience. We used a normally distributed prior with mean 1.6 and the model variance from the sample to estimate the posterior distribution of parameters using 20000 Monte-Carlo Markov Chain (MCMC) simulations.

Results of the BMA regression model indicates that if a trader has an export licence, it is associated with 9% increase in business resilience. Further, if the business holds other forms of business apart from the grain trading, it is associated with a 15% increase in business resilience. Traders that engage in multiple marketing functions are associated with 11% increase in profitability. A male trader is associated with 30% reduction in business resilience. Traders that often replace assets and actively

FIGURE 3.2: Results of Bayes Model Averaging showing the competing top 20 best fitting models in determining key success factors for business resilience and survavivability. the dependent variable is the natural log of business age. We conducted 20000 Monte-Carlo Markov Chain (MCMC) simulations. The y-axis shows variables included during the estimation. The bottom x-axis shows log Posterior odds – a higher figure indicates the best fitting model. The top x-axis shows the rank of the models where 1 is the best fitting model and 16 is the worst possible model. A red colour means that the variable should be included in the parsimonious model while a black colour means that the variable should be excluded. R-square values for the top 5 competing models are as follows 0.338, 0.349, 0.341, 0.334, 0.345 which justifies use of BMA.



innovate are associated with 11% increase in business resilience. Traders that spent more time searching for market information are associated with a 53% reduction in business resilience. Traders that have a wide geographical coverage are associated with 11% increase in business resilience. In addition, a 1% increase in friends running grain trading business results in 14% increase in business resilience. Further, a 1% increase in experience with brokers results in 56% increase in business resilience. When the trader increases interactions with distant traders within the region by 1%, business resilience increases by 12%.

TABLE 3.5: Determinants of maize traders' business resilience in Malawi

	Posterior with informative prior			Posterior with reference prior			OLS with bootstrapping		
	Mean	SD	p($\beta \neq 0$)	Mean	SD	p($\beta \neq 0$)	Coef.	Std. Err.	Bias
Registered business	0,0114	0,0433	0,1880	0,009	0,038	0,126	0,128	0,099	-0,008
Has export licence	0,0922	0,1021	0,5982	0,068	0,100	0,408	0,162	0,124	0,002
Runs other businesses	-0,1350	0,0633	0,9536	-0,106	0,080	0,749	-0,215***	0,069	0,001
Engages in value addition	0,2383	0,0883	0,9925	0,249	0,099	0,966	0,174	0,114	-0,007
Trader is male	-0,3079	0,1016	0,9965	-0,310	0,115	0,978	-0,349**	0,165	-0,009
log No.family members in business	-0,0007	0,0136	0,0858	0,000	0,011	0,060	-0,040	0,052	0,002
log asset replacement record	-0,5291	0,2559	0,9481	-0,457	0,318	0,790	-0,681***	0,238	-0,057
log time spent searching for market info	-0,1068	0,0317	0,9982	-0,113	0,033	0,996	-0,094**	0,042	-0,004
log Geographical coverage (km) radius	0,1139	0,0307	0,9995	0,119	0,032	0,998	0,125***	0,035	0,005
log No. District but distant traders	0,0040	0,0171	0,1451	0,003	0,016	0,101	-0,009	0,039	0,004
log Experience with broker (years)	0,5576	0,0602	1,0000	0,587	0,063	1,000	0,594***	0,084	0,002
log No. friends running business	0,1426	0,0350	0,9999	0,148	0,036	1,000	0,185***	0,045	0,895
log No. Traders from the same region	0,1199	0,0370	0,9977	0,128	0,039	0,994	0,109***	0,041	-0,001
Christian Catholic	-0,0665	0,0804	0,5587	-0,044	0,073	0,362	-0,113	0,131	0,009
Christian Protestant	-0,0007	0,0337	0,1517	0,001	0,024	0,089	-0,011	0,110	0,003
Moslem	0,0291	0,0666	0,2844	0,014	0,048	0,147	0,205	0,153	0,007
Chichewa	-0,0039	0,0360	0,1022	-0,003	0,030	0,067	-0,011	0,164	0,002
Chiyao	0,0025	0,0489	0,1024	0,003	0,041	0,069	-0,173	0,244	0,010
Chilomwe	0,0040	0,0456	0,0966	0,002	0,038	0,064			
Market FE	YES			YES			YES		
District FE	YES			YES			YES		
Seasonal FE	YES			YES			YES		
No. Traders	172			172			172		
Note:							*p<0.1; **p<0.05; ***p<0.01		

3.4 Discussion

In this study we analysed effects of social capital, industry size and firm performance in the maize sub-sector in Malawi. Our results explain three important findings. First, trader and industry characteristics shape business performance and resilience. Second, the complex nature of business performance and resilience can be explained by unpacking trader characteristics, closeness and wider social interactions. Our results show that trader and industry characteristics influence profitability and resilience of traders businesses in the maize subsector. First, we found that registered traders were more profitable than unregistered ones. For example, in order for firms to sell to large agencies such as the National Food Reserve Agency (NFRA), they are required to register their businesses. Having a registered business therefore guarantees that the trader can access most lucrative markets (McKenzie and Sakho, 2010). On the other hand, unregistered businesses tend to have a narrow base for expanding their business and profitability as they are usually credit constrained – this observation is consistent with (Fafchamps and Minten, 2001) who found positive association between formality and performance in Brazil.

We found that at market level, traders behave in an oligopolistic manner but as one expands to the district and regional levels, the market becomes more competitive. This observation is not surprising as it is usual to find traders who know each other at market level. Further, traders at market level formed committees of traders that traded in common commodities. This organization could lead to possibilities for collusion (Varian, 2014; Mas-Collel and Green, 1995). Our results are in stark contrast with (Cai and Szeidl, 2016) who found that when firms interact, performance increases. However, their finding was based on a sample that had larger businesses while this study was based on a sample of smaller businesses. Noteworthy, in support of our result, Levine et al. (2014) explain that when firms interact, it leads to collusion, which might end up creating price bubbles that eventually depress industry profits. Based on our findings, we tend to subscribe to Levine's explanation that at community market, where traders know each other, they can collude to set prices and therefore create price bubbles which might eventually lower community welfare as consumers would be buying an inefficiently priced maize grain. Of note, in

Zambia, Sitko et al., 2018 found that market entry of bigger traders increased market performance by decreasing market prices through improved market information channels and high levels of investment.

We find that social capital exerts an influence in shaping business performance and resilience. For instance, results show that traders operating within the same market and district experience an increase in business resilience. We also find that close ties with family members when running the business encourages business resilience. Our results are in agreement with the findings of Islam, Habes, and Alam (2018), Liu and Li (2018), and Madigan and Raftery (1994) who found that social capital and business performance and resilience are highly correlated. Our results are not in agreement with Portes (2014) who indicated that such closeness might reduce the business into a large family safety net on which family members use the firm's resources to the detriment of the business' performance. Rather, we find that traders who interact a lot with friends and distant traders have more resilient businesses.

Our results support the narrative that social capital leads to businesses that are more resilient, they also provide support for business performance. We find strong posterior probabilities that the association between firm performance and closeness with friends, religiously affiliated and ethnically close traders in the maize business is not equal to zero. Our results also strongly support other notions of social capital such as number of family members in business. Family members, as Portes (2014) observed would assist in supporting the business with capital and also providing human resources. This might explain the positive outcomes.

To sum up, results present evidence that long term interaction among traders leads to resilient businesses. Secondly, interactions among closely related traders such as family members, and friends lead to more resilient businesses. From the theoretical framework, the result that close ties with family and friends and increased interaction among traders is highly suggestive of both group and kin selection. As Nowak (2006) put it, natural selection mostly favours some level of altruistic cooperation among genetically related individuals. Evidenced by the significant positive association between relatedness and firm profitability, the Hamiltonian rule Hamilton (1964) would lead us to a conclusion that the relatedness we view in the results

outweighs its altruistic cost such that the result is positive firm performance for family members.

3.5 Conclusion

This study assessed effects of social capital, industry structure on performance and resilience of the firm. Results show that characteristics of the industry namely industry size, market concentration, proportion of registered firms, and proportions of firms having export licenses affect both firm performance and resilience. Second, results indicate that ethnically close traders operating within the same area tend to have more productive businesses. In evolutionary game theory, this suggests strong group and kin selection. On the other hand, results showed that group selection prevails as a dominant strategy in building business resilience as close association with friends in the business led to a more resilient business. In order to foster better business performance and resilience, efforts should be put in place to account for social capital arrangements and industry characteristics. For example, village banks and savings and credit cooperatives among similar groups could help improve resilience by reducing credit constraints since individuals would have similar behavioural traits thereby fostering cooperation.

Chapter 4

Business registration and firm performance: A case of maize traders in Malawi

4.1 Background

Business formality can affect performance by effecting changes in firms' profitability[1]. From a public finance policy perspective, government entities need to achieve a highly developed and diversified taxable base of economic activities by registering informal businesses (Ahmad and Best, 2012). A good tax revenue base would assist government in its recurrent expenditure and investment spending which have a demand stimulating effect on the commodity markets (Ahmad, Best, and Pöschl, 2012; Breisinger, Thomas, and Thurlow, 2009; Hausmann, Rodrik, and Velasco, 2008). Further, a formalized business environment is more transparent to the activities of both firms and the government. When more businesses are registered and a market shock occurs, it is easy to craft interventions to bolster resilience (Dabla-Norris, Gradstein, and Inchauste, 2008).

On the other hand, businesses characterized by high levels of informality are difficult to track (Levy, 2010). While it is difficult to cheat in tax returns when a firm is registered (Ahmad, Best, and Pöschl, 2012), the job of national accounting becomes not only easier but also more accurate when firms are formally registered (Dabla-Norris, Gradstein, and Inchauste, 2008).

[1]This chapter was accepted in the journal of Development in Practice. Routledge. Scopus/SJR ranking: Q2. Current status: Awaiting online production.

Most African countries are associated with high levels of informality (Auriol and Warlters, 2012). Thus, they are characterized by small unregistered businesses (Aidis and Van Praag, 2007). Nevertheless, small firms in Africa generate more revenue which is unfortunately undocumented (Türkler and Kabatas, 2012). An economy with a high level of informality is associated with low government revenue, deepening inequality and inequity and low levels of accountability (Kabatas and Türkler, 2012).

While the link between business formality and fiscal policy is well established, there is mixed evidence on whether informal businesses perform much better than formally registered businesses. However circumstances and contexts differ markedly. Literature cites several key issues, such as weak institutional support (Benhassine et al., 2018), complex tax policies, lack of access to information (De Giorgi and Rahman, 2013) and opportunities for tax evasion (Mironov, 2013) that encourage informality. Other literature however, show that under different circumstances, performance can improve if businesses are registered (Chow-Chua, Goh, and Boon Wan, 2003). To adequately understand whether business registration improves performance, we need to critically assess the literature in light of settings, circumstances, and the quality of tools used to gather such evidence. We start by evaluating the conceptual literature and later the methodological approaches.

Does business registration increase business performance? Williams and Kedir (2016), using observational data from India, assessed whether business registration improved performance. Using variables such as business sales, employment, and productivity growth, the study found that when the firm was unregistered or delayed its business registration, there was a positive association with the performance indicators except for productivity growth. Thus, the study rejected the contrary views of Ahmad et al (2012) and La Porta and Shleifer (2014) that informality leads to lower performance and hinders economic growth prospects. McKenzie and Sakho (2008) subjected the same question to Bolivian observational data using monthly profit as a key dependent variable and indicator of business performance. The study found mixed results. In terms of performance, smaller and larger firms benefited from registering while medium firms did not see any growth.

De Giorgi and Rahman (2013) used a randomized control trial in Bangladesh to

answer the question. The study embarked on a campaign to increase knowledge of the benefits of formalizing a business. The study controlled for location, human capital, sales, ability to export or import and informality. The study found that after the campaign, awareness of benefits increased but did not increase registration. The study also reported that registering businesses increased costs, which deterred formalization. While the study was internally valid, it does not provide sufficient room for externally valid inference.

In a similar study using observational panel data from Mexico, Bruhn (2013) found that unregistered businesses were unwilling to formalize but former employees started opening up new small businesses after registration rules were reformed. Contrary to the de Giorgio and Rahman (2013), the study found that it is not true that small firms, that use low levels of technology, do not register due to high costs of registration and the complexity of going through the process. A similar randomized control trial from Benin, after providing information, business services and training, and controlling for education and firm characteristics found that just providing information moderately increased formality but when combined with services and training, formalization increased (Benhassime et al., 2003). So far, evidence for access to information and costly registration is mixed and inconclusive for externally valid inference. Thus, more studies are required.

Noteworthy, Williams and Kedir (2016) and McKenzie and Sakho (2008) differ on the mechanisms driving business performance. While the latter uses owner characteristics such as sex, age, education and more abstract variables such as entrepreneurial efficacy, the former study emphasizes on firm characteristics such as firm age, human and physical capital composition of the firm and levels of innovation within the firm. Thus, we find that using completely different albeit important mechanisms, one can also easily find different results. A better way to ascertain the mechanisms is to blend the indicators.

Apart from business registration, other mechanisms that explain business performance are availability of social economic amenities and location of the business enterprise. In an observational study from Kenya, Gulyani and Talukdar (2010) found that after controlling for the aforementioned factors, income levels increased among

owners of microenterprises. Given the critical conceptual literature review, we postulate the following hypothesis:

- After controlling for other factors, business registration affects business performance.

The aim of this study is, therefore, to assess whether business registration leads to more efficient firms in the tumultuous African environment. We use Malawi as a case study because the land locked economy has recently been facing high levels of informality, has a very low tax base, chronically faces revenue shortages, low economic integration and has high levels of unemployment (Fontaine, 2010; Campos, Goldstein, and McKenzie, 2015). Malawi as an economy could benefit from a set of economic policies that aim at increasing the number of productive activities that generate more value addition. Our view is in stark contrast to the social transfer payment stand point that the Malawi government has been using to stimulate effective demand (Ellis and Maliro, 2013; Baird et al., 2012).

Our study contributes to the growing literature on complexity of economic systems (Cassata and Marchionatti, 2011), private and public sector reforms such as Ahmad, Best, and Pöschl (2012). We also complement recent work on fiscal policy reform by Ahmad, Brosio, and Pöschl (2014) by bringing a more grass-root level case from micro-enterprises in Africa. Using maize, a staple food, for Malawi, our study also contributes to the literature on food price policy design. Further, our results augur well with literature on instrumental variable estimation (Angrist and Pischke, 2008; Angrist, Imbens, and Rubin, 1996; Angrist and Pischke, 2014; Mason and Ricker-Gilbert, 2013).

The key message from our study is that, given the current business environment, if a small business is registered it loses revenue due to taxation, and costly registration processes our results indicate that, all things being equal, registered businesses are four times less profitable and efficient. We reiterate Williams and Kedir (2016) position that, for small businesses, it is much better to delay the registration. Business registration could increase if the current institutional environment is reformed to encourage small business growth.

The remainder of the paper is structured as follows. Section 2 provides the methodology used in the paper by outlining the data sources, theoretical framework

and identifying the causal link between business registration and profitability. Section 3 presents results which combine descriptive and inferential statistics. Section 4 presents a discussion of results while section 5 concludes the paper.

4.2 Evolution of price policy and agricultural trade informality in Malawi

For a long time maize price policy has been synonymous with the whole agricultural policy in Malawi. Thus, in order to understand trader behaviour, a bit of historical context on evolution of policy and how it shapes trader perceptions and behaviour is warranted.

Malawi's agricultural sector is divided into the smallholder and estate subsectors. Smallholder farmers are the majority of food producers in the country and produce over 70% of the production (Zeller, Diagne, and Mataya, 1998; Orr, 2000; Deininger and Xia, 2018). Large farm commercial farmers, locally known as estate farmers, usually operate under leasehold and freehold.

During pre-colonial times, between the 16th and 17th century, maize was introduced to the region from America. When initial white settlers came, they needed a cheap source of calories to feed their labourers. Due to its high yielding characteristics, it was readily adopted by smallholder farmers and soon became the staple food (Matumba et al., 2014; Widgren et al., 2016).

During colonial times, the state sought of ways to enable farmers sell their produce so that they can earn a living. In order to do this, the colonialists instituted farmers marketing boards whose agenda was mainly to tax and control smallholder farmers – that is to ensure that smallholders do not compete with white settlers. In 1971, seven years after attaining its independence from the British Government, the new Malawi government established the Agricultural Development and Marketing Corporation (ADMARC) (Harrigan, 2008). ADMARC had three mandates: to encourage exports of agricultural produce, establish opportunities for new markets and make food accessible to the local economy. ADMARC did not abandon all of the extractive policies from the former agricultural boards. It continued to extract

resources from smallholder farmers by offering them low domestic prices as compared to international markets so that it could finance the estate sector (Harrigan, 2003a). This policy resulted in poor performance of the smallholder-sub-sector. To illustrate, the estate sub-sector grew by 17% while the smallholder sector grew by a meagre 3%. Further, smallholders were prevented from cultivating high value crops but were encouraged to grow maize.

Due to some exogenous shocks to the agricultural sector in Malawi, which led to output reduction of up to 35%, the government took a structural adjustment loan from the World Bank in 1981 to bail out the agricultural sector. However, the World Bank loan came with a set of conditions which later came to be known as structural adjustment conditions. The loan conditions mainly focused on removing the government's bias against the agricultural sector by improving smallholder prices and stimulating production of crops, which was predominantly maize and few other staples. The government implemented the policies against the resistance from the agricultural sector stakeholders. Resultant, output to sell to ADMARC, then a sole buyer i.e. a monopsony increased. This stifled private traders participation in the market.

Smallholders' production, however, did not increase due to further restrictions from the government. Further, among the conditions, government was advised to remove the fertilizer subsidy program which upon its removal, maize production fell. Demand soared. The government, through the Ministry of Agriculture had more faith in market interventions while the World Bank believed in the free market mechanism (Harrigan, 2003b). Due to the uncertainty of private trader participation in maize markets and food markets in general, formal private traders were virtually non-existent (Harrigan, 2001).

The latter years of the 1980s lead to poor sequencing and mixing of pricing policies that led to low maize output and a food shortage crisis. Moreover, due to a liberalization condition, government owned ADMARC failed to purchase output from smallholder farmers. Coupled with the hunger crisis, farmers had nowhere to sell their produce and earn income. This pervaded poverty. Resultant, the Malawi government had a policy reversal back to the former price policies but with an increase in smallholder prices (World Bank, 1990).

The year 1992 was a drought year and maize output very low and the situation from 1980s was aggravated. Following the policy reversals of the latter 80s, the early 1990s saw a re-appraisal of the Washington Consensus to a focus on the Theory of the Second Best which encouraged investments that were largely non-price interventions.

The year 1994 saw Malawi change from a dictatorship to a democracy. Noteworthy, during the dictatorship, successful formal agricultural and non-agricultural businesses were often expropriated and owners detained indefinitely without trial which led to local investor fear of entrepreneurship (Mapanje, 2011). The change in government brought some changes in government policy. Smallholder farmers were now allowed to grow more lucrative commercial crops such as burley tobacco. Due to support from donors, the research community were able to come up with more high yielding maize varieties. Further, to address the hunger and poverty situation in the country, in 1996, the government called upon an extraordinary meeting to address the poverty and hunger situation. The main output of the meeting was that smallholder farmers, generally the country's poorest should receive a package of maize seed, fertilizer and legume seed in order to jump start agricultural productivities. This program was later known as the Starter Pack Program (Conroy, 2006). Further, as part of the structural adjustment program, traders were allowed to establish their businesses and to trade freely in all agricultural commodities. In this climate, the starter pack program was a success due to its appeal to science such that by 1998, the country was food self-sufficient – it had enough maize and legumes. Later in 1999 government was ill advised by the World Bank to open up borders and export the surplus maize. The export, coupled with poor rainfall in the country in the 1999-2000 agricultural season led to poor agricultural output and hunger. The Malawi government with donor support imported maize from neighbouring countries to avert the crisis (Conroy, 2006).

In 2005 the government of Malawi introduced the Farm Input Subsidy Program FISP to address food security challenges and stimulate effective demand for food and agricultural inputs (Chibwana, Fisher, and Shively, 2012). The food subsidy program resulted in surplus agricultural production for several years which maintained lower maize prices in the country. Small itinerant traders - often unregistered

vendors - play an integral role in distributing grain throughout the country.

Interestingly, during the course of the subsidy program alone, there have been a number of policy reversals and a lot of interventionist policies (Tchale and Keyser, 2010; Chinsinga, 2011). For instance, the Malawi Government has instituted on-and-off interventions that were not timed well. The result has been pervasive poverty as some of the beneficiaries of the much touted FISP have failed to graduate from the program. To illustrate, the government has been reporting surplus output from agricultural production but once the output is in the country, the government institutes trade bans such as export bans (Aberman, Meerman, and Benson, 2018). Furthermore, the government has institute a number of floor prices which have not been strictly adhered to. For instance, in 2016/17 season, the government announces strict price floors when ADMARC and the National Food reserve agency was selling its maize grain at higher prices. Although the government has a functioning famine early warning system, its responsiveness is quite lax – it is often associated with insufficient response strategies.

4.3 Methodology

4.3.1 Data and measurement

Study area, data collection and time context

The study was conducted in five districts in the central region of Malawi namely, Lilongwe, Mchinji, Kasungu, Dowa, Ntchisi, and Dedza. The central region of Malawi was selected because it is a major maize producing district and thus has a large proportion of maize traders than the rest of the country (Jones, Shrinivas, and Bezner-Kerr, 2014; Msowoya et al., 2016). Most traders found within this part of the country would be representative of other traders who sell maize across the country. Further, the study area has had the most consistent market price data over the past two decades (Sitko et al., 2017).

During the data collection period, we made contact with the market authorities to obtain permission to collect data during market days. Then we requested a list of maize traders in the market from which we systematically picked traders in a

linear fashion. Usually, the total number of maize traders (N) per j-th market was $N_j \leq 50$. In the case where the market did not have a proper list, we conducted a market listing of all maize traders in the market to ascertain the number of traders. We assumed that half of the maize businesses were highly performing. Thus, we let p =0.5. Assuming a 95% confidence interval which gives a z-value equal to 1.96 and a level of precision (e) of plus or minus 10%, we found that our sample size $n = (z^2 p(1-p))/e^2 = 96$. We then increased our sample size by half in order to account for unforeseen circumstances such as individuals who may not want to respond and other logistic failures.

We visited 5 districts in the central region namely Kasungu, Dowa, Lilongwe Mchinji and Dedza covering 15 main markets in total. From the initial population estimates, it means we covered about 750 businesses that sell maize. We numbered the traders in each list from 1 to N_j per market in ascending order. Then from each market, we picked a sample of 15 traders in the following way. First, we took a random number between 1 and 50 in order to pick the first trader. Then we counted every third trader until our sample was exhausted. Thus, we followed an every third systematic sample.

We used computer assisted personal interview software called SurveyCTO in order to conduct our trader interviews. In this setting, we coded our semi-structured questionnaire into the computer server such that every interview was recorded in real time. Trader basic characteristics, industry structure and social capital data was collected to form a baseline for further analysis. Later on, traders were visited to collect data during the harvest season. We mainly collected data on output, revenue and pricing. In the event that it was not possible, to catch up with the trader, we contacted them using mobile phones. At the end we managed to interview 172 traders as summarized in Figure 1. We collected 516 data points in 3 waves of panel data using systematic random sampling following the agricultural season in the country.

Ethical clearance was reviewed and obtained from the University of Bonn's Center for Development Research (ZEF). During the data collection period, we made contact with the market authorities to obtain permission to collect data during market days. Then we requested a list of maize traders in the market from which we systematically picked traders in a linear fashion. In the case where the market did

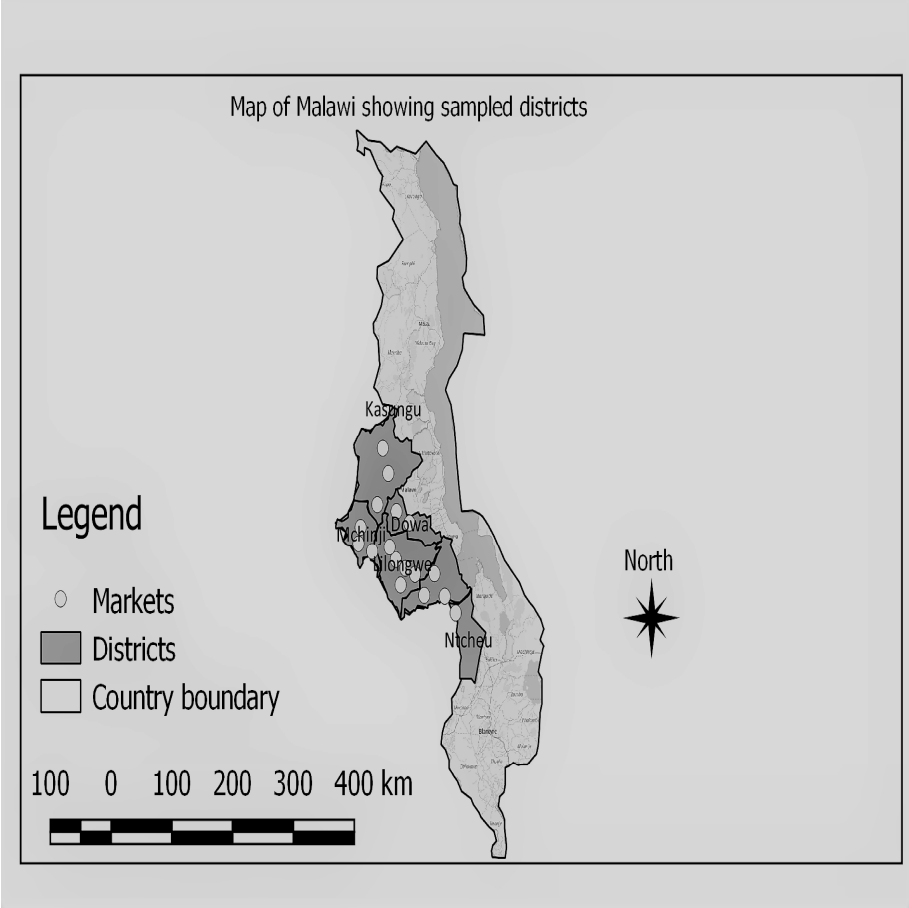
not have a proper list, we used systematic sampling to pick the traders. Then trader basic characteristics, industry structure and social capital data was collected to form a baseline for further analysis. Later on, traders were visited for further seasonal data mainly on output, revenue and pricing. In the event that it was not possible, we contacted them using phones.

We collected data using systematic random sampling following the agricultural season in the country. Thus we collected the data during the warm rainy season in November of 2017 which is the onset of the planting season. According to Famine Early Warning System (FEWSNET) (2017), it was a period when prices were low and stable due to maize supplies which were above average. Atypical of the data collection time, months following this season are historically characterized by scarcity of grain and higher prices. However, this was not the case in the Central region as prices were stable as there were sufficient supplies. FEWSNET cited that other factors that might have led to price stability were informal inflows of maize from neighbouring Zambia and Mozambique. Our data do not deviate much from the FEWSNET estimates that prices would range between MK50 and MK105 (Famine Early Warning System (FEWSNET), 2017). We further, collected data during the harvest season when food prices were seemingly declining due to increased supply. Our data during this season are also consistent with the FEWSNET estimates of maize prices being 8 to 33 percent lower than the other seasons. This is an indicator of abundant supply. Thus, when interpreting the results, these FEWSNET finding are also taken into consideration.

Empirical Estimation

Which method is the most suitable to test the null hypothesis that business registration affects performance? To answer this question we reviewed the relevant literature for methodological approaches. From an econometric perspective, the best method to assess causal effects depends on the hypothesis at hand (Deaton and Cartwright, 2018). Methodological evidence for testing our hypothesis reveals the following distinct approaches namely, a randomized control trial (RCT) (de Giorgio and Rahman, 2013; Benhassime et al., 2008;), exploiting a natural experiment through panel data (Bruhn, 2013), observational data using instrumental variable

FIGURE 4.1: Map of Malawi showing the study area. Markets are specific points where the data was collected using systematic sampling in a particular district.



estimation (McKenzie and Sakho, 2008), and control function approaches (Williams and Kedir, 2016).

Deaton and Cartwright, (2018) reported that although there is so much trust in RCTs in terms of internal validity, the method does not precisely deliver a direct causal effect automatically without paying attention to other considerations. Among such considerations, unobservable heterogeneity is often a problem. In addition, RCTs are expensive to implement such that in some cases, the value for money might be maximized if a well-designed observational study was implemented. From our study's perspective, an RCT would not work based on the latter reason. However, we triangulate our findings with de Giorgio and Rahman, (2013) and Benhassime et al., (2008).

Exploiting a natural experiment using panel data as the case of Bruhn, (2011) is appealing to the purposes of our study. Although no policy change occurred,

the appeal of controlling for unobservable heterogeneity in business observations is important.

McKenzie and Sakho, (2008) subjected their observational data to instrumental variable (IV) estimation to cleanly identify the causal effects. Noteworthy, Angrist & Pischke (2008) cautioned that use of IVs should not only follow the study context and hypothesis at hand but should also be valid and strong. They cautioned that finding strong instruments is often difficult. Our study context permits the use of instrumental variable estimation.

Williams and Kedir, (2016) used Heckman's sample selection procedure. The approach models the mechanisms that affect business registration through a control function first, and later models the effects of registration on performance using a ratio of the predicted probability density function to the cumulative density function i.e. the inverse Mills ratio as an explanatory random variable. The method works better using observational data but when using panel data, it is advised to use bootstraped standard errors (Wooldridge, 2010).

To conclude, we adopt a short but rapidly followed observational panel data survey design and later use instrumental variable estimation techniques. As a robustness check, we implement Wooldridge (2010)'s approach to check our IV approach.

In order to ascertain the effect of registration on business performance, an instrumental variable (IV) regression technique is used. The IV regression is a method that is used to assess direct causal effects in the absence of randomized experiments (Angrist and Pischke, 2008). For instance, had it been that an external individual randomly registered maize trading firms and left others unregistered then observed the performance differences in a controlled manner, then, an ordinary least squares regression technique would have been used. In that case, given that D_{ijt} is the state of whether the firm is registered, i.e. $D_{ijt} = 1$, or the firm is not registered $D_{ijt} = 0$ and business profitability is Y_{ijt}. Then the difference in the business performance outcomes, i.e. $Y_{ijt}(1) - Y_{ijt}(0)$ can be estimated by ordinary least squares regression techniques. That is,

$$Y_{ijt} = \beta_0 + \beta_1 D_{ijt} + \epsilon_{ijt}, \tag{4.1}$$

where β_i are parameters to be estimated. To control for other factors that might affect

firm performance, we add a number of variables X_{ijt} which would make our OLS regression

$$Y_i = \beta_0 + \beta_1 D_{ijt} + \beta_3 X_{ijt} + \epsilon_{ijt}, \tag{4.2}$$

However, since the individual self-selects into registering their firm, we suspect that firm registration might be correlated with the error term. For instance, while having controlled for a considerable number of factors, some individuals might have more aptitude for entrepreneurship and would register their businesses. Aptitude in this case might be in the error term. We look for a random variable that is correlated with business registration but is not correlated with the error term. Thus, when clearly identified, the IV estimate will be of the form

$$\hat{\beta}_{IV} = \frac{Cov(x_{ijt}, y_{ijt})}{Var(x_{ijt})}. \tag{4.3}$$

In our study, we use geodetic distances from Lilongwe the capital city, where business registration takes place and business age as instruments for business registration. We argue that while age of the business and distance likely influence the likelihood to register, it may not directly influence firm's profitability. We fitted the regression using the following form

$$\ln \text{Profit}_{ijt} = \beta_0 + \beta_1 \text{Registration} + \beta_2 X_{ijt} + \delta_j + \gamma_t + \epsilon_{ijt}, \tag{4.4}$$

where ln Profit is the natural log of profit of firm i from market j in season t; Registration is a dummy variable taking the value of 1 if the business is registered and 0 otherwise; X_{ijt} is a vector of control variables; δ_j are market specific dummies; while γ_t is are the seasonal dummies. Then, we tested the robustness of the instrument using Ordinary Least Squares regression to assess it association, used The Kleibergen-Paap test for underidentification and the Stock-Watson test for weak instruments.

As a robustness check for our IV estimator, we use an endogenous switching regression model proposed by Maddala (1986). We start by reformulating equation

4 by removing the IV and explicitly specifying a selection mechanism that incorporates as many confounders of business registration as possible. The selection equation takes the form

$$D^*_{ijt} = Z_{ijt}\kappa + u_{ijt} \tag{4.5}$$

where $D_{ijt} = 1$ if the latent variable $D^*_{ijt} > 0$ and $D_{ijt} = 0$ if the latent variable $D^*_{ijt} \leq 0$. Using a probit regression model we predict the propensity score – the probability of registering a business – as

$$Prob(D_{ijt} = 1|Z_{ijt}) = \Phi(\kappa Z_{ijt}) \tag{4.6}$$

$$Prob(D_{ijt} = 0|Z_{ijt}) = 1 - \Phi(\kappa Z_{ijt}) \tag{4.7}$$

The random variables ϵ_{ijt} and u_{ijt} and bivariate normally distributed with a zero mean and a variance covariance matrix equal to

$$\begin{bmatrix} \sigma_\epsilon & \rho \\ \rho & 1 \end{bmatrix}$$

Having explicitly modelled the selection process, we can estimate the potential outcome model – restate equation 4 – when $D = 1$ as

$$\log \text{Profit}_{ijt} = \beta_1(\kappa Z_{ijt} + u_{ijt}) + \beta_2 X_{ij} + \delta_j + \gamma_t + \epsilon_{ijt}, \tag{4.8}$$

and when the business is not registered as

$$\log \text{Profit}_{ijt} = \beta_2 X_{ijt} + \delta_j + \gamma_t + \epsilon_{ijt}, \tag{4.9}$$

Maddala (1983) provides the joint probability density and likelihood functions for equations (7a) and (7b) in cross-section form while Wooldridge (2010) provides detailed exposition on the asymptotic properties.

Since we are operating in a panel data framework, we adopt a dummy variable fixed effects approach and use bootstrapped standard errors with 250 replications. Of note, these standard errors are the most conservative in the class of robust standard errors.

4.4 Results

4.4.1 Descriptive statistics

Table 4.1 summarizes results of descriptive statistics of key variables used to asses the effect of business registration on performance. Results indicate that 76% of the firms were not registered. The average profit of firms in the sample was MK600,764.64. Noteworthy, there were marked differences between registered and unregistered businesses. Using student's t-test, results were significant at 1% that registered businesses were twice as profitable. Results further indicate that unregistered firms had less assets than registered firms. In addition, results also show that registered businesses stay longer in business. Results for this difference is significant at 1%. Furthermore, we find that registered firms had more 33% more export licenses than unregistered firms. Results also indicate that registered firms were covering a larger geographical area than unregistered firms. Registered firms were 77% likely to have more businesses than unregistered businesses. The registered firms in the sample were more likely to sell other commodities apart from maize than unregistered firms. When the market had more firms, then it was more likely that firms would be unregistered. Furthermore, results also indicate that registered firms are more likely to have more employees than unregistered ones. In addition, firms that were registered were more likely to have more interactions with other traders.

4.4.2 Effects of firm registration on performance in form of profitability

Having controlled for the factors in the descriptive statistics, we computed geodetic distances i.e. the shortest great circle distances between a given market and Lilongwe, where business registration takes place, as an instrument for business registration. We assume that the closer the trader is to the registration center the more likely they are to be registered and we cannot be certain whether this directly impacts profitability. Even if it were to be correlated, there could be no plausible economic explanation. The instrument uses curves between two points using latitudes and longitudes on the mathematical model of the earth using WGS 1984 datum and Vincenty's equations (Vincenty, 1975).

TABLE 4.1: Descriptive statistics for variables used in the study.

VARIABLES	Business was registered				
	No	Yes	Total	Diff.	t
	(1)	(2)	(3)	(4)	(5)
Profit per kg in MWK	17.871	19.069	18.164	-1.198***	-5.789
Business age	6.584	9.357	7.262	-2.773***	-5.478
Has export licence	.015	.333	.093	-.317 ***	-12.080
Geographic coverage	22.800	2.357	2.299	-.771	-.344
Has other businesses	.408	.643	.465	-.235***	-4.689
Trades in other commodities	.877	.929	.890	-.054	-1.609
Experienced shock	.023	.095	.041	-.072***	-3.602
Sex of trader	.923	.905	.919	.018	.653
Log of industry structure	2.309	1.802	2.187	.507***	5.122
Catholic	.146	.1667	.151	-	-
Protestant	.631	.714	.651	-	-
Islam & Other	.223	.119	.198	-	-
No. Employees	2.592	3.786	2.883	-1.193***	-4.415
No. Traders from same region	1.092	1.667	1.232	-5.751***	-4.714
No. Distant traders	8.215	9.643	8.564	-1.427	-1.539
GPS Latitude	-1.370	-1.372	-1.370	-	-
Domestic maize price	120	120	120	-	-
Border maize price (Mchinji)	160	160	160	-	-
Nominal Protection Coefficient (NPC)	0.750	0.750	0.750	-	-
Sole Traders	.846	.810	.837	.037	.967

NOTE: *Significantly different from zero at 90 percent confidence
**Significantly different from zero at 95 percent confidence
***Significantly different from zero at 99 percent confidence

The second instrument used is the age of the business. We make a basic assumption that traders who have stayed long enough in business might eventually decide to register. However, the level of profitability and business resilience are not necessarily correlated as shown in the first stage regressions and correlations. Our instruments are significantly correlated with with the dependent variable.

Having tested for relevance, by assessing the strength of the relationship with business registration using ordinary least squares regression as a first stage, the IV regression was fitted using plm and ivreg packages using bootstrapped standard errors replicated 1000 times in R Statistical Package. The KleibergenPaap test for underidentification, a Lagrange Multiplier test of whether the excluded instruments in the model were correlated with endogenous regressors was rejected at all conventional critical values of 10%, 5% and 1% respectively with an a χ^2 value equal to 21.526. Results of the Cragg-Donald Wald F-Statistic weak identification test, which tests the hypothesis that the excluded instruments are weakly correlated with the endogenous regressors was rejected with an F-Statistic equal to 25.93 at all Stock-Yogo

TABLE 4.2: Effect of business registration on business profitability using instrumental variable estimation: First stage regression

	DEPENDENT VARIABLE: Business is registered			
	OLS Model		Probit Model	
	(1)	(2)	(3)	(4)
EXPLANATORY VARIABLE	Coef.	Std. Err.	Coef.	Std. Err
Has export licence	0.608***	0.059	2.225***	0.283
Geographic coverage (km)	-0.001	0.001	-0.005	0.004
Has other businesses	0.089**	0.037	0.274*	0.163
Trades in other comm	0.074*	0.044	0.688***	0.218
Experienced shock	0.377***	0.102	1.378***	0.281
No. Family in business	0.005	0.013	0.035	0.056
Sex of trader	0.074	0.061	0.256	0.350
Log of industry size	-0.060***	0.016	-0.342***	0.073
Religion of trader				
Catholic	0.024	0.056	0.285	0.266
Protestant	0.017	0.041	0.094	0.205
Islam and Other	-	-	-	-
Seasonal dummies				
Harvest	0.000	0.038	-0.000	0.179
Planting	0.000	0.038	-0.000	0.179
Trader interactions				
Same region (No.)	0.002	0.001	0.015*	0.008
distant traders (No.)	-0.001	0.002	-0.008	0.010
Sole trader (Yes= 1)	-0.094*	0.049	-0.540***	0.187
Distance from Lilongwe	-0.001**	0.001	-0.005*	0.003
Business Age	0.018***	0.003	0.091***	0.014
Constant	0.131	0.087	-1.420***	0.461
Observations	510		510	
R-squared	0.349			

NOTE: Huber robust standard errors were used to correct for heteroscedasticity
*Significantly different from zero at 90 percent confidence
**Significantly different from zero at 95 percent confidence
***Significantly different from zero at 99 percent confidence

weak identification critical values(Stock and Yogo, 2005).

Although not directly comparable since OLS presents an Average Treatment Effect (ATE) - the difference in the average profit between those firms that registered their businesses and firms that did not while the IV presents Local Average Treatment Effect (LATE), i.e. the treatment effect of those that have been induced to register their business based on the selected instrument, we present the OLS results, 2SLS and then use IV using a probit model as a first stage in `sampleSelection` R statistical package since our endogenous variable is binary. Table 3.2 summarizes results from the econometric estimation of the effect of business registration on firm performance.

The Hansen J statistic for overidentification of the instrument indicated that the equation is exactly identified. In summary, we find that the instrument selected – the geodetic distances from the registration point is – 1) relevant and 2) not a weak

TABLE 4.3: Effect of business registration on business profitability using instrumental variable estimation: Final IV estimation

	Dependent variable: Nat. log of profit		
	Pooled OLS (1)	Pooled IV (2)	ESR (3)
Business is registered (Yes=1,No=0)	0.368*	-4.104***	-0.919**
	(0.220)	(1.329)	(0.423)
Exporter	2.736***	5.741***	3.601***
	(0.339)	(0.984)	(0.421)
Does other businesses	0.494***	0.989***	0.638***
	(0.173)	(0.274)	(0.181)
Sex of trader	1.449***	1.312***	1.410***
	(0.306)	(0.416)	(0.309)
No. Family members in maize business	0.032	-0.397*	-0.091
	(0.148)	(0.236)	(0.154)
No. Traders interacted with daily	-0.177*	-0.276*	-0.205*
	(0.102)	(0.142)	(0.104)
Innovation (Use of technology/replacement)	-1.681***	-2.719***	-1.977***
	(0.648)	(0.929)	(0.662)
Time spent gathering information daily	0.408***	0.768***	0.512***
	(0.106)	(0.178)	(0.112)
Age of business	-0.007	-0.526***	-0.330
	(0.143)	(0.225)	(0.159)
Geographic coverage of business in km radius	-0.252	-0.526**	-0.330**
	(0.155)	(0.225)	(0.159)
Nat. log. No. friends in maize business	0.036	-0.001	0.026
	(0.093)	(0.127)	(0.095)
Nat. log No. traders within region interacted with	0.081	0.248	0.129
	(0.118)	(0.167)	(0.121)
Nat. log. No. Distant traders interacted with	-0.003	0.007	0.001
	(0.127)	(0.173)	(0.130)
Nat. log. No. Years interacting with brokers	-0.096	0.028	-0.06
	(0.130)	(0.180)	(0.133)
Christian Catholic	-0.207	-0.303	-0.235
	(0.195)	(0.265)	(0.197)
Christian Protestant	0.119	-0.182	0.034
	(0.324)	(0.448)	(0.330)
Moslem	0.213	0.149	0.196
	(0.267)	(0.363)	(0.272)
Other religion but not traditional	-1.458	-1.569	-1.48
	(1.129)	(1.531)	(1.159)
Mother tongue - Chichewa	-0.44	-0.894	-0.572
	(0.484)	(0.669)	(0.492)
Chiyao	3.102***	2.639*	2.972**
	(1.140)	(1.551)	(1.155)
Chilomwe	2.502**	1.271	2.153*
	(1.245)	(1.725)	(1.265)
Chisena	2.892**	2.583	2.809**
	(1.216)	(1.651)	(1.235)
Constant	10.449***	12.181***	10.944***
	(1.479)	(2.067)	(1.503)
Observations	516	516	516
R2	0.281	0.068	
Adjusted R2	0.25	0.028	
Log Likelihood	-1,209.62		
rho	0.448*** (0.116)		
Residual Std. Error	1.794 (df = 494)		
F Statistic	9.179*** (df = 21; 494)	112.898***	
Note:	*p<0.1; **p<0.05; ***p<0.01		

instrument.

For robustness checks, we present OLS, Pooled IV and then use an endogenous switching regression (ESR) (Maddala 1986) to explicitly model the business registration selection mechanism. The ESR technique is the best way to gauge how well the selection mechanism has been controlled for through use of propensity scores. Table 3 summarizes results from the econometric estimation of the effect of business registration on firm performance.

Since we rejected the use of pooled OLS and establish that there is endogeneity in our models, we use IV and ESR results. We find that business registration has a negative effect on firm profitability. Our results indicate that a discrete change from an unregistered business to a registered one is associated with a -4.104 change in the natural log of the profits of the business. This result is two-sided statistically different from zero at 99%. From the diagnostic statistics, both models are consistent and have the same direction. More substantively, when proximity to the registration center – the instrument – induces traders to register their businesses, it is associated with a loss in profitability amounting to MWK60 . In addition, when the entire selection mechanism is taken into account –, a shift from and unregistered trader to a registered one is associated with a MWK2 per kg loss in profits. This is in contrast to the rejected pooled OLS comparison of expected profits between registered and unregistered ones which shows registered businesses are 37% more profitable. The latter estimate ignores self-selection of the registration decision, which biases the results upwards. Noteworthy, the pooled OLS results are only significantly different from zero at 90% confidence while the rest are significant at 99% and 95%, respectively. Further, the IV model overestimates the impacts while the ESR is the most conservative.

Other factors affecting business performance include whether the trader imports or exports which is associated with an increase in profits by a factor of 5. This result is statistically significant at 5%. Second, we further find that businesses that trade in other commodities are associated with a 98% increase in profits. This finding was statistically significant at 1%. We find that if the trader was male, it was associated with over 100% more profitable businesses. When more family members are involved in the business, it is associated with less profitability. However, we find

that this result is barely robust at $p < 0.10$. Similarly, interactions with traders also have a profit reducing effect albeit barely robust at $p < 0.10$. Frequent replacement of assets also has a profit reducing effect at $p < 0.01$.

Indicators of social capital also play a significant role in business performance. However the magnitudes are mixed. For instance, when endogeneity is controlled for, tribe has a positive effect while friends' interactions and religion have no effect.

4.5 Discussion

In this study we assessed the effect of business registration on performance of the firm in terms of profitability among maize traders in Malawi using an instrumental variable approach. We find three results. First, from the descriptive analysis, we find that the informal unregistered businesses are more than the registered businesses. Second, econometrically, we find a causal path that business registration negatively affects profitability. Third, social capital plays a, but nevertheless not so robust, role in business performance.

The result that the informal, unregistered businesses form a majority in the sector is not surprising as it has also been reported by Chen et al. (2007) who indicated that the informal sector has a mixture of wage workers, self-employed individuals and entrepreneurs who produce commodities that are legally acceptable. Chen et al. (2007) further reported that given favourable conditions such as reduced barriers to business registration and a suitable regulatory environment, most unregistered firms would also register. This observation also concurs with our key informant interviews with informal traders who reported that it was difficult to access information about business registration.

Further, it was reported that other barriers were that the registration authorities were unavailable in the areas where most small businesses operate. If business registration and regulatory authorities were to set up business registration bureaus at district level, then the level of informal businesses would reduce. Our finding of significant barriers to register the businesses due to distance are also in agreement with Grimm, Krüger, and Lay (2011) who also found that at the lower level of business activity, there are negligible capital costs to running the business among unregistered

firms.

However, as firms increase in size, they start facing significant barriers if they are not registered. One, case in point from our study is the access to export licences. We found that businesses that are registered were 88% more likely to have an export license compared to those that were not registered. In addition, businesses that have export licenses and access international markets make more profits than unregistered ones. As the descriptive statistics show, only 33% of the sample have access to international markets. This may mean that the industry is highly concentrated at the export level since only few companies have access to international markets. Resultant, most businesses without export licenses will be forced to sell at depressed domestic market prices, something that does not lead to efficient allocation of resources as there will be an over-abundance of supply leading to consumers consuming too much of the inefficiently allocated commodity (Estrades, Flores, Lezama, et al., 2017; Tsakok, 1990). This may affect firm performance by lowering profits of unregistered businesses which may negatively affect performance of the entire industry.

The results of large unregistered businesses coupled with lower Nominal Protection Coefficients (NPC) is suggestive of an agricultural taxation price policy. Magrini, Balié, and Morales-Opazo (2017) reported that price incentives at the border, such as removal of tariffs on agricultural commodities, repeal of export bans, can stimulate profitability and eventually sector supply. However, our results which show large levels of agricultural taxation suggest that as long as large numbers of unregistered firms who have no access to agricultural licenses exist, performance and general competitiveness in the industry will remain low.

Our key result that business registration significantly decreases profitability - a direct measure of business performance - is in agreement with Williams and Kedir; McKenzie and Sakho (2008) but are not in line with Chen et al. (2007) who found that firms that have formalized have a high chance of surviving turbulent business environments. Our results appeal to literature from developing countries where entrepreneurs face significant registration costs (Benhassime et al., 2018) and lack of information (de Giorgi and Rahman, 2013). Thus, we reject our null hypothesis that business registration leads to profitable businesses.

Our results stand in stark contrast to the formality literature such as Aidis and

Van Praag (2007) and La Porta (2014). Aidis and Van Praag (2007), in a study from Lithuania, found that although informal young entrepreneurs might see a surge in business performance in early stages, setting up legal businesses formally leads to more stable businesses. We argue that eventually, such opportunities can only be harnessed by reforming the tax and regulatory environment. Coupled to business registration, maize trading businesses that are run by males are more profitable compared to their female counterparts.

This result contrasts Chirwa (2008) who found that female run micro-enterprises in Malawi perform much better than male run businesses. However, Chirwa (2008) was more general and did not particularly specify whether the firms were formal or informal as compared to this study, which focuses on maize traders who formalized their businesses. Further, our result that trader characteristics play an important role in business performance corroborates Barbieri and Mshenga (2008) who also found that trader characteristics such as number of employees, length of time doing business, age of the trader and asset ownership and gender have significant effects on business performance.

When we control for endogeneity of business registration, we find that measures of social capital have different effects on business performance. Interactions with traders, though they had positive effects, were not statistically significant. However, we found that family based businesses were less profitable – hence low performing. Diéguez-Soto, López-Delgado, and Rojo-Ramírez (2015) reported that most family run businesses are often risk averse and would not venture into expansion strategies such as expanding their businesses by taking in credit for fear of losing a family business.

4.6 Conclusions

This study assessed the effect of firm registration on business performance in Malawi's maize sub-sector. Primary data from the trader survey conducted in the central region of Malawi was used. The data reports business characteristics, seasonal revenue, variable and transaction costs and profits from 15 markets across five districts of Kasungu, Dowa, Lilongwe, Mchinji and Dedza, respectively. To assess

the effect of firm registration on business performance, an Instrumental Variable estimation technique was used. Our study points to three key results. First, we found that registered businesses comprise 24% of all traders in the sample. Second, results indicate that firms that were registered were four times less profitable as unregistered businesses. Third, across various indicators, results show that social capital has significant positive effects on business perfomance.

In order to improve performance of businesses in the agricultural sector, the role of business registration should not be overlooked. The study recommends reforming the ease of registering businesses, reforming the tax policy and devolving business registration processes to district councils so that businesses can register at the lowest level as this could reduce informality and enhance accountability of firms.

Chapter 5

Entrepreneurship, food security and welfare in Malawi

5.1 Introduction

Entrepreneurship can be a catalyst for economic growth through innovation (Schumpeter, 1934; Anokhin and Schulze, 2009) [1]. While factors, such as choice, personal characteristics, success and failure, entry and exit mechanisms, that drive entrepreneurship have been widely studied in management literature (Mwatsika, 2015; Naudé, 2014), there is a huge disconnect on implications of entrpreneurship on welfare and economic growth (Naudé, 2010). While in the past development economics literature largely relegated entrepreneurship to management sciences, it is only recently that its formalization has taken root. Naudé (2010) pointed out that the main reasons for the disconnect between entrepreneurship in management sciences and in mainstream development economics has been that, in the past, entrepreneurship was vaguely defined to be incorporated into formal economic growth theories.

The second reason is that entrepreneurship has commonly been treated as a binding constraint to economic growth. However, recent advances in economic theory have made entrepreneurship tractable by formalizing it in modern economic growth theories (Gries and Naudé, 2010). Using such growth models has enabled development research evaluate the implications of venturing into entrepreneurship on the inequality (Kimhi, 2010), productivity (Audretsch, Keilbach, Lehmann, et al., 2006), economic transformation (Gries and Naudé, 2010) and welfare (Tamvada,

[1] An earlier version of this chapter was selected for presentation at the Agricultural and Applied Economics Association meeting, Atlanta, GA, July 21 – July 23

2010; Henrekson, 2005; Otoo et al., 2011). However, most of the work has been concentrated in developed countries (*see* Chowdhury, Audretsch, and Belitski, 2019; Erken, Donselaar, and Thurik, 2018; Parker, 2018; Audretsch, Keilbach, Lehmann, et al., 2006; Hamilton, 2000). Of the few studies conducted in developing countries, none have explored the implications of entrepreneurship on one important indicator of welfare, food security. In most African countries, achieving food security is one of the key goals such that evaluating the impact of entrepreneurship on such indicators would be of much policy relevance.

In the belief that entrepreneurship would induce structural change in economic activities by creating more value added and, therefore, growth to achieve the Millennium Development Goals (MDGs) of ending poverty and hunger, the Malawi Government prioritized promotion of entrepreneurial activities. As a market oriented strategy to ensure that all individuals meaningfully participate in wealth creation and poverty reduction, the government invested approximately seven million US Dollars in development of technical, entrepreneurial and business management skills through various vocational training and all schools across the country between 2011 and 2016 (Government of Malawi, 2011b).

The question of evaluating the effect of entrepreneurship on food security is complex because of several problems. First, the definition of entrepreneurship itself is elusive in literature. Adopting Williams (2008)'s narrow definition, that an entrepreneur is an individual running a business that is less than 42 months, we can trace the number of individuals and households that are involved in entrepreneurship. In fact, most businesses in Africa are less than five years.

In the same vain, the government prioritized strategy was nationwide and non-ignorable as opposed to randomized or sequential exposure. Thus, we can only observe compliance by individuals who became entrepreneurs. Entrepreneurs can be systematically different from non-entrepreneurs since we cannot easily describe the mechanism and motivations that determine entry into entrepreneurship let alone simply attribute the effect to the government strategy. Dawson and Henley (2012), in a review of literature on motivations driving individuals to venture into entrepreneurship, noted that people chose to start new businesses because of "push" or "pull" motivations. On one side, individuals are drawn into entrepreneurship

because of the need for self-personal efficacy (Pistrui et al., 2001), inability to find suitable paid employment (Block and Landgraf, 2016) and other pecuniary motives. Dawson and Henley (2012) reported that individuals would venture into entrepreneurship because an external opportunity has availed itself. On the pecuniary motives, their study noted that women usually venture into entrepreneurship to feel independent from their spouses and have a feeling that they are in control of their own lives. The study also noted that when the economic environment is not conducive such as in a recession, individuals, especially men, venture into entrepreneurship. The latter is a push factor while the former were classified as pull factors. Nevertheless, Williams (2009) reported that putting entrepreneurship motives into two categories obfuscates the reasons for examining motivations. The study advocates for a holistic take on the mechanisms for venturing into entrepreneurship. This view is consistent with Wry and York (2019).

While it may not be possible to control for all these motivations, what is clear is that the decision to venture into entrepreneurship is endogenous and the sample of entrepreneurs may be systematically different from the entire population. However, with a proper selection bias correction framework, we can conditionally assess the treatment effect of entrepreneurship on food security.

This paper, therefore, assesses the distributional impacts of entrepreneurship on household food and nutrition security. In particular, we examine implications of entry into entrepreneurial activities on food consumption, dietary diversity and welfare. We also explore the mechanisms driving entry into entrepreneurship and food consumption expenditure patterns.

The Government programme to increase entrepreneurial activities is also hard to evaluate if it increased incomes and reduced hunger. Part of the problem is that it is ethically and politically difficult to randomize access to program resources mainly due to the self-selecting nature of individuals getting into entrepreneurship. For those households that venture into entrepreneurial activities, there could potentially be general equilibrium effects at population level due to backward and forward linkages of multi-sectoral activities.

We specifically assess the distributional impacts of entrepreneurship on household real consumption expenditure, food and nutrition security. In particular, we

examine whether entry into entrepreneurial activities leads to more diverse diets as incomes change. We also explore the mechanisms driving food consumption expenditure patterns among entrepreneur households between 2011 and 2016.

Our study contributes to literature by combining modern economic growth theory with endogenous entrepreneurship assumptions. We further, empirically, apply a novel quantile regression technique that adjusts for selection bias to a recent three wave panel Living Standards Measurement Survey (LSMS) from Malawi. Literature on off-farm entrepreneurship and welfare outcomes in African settings is scarce and this study aims to bridge that gap.

The rest of the paper is structured as follows. The second section presents the methodology where the theoretical framework, identification strategy and data are presented. The third section presents results beginning with descriptive analysis, then explicitly modeling entry into entrepreneurship to isolate Malawian context specific drivers. Then propensity score analysis follows to balance the data and isolate treatment effects on the treated at household level. A quantile regression model adjusted for selection bias is presented to assess heterogeneous effects of entrepreneurship. Section four discusses the results using economic theory and recent literature to draw policy implications. Section five summarizes and concludes.

5.2 Methods

5.2.1 Theoretical framework

An equilibrium model with endogenous entrepreneurship

Table 5.1 summarizes key equations of the model. Our model starts with entrepreneurial firms or people in each of the sector s producing output Q using factors F using constant returns to scale, equation 1 in Table 5.1. Entrepreneurial and managerial ability are part and parcel of the factors F. The model takes productivity (a) as endogenous and subject to the entrepreneur's capabilities and endowments, such that it determines shares of production technologies. We assume that firms maximize profits in such a way that factor payments W are equal to production revenues.

Labour l is unemployed and fully mobile in the agricultural sector while in non-agricultural sectors is fully employed and sector specific. That is, unskilled labour from agriculture can easily move across the sectors i.e. a smallholder farmer can easily move to be employed or start a business in another sector while it is difficult for architects or doctors to switch between sectors but they can produce other economic activities e.g. entrepreneurial firms within those sectors. Land n, and capital are fully employed and sector specific. The entrepreneurial firm face investment demands I – equation 4, Table 5.1.

Households in the model maximize a utility function subject to a budget line in equation 3, Table 5.1. That is, households pool their resources and livelihood activities and maximize a common utility function in cooperation (Becker, 1974). Of note, household income Y is a function of total returns W – equation 2 – from productive activities of the entrepreneurial firm since they are eventual owners of factors of production F. Further, households face consumption demands D such that they utilize their income Y to purchase commodities at given market prices P.

We further assume that product, labour, capital and land markets are in equilibrium – equations 7,8,9 in Table 5.1. We also assume that entrepreneurial firms engage in international trade and government collects revenue through various taxes and levies but to keep the model sufficiently simple we have abstracted from its explicit modeling. For details see (Lofgren, Harris, and Robinson, 2002; Pauw et al., 2011). Normally, due to the complexity of linkages in the model, the model is solved analytically. However, since we have explicitly shown how each of the equations are linked, it is easier to assess equation (3) econometrically and assume that the other linkages are implicitly controlled for.

5.2.2 Identification strategy

A counterfactual framework for entrepreneurship and welfare outcomes

The fundamental question of any causal analysis is to find out what would have happened to treated units had it been that they were not treated or what would have happened to control units had it been that they were treated. In our case, we would like to know what would have happened to entrepreneurs' welfare outcomes had it

TABLE 5.1: Key Equations of the equilibrium growth model with entrepreneurship

Production function	$Q_s = a_s \cdot \pi_s \cdot \Pi_f F^{\delta_s}$	(1)
Factor payments	$W_f \cdot \Sigma_s \delta_{fs} \cdot P_s \cdot Q_s$	(2)
Household income	$Y_h = \sum_{fs} \theta_{hf} \cdot W_{f \cdot F_{fs}}$	(3)
Consumption demand	$P_s \cdot D_{hs} = \beta_{hs} \cdot (1 - v_h) \cdot Y_h$	(4)
Investment demand	$P_s \cdot I_s = \rho_s \cdot (\sum_h v_h \cdot Y_{ht})$	(5)
Product market equilibrium	$\sum_h D_{hs} + I_s = \sum Q_s$	(6)
Labour market equilibrium	$\sum_s F_{fs} = l - f$ where f is labour	(7
Capital market equilibrium	$F_{fs} = k_f$ where W_f is capital	(8)
Land market equilibrium	$F_{fs} = n_{fst} \lambda_{sf}$ where n is land	(9)

Subscripts	*Exogenous variables*
f Factors of production	K Capital supply
h Household groups	L Labour supply
s Economic sectors	N Land supply
Endogenous variables	*Exogenous parameters*
B *cap* b Foreign savings balance	A Production Shift parameters
F Factor demand quantity	B cap β Household budget share
I Investment demand quantity	Θ Household share of factor income
P Commodity price	P cap ρ Investment commodity expenditure share
Q Output Quantity	Y Household marginal propensity to save
W Average factor returns	
Y Total household income	

Note: Adapted from Pauw et al. (2011)

been that they were not entrepreneurs. On the other hand, we also examine what would have happened to non-entrepreneurs had it been that they had ventured into entrepreneurship. The key problem is that we can not observe both sides at the same time. We therefore have a missing data problem which is known as the fundamental problem of causal inference (Guo and Fraser, 2010).

Our analysis attempts to use available data for entrepreneurs and non-entrepreneurs to ascribe welfare values for their counterfactual outcomes. Thus, if we assume a treatment variable W_i where $W_i = 1$ if an individual is an entrepreneur and $W_i = 0$ if the individual is not an entrepreneur. We also assume that there are two potential outcomes (Y_1, Y_0) for entrepreneurs and non-entrepreneurs and an

actual measured outcome Y_i. Rubin (2005) presents the observed outcome as

$$Y_i = W_1 Y_{i1} + (1 - W_1) Y_{i0}. \tag{5.1}$$

where W_i acts as a switching variable. In order to make statements about causality, we cannot only use information about individuals who participated $Y_{i1} \cdot (W_i = 1)$ but we must also use information about individuals who did not participate $Y_{i0} \cdot (W_i = 0)$ and then eventually compare Y_{i1} and Y_{i0}. Therefore, to make a causal statement whether $W = 1$ causes Y_1, we must evaluate the evidence in the data on potential outcomes under $W = 1$ and $W = 0$. Thus, given an arbitrary cut off point p, where $Y_{i1} > p$ if $W_i = 1$ and $Y_{i0} < p$ if $W_i = 0$, we can deduce that $W_i = 1$ causes $Y_{i1} > p$ if after evaluating the evidence under $W_i = 0$, we find that indeed $Y_{i0} < 0$. Under an assumption of perfect randomization, where participants are randomly assigned $W = 1$ and non-participants $W = 0$, Hernan and Robins (2018) and Guo and Fraser (2010) state that we can compare the average outcome under $W = 1$ and that under $W = 0$. The standard estimator for calculating treatment effect is,

$$\gamma = E(Y_1|W = 1) - E(Y_0|W = 0) \tag{5.2}$$

where E is an expectation operator and γ is the Average Treatment Effect (ATE) of participating in entrepreneurship. Thus, $E(Y_0|W = 0)$ represents a counterfactual for $E(Y_0|W = 1)$ and $E(Y_1|W = 1)$ represents the counterfactual when $E(Y_1|W = 0)$. In a perfectly randomized framework, an ordinary least squares regression can be used i.e.

$$Y_i = \alpha + \gamma W_i + \epsilon \tag{5.3}$$

where α is a regression constant representing the average effect when $W_i = 0$, τ is the ATE and ϵ is a regression error term (White, 2006). When the assignment mechanism to participant and non-participant status is not randomized, that is if either individuals self-select or there appears to be another mechanism, then the latter and the former do not represent the counterfactuals. Thus, $E(Y_0|W = 0) \neq E(Y_0|W = 1)$ and $E(Y_1|W = 1) \neq E(Y_1|W = 0)$. Estimation of effects using τ in

equations 5.2 and 5.3 would lead to biased estimators i.e. effects that are influenced by outliers. However, given a number of assumption, it is possible to estimate causal effects using the Rubin counterfactual framework.

In order to estimate the effects, we first assume that conditional on observable control variables X, assignment to participation and non-participation is independent of the potential outcomes $(Y_1, Y - 0) \perp W|X$. Thus, we assume that given the control variables, the selection mechanism into entrepreneurship is independent of the welfare outcomes. this is known as the conditional independence assumption (CIA) (Huber and Melly, 2015; Guo and Fraser, 2010; Rosenbaum, 1984). To check the validity off this assumption, we conduct a bivariate comparison of control variables using student's t-tests for continuous variables and chi-square tests for categorical variables. If the control variables are statistically different between the participants and non-participants, then the correlation is non-zero, $\rho(W, X) \neq 0$ and CIA is violated.

Second we assume that the value of the outcome Y_i for individual i with participation status W_i will not change regardless of the procedure used to assign the participation status and the participation status of other individuals. This is called the Stable Unit Treatment Value Assumption (SUTVA) (Rubin, 2005). During the assessment, it helps rule out interactions among individuals and general equilibrium effects.

Third, $w \perp \epsilon|X$: we assume that the participation status is independent of the error term given the control variables . In this assumption, we assume that our selection mechanism has been adequately modeled such that there are no confounding nor omitted variables and that there are no measurement errors. Thus, all relevant drivers of selection into entrepreneurship have been thoroughly accounted for.

Fourth, $X \perp \epsilon$: we assume that the control variables are not correlated with the error term. This assumption rules out that some of the explanatory variables are independent variables in themselves.

Fifth, $X \perp W$: we assume that the treatment status is independent of the explanatory variables. This rules out perfect collinearity in our model which would prevent the model from achieving rank conditions.

Sixth, $\epsilon \sim$ i.i.d, $N(0,1)$: we assume that the error term is independent and identically distributed with mean 0 and standard deviation of 1.

Adjustments to counterfactual assumptions and estimation

At the administrative level, the government strategy and efforts to encourage participation in entrepreneurship for economic development does not discriminate no assigns participation status randomly. On the contrary, individuals self select into program. Thus the randomization assumption is violated and we only observe voluntary compliance into entrepreneurship $W_1 = 1$. Therefore, the effect we measure is a form of intent to treat.

Since we have three time periods, we also have a problem of time varying treatment effects. To illustrate, taking 2010 as time 0, we can have $2^3 = 8$ treatment situations. For example, it is possible, where $W = 1$ is represented by 1 otherwise 0, to have a universal set of

$$\mathbb{U} = \{(1,1,1),(0,1,1),(0,0,1),(1,0,0),(1,1,0),(0,1,0),(1,0,1),(0,0,0)\}$$

of the static treatment situation. In this case, a an individual drawn randomly from the population has a one in eight chance of being found in one of the participation situations. Following Hernan and Robins (2018), we invoke the full sequential exchangeability also known as the joint independence assumption that, given the participation history $a \in \mathbb{U}$ of the household in 2010, 2013 and 2016, i.e. $t = 0,1,2$ and a vector of control variables, the participation into entrepreneurship is independent of the welfare outcomes. That is

$$(Y^a, X^a) \perp W_t | W_{k-1}, X_t \quad \forall k = 0,1,2 \quad \text{and} \quad a \in \mathbb{U}. \tag{5.4}$$

Accordingly, the full sequential exchangeability assumption represents all counterfactuals of the participation status across the three time periods. Bang and Robins (2005) provided doubly robust estimators to assess treatment effects. We will use the doubly robust estimated to draw inference at individual level.

There is also a possibility that effects of participation could vary across individuals such that the average treatment effect could not be truly representative. For example, effects of participating into entrepreneurship could be larger for poorest households as compared to richest households. To account for this variation in effects, we use conditional quantile regression models. Using conditional quantile regression models allows us compute quantile specific treatment effects. In this case, given control variables X, we can express equation 5.3 as

$$Q_\tau(Y_i|W, X) = X'\beta + W'\gamma + F^{-1}(\epsilon) \tag{5.5}$$

where Q_τ is a quantile analogue of the expectation operator E for quantile τ; β is a vector of unknown parameters to be estimated and $F^{-1}(\epsilon)$ is the probability distribution of the error term ϵ (Cameron and Trivedi, 2010; Angrist and Pischke, 2013). Therefore,

$$\gamma_\tau = Q_\tau(Y_{i1}|W = 1, X) - Q_\tau(Y_{i0}|W = 0, X) \tag{5.6}$$

is the Quantile Treatment Effect (QTE). Equation 5.6 is difficult to estimate in the presence of self selection. Abadie, Angrist, and Imbens (2002) developed an instrumental variable estimator for QTE equation 5.6 where in the presence of a suitable instrument for W, say Z, the QTE can be identified as

$$(\gamma, \beta) = \arg\min E\{\rho_\tau(Y_i - aW_i - X_i'b)|W_i = 1\} - E\{\kappa_i\rho_\tau(Y_i - aW_i - X_i'b)|W_i = 0\} \tag{5.7}$$

where

$$\kappa_i = 1 - \frac{W_i(1 - Z_i)}{1 - P(Z_i = 1)|X_i} - \frac{(1 - W_i)Z_i}{P(Z = 1)|X_i}$$

; where Z_i is a dummy instrumental variable (Angrist and Pischke, 2013). However, since not only one instrument affects W but a vector of variables and the difficulty of finding a suitable instrument of entrepreneurship, it is proper to explicitly model the selection mechanism using propensity scores (Heckman, 1977). We, accordingly, model the selection mechanism using a distribution function of the percentile error in the food security outcome equation and the error in the entrepreneurship participation decision using Arellano and Bonhomme, 2017 framework with an adjustment

for the extended treatment effects model (Heckman, 1977; Maddala, 1983). Distributional parameters are estimated by a rotated check function method of moments minimization. Thus, estimates across the percentiles are corrected for selection bias. The extension of the quantile sample selection model to a generalized treatment effects model presents a novel methodological contribution of out study. Thus, the estimated model is

$$Q^S(\tau, Z) = X'\beta(\tau^*(Z)) \tag{5.8}$$

where Y_{it} is the outcome of interest for household i at time t (household real consumption expenditure, value of food consumption, dietary variety and nutrient intake per capita). The quantity $\tau^*(Z) = G^{-1}(\tau, \Phi(Z'\gamma); \rho)$ where Z is a vector of all relevant explanatory variables such that $X \subset Z$ and $W \subset Z$. $p(Z) = \Phi(Z'\gamma)$ is the propensity score and $V(\Phi(\eta))$ is the rank of unobservable scalar $\eta \sim U(0,1) \perp Z$ and $\Phi(\cdot)$ is a normal conditional distribution function (CDF). $(U, V) \sim$ bivariate Gaussian copula with a correlation coefficient $\rho \perp Z$ and τ is the percentile in question $\tau \in (0,1)$. Thus, $G(\tau, p; \rho)$ and S means conditional on selection Arellano and Bonhomme, 2017.

5.2.3 Data

We use a panel of Integrated Household Surveys (IHS) from Malawi conducted between 2010, 2013 and 2016. The IHS is part of the World Bank's Living Standards Measurement Surveys which are designed to collect socioeconomic characteristics of households in order to aid in policy design and evaluation. Use of the IHS to explore effects of entrepreneurship on food security contributes to a robust discussion on evidence based development policy design.

The data has household, agriculture, and community modules that are particularly relevant to the study. From the household questionnaire, we obtained a roster of household characteristics such as household size, sex, age, marital status and education composition of members. We obtained food consumption information, such as amount of food consumed in the past seven days and expenditure levels if any

from the household questionnaire. Due to home production and consumption aspects of households, some households reported consumption but no expenditure. In that case, a nearest neighbour's unit cost was computed and was triangulated using a community market questionnaire. A key assumption in imputing the zero expenditures from their nearest neighbours when the household had actually consumed a food item is that at community level, the marginal cost of producing food at household level is equal to the prevailing market price. When the value of the food items consumed was calculated, we aggregated the expenditures to come up with the food budget. From the aggregated food expenditure, we calculated budget shares as expenditure on a food item divided by total food expenditure. We also computed total household expenditure by including non-food items. When the food expenditure and non-food expenditure is combined, we can calculate total household expenditure per capita.

Using the FAO's food composition table for use in Africa, nutrient composition of the food items consumed at household level was computed at and converted to per capita levels per day. We computed energy (kcal consumed per adult equivalent as a dependent variable for food security.

We calculate a Berry index of dietary variety as function of shares $s_i = q_i/Q$ of actual quantities of food consumed where q_i is the quantity of the commodity i consumed and $Q = \sum q_i$. Hence the Berry index is calculated as $BI = 1 - \sum_i s_i$. The BI lies between 0 and $1 - 1/n$ such that as the number of food items increases, the index approaches 1. The quantity $1 - 1/n$ describes a case where an individual household consumes equal shares of each commodity (Drescher, Thiele, and Mensink, 2007). In a Malawian setting, where there are high poverty levels, this situation cannot happen. According to Timmer et al. (1983), poor people allocate most of their expenditure to starchy foods. Malawi's diets are also predominantly starch based (Verduzco-Gallo, Ecker, and Pauw, 2014).

Some drivers of food security are whether a household is agricultural or not. To determine whether a household is agricultural or not, we used the agricultural household questionnaire and examined whether a household cultivated a non-zero amount of land during the rainy and dry season. Most agricultural activities are rain fed and to a certain extent some households practice irrigation during dry season. In

addition, we also examined whether a household practiced perennial crop farming or animal farming. We therefore defined an agricultural household as a household that fulfilled any one or more of these conditions.

In the same manner, we investigated whether a household was a net food buyer or seller or autarkic by subtracting the value of food consumption from the value of food production. If the value of food production was greater than the value of food consumption, then the household was defined as a net seller of food. If the difference was negative, we define the household as a net buyer of food. If the difference was equal to zero, then household was defined as autarkic (Timmer et al., 1983).

Smallholder farmers are usually entrepreneurial in their behavior. They are usually involved in commercialization – i.e. they buy inputs, and sell agricultural output. Following Von Braun, Kennedy, et al. (1994) and Carletto, Corral, and Guelfi (2017), we also examined the households' commercial agricultural orientation. We took a ratio of the value of agricultural output sold at the market to the value of agricultural production. The higher the ratio of output sold, the more commercially oriented the farmer.

Farm size of the household matters in determining whether the household can engage in off-farm activities. Some landless households may venture into off-farm entrepreneurship because they have no options in agricultural production. We therefore calculated farm size as the total area of land cultivated by the household during the rainy and dry agricultural seasons. This is calculated as a sum of all parcels cultivated by the household.

Other variables that were obtained from the agricultural questionnaire relevant for food security were whether the household adopted improved technology and had access to inputs. We used adoption of improved seed as an indicator of technology adoption. Mutenje et al. (2016) found that adoption of improved technology is associated with increased food security. Secondly, we also create a dummy variable whether a household received subsidized farm inputs or not. The Government of Malawi introduced a farm input subsidy in 2005 to improve effective demand for agricultural inputs (Kankwamba, Kadzamira, and Pauw, 2018).

Mendola (2007) used institutional factors as control variables in assessing average causal effects of technology adoption on welfare. In this study, we also use

institutional and community variables as control variables. Our community and institutional control variables include whether a household has access to a savings and credit cooperation, distance to the main road, distance to the main auction market and distance to the main population center. In addition, we also control for year, covariate and idiosyncratic shocks, and location dummies. Location is determined by district and rural-urban stratification dummies.

5.3 Results

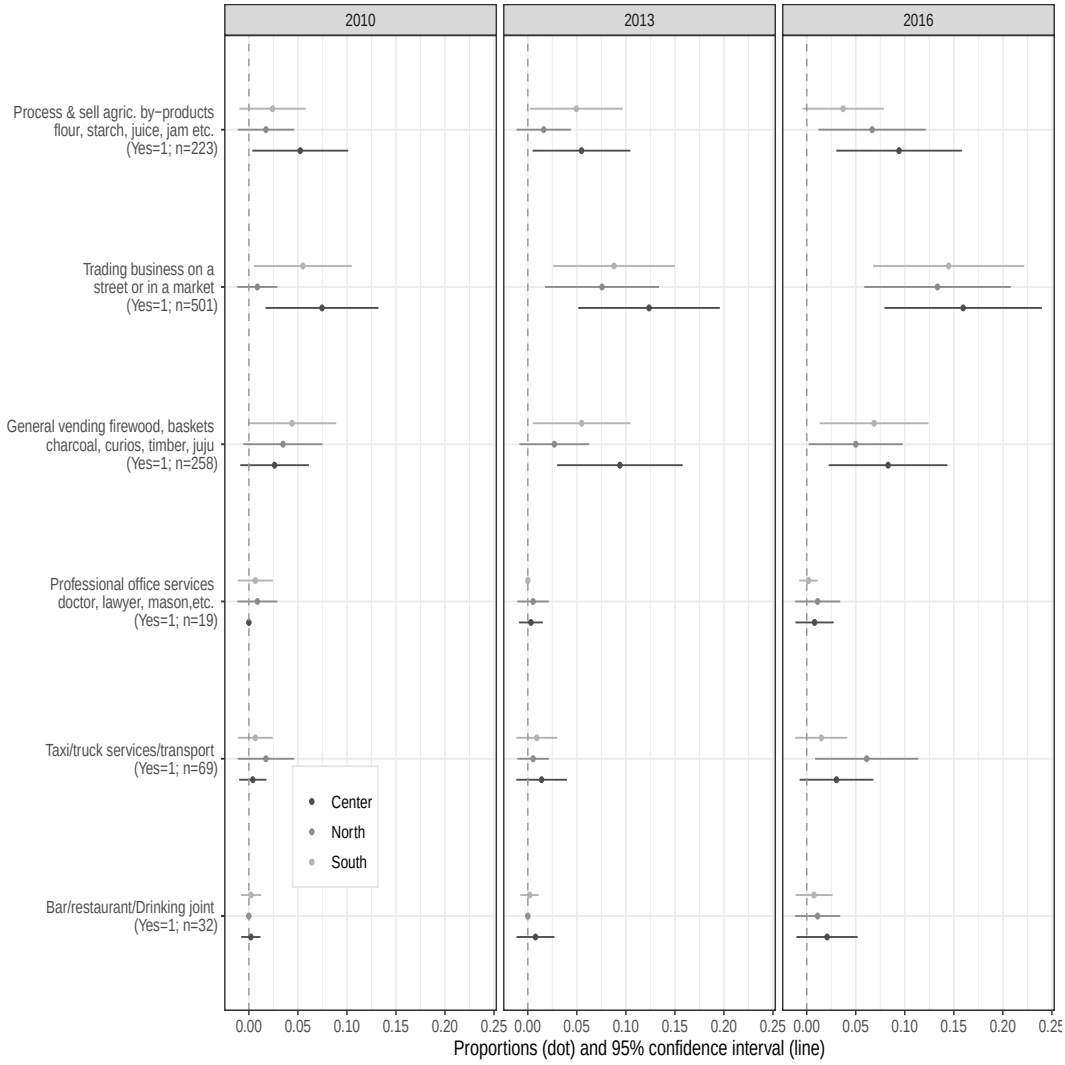
5.3.1 Descriptive statistics

Defining and contextualizing entrepreneurship

It is important to clearly define entrepreneurship and contextualize it. In this section we outline the indicators, patterns and some motivations that may contribute the distribution of microenterprises. The indicators are self-triangulating – i.e. they may at some points reflect the same information in order to elicit accurate information on whether the household participated in an enterprise. As such, multiple responses are allowed across the indicators. Of note, the analysis abstracts from on-farm entrepreneurship due to identification issues since most farm households combine production and consumption decisions. However, we control for this aspect by factoring in a farm commercialization indicator – a ratio of the value of agricultural sales in markets to the value of agricultural production.

Figure 1 summarizes key variables that were used to come up with an indicator for off-farm entrepreneurship. The indicators are disaggregated by survey period and geographical region. Six indicator variables were used, describing varying types of participation in off-farm enterprises. We find that households that processed and sold agricultural by-products – i.e. flour, starch, juice, beer, jam, oil, seed, bran, etc., in IHS3 in 2010/11, comprised 2.5% of the sample in the Southern region, 2% in the Northern region and 5% in the Central region. Considering the same indicator during the IHSP 2013 survey, we find that 5% of the sample in both the Southern and Central region, respectively and 2% in the Northern region processed and sold agricultural by-products either from home, along streets or at the market. The 2016

FIGURE 5.1: Proportions of households engaged in different forms of off-farm businesses



IHS4 survey period shows that 3% of households in the Southern region, 6% in the North and 9% in the Central region processed and sold agricultural by-products.

Some households owned a fixed trading business such as a hawker, a stall or a grocery store at home, along the street or at the market. These might represent a different category of entrepreneurs who could face different fixed costs as compared to itinerant traders. When disaggregated, we find that in IHS3 in 2010, 6% of households in the Southern region, 7.5% in the Northern region and 7.5% in the Central region operated a fixed trading business. In the 2013 IHSP survey, we find that 8% of households in the Southern region, 2% in the Northern region and 12.5% in the Central region operated a fixed trading business.

General vending is also widely participated in Malawi. We define general vending as the tendency of small traders to move across residential locations or at some collective point selling commodities such as firewood, weaved baskets, charcoal, curios, traditional medicines, juju etc. In the 2010 IHS3 survey, 6% of households in the Southern region, 2.5% in the Northern region and 7.5% in the Central region participated in general street vending. In the 2013 IHSP survey, 6% of households in the Southern region, 2.5% in the Northern region and 9% in the Central region participated in general street vending. In the 2016 IHS4 survey, 14% of households in the Southern region, 12.5% in the Northern region and 17.5% in the Central region participated in general street vending. Clearly, general vending increased in the 2016 survey period significantly compared to other surveys.

Throughout all surveys, we find low prevalence of households that held their own offices and practiced professional services such as doctors, lawyers, translator, private tutor, midwife, etc. All surveys reported less than 2% of this category throughout all the regions.

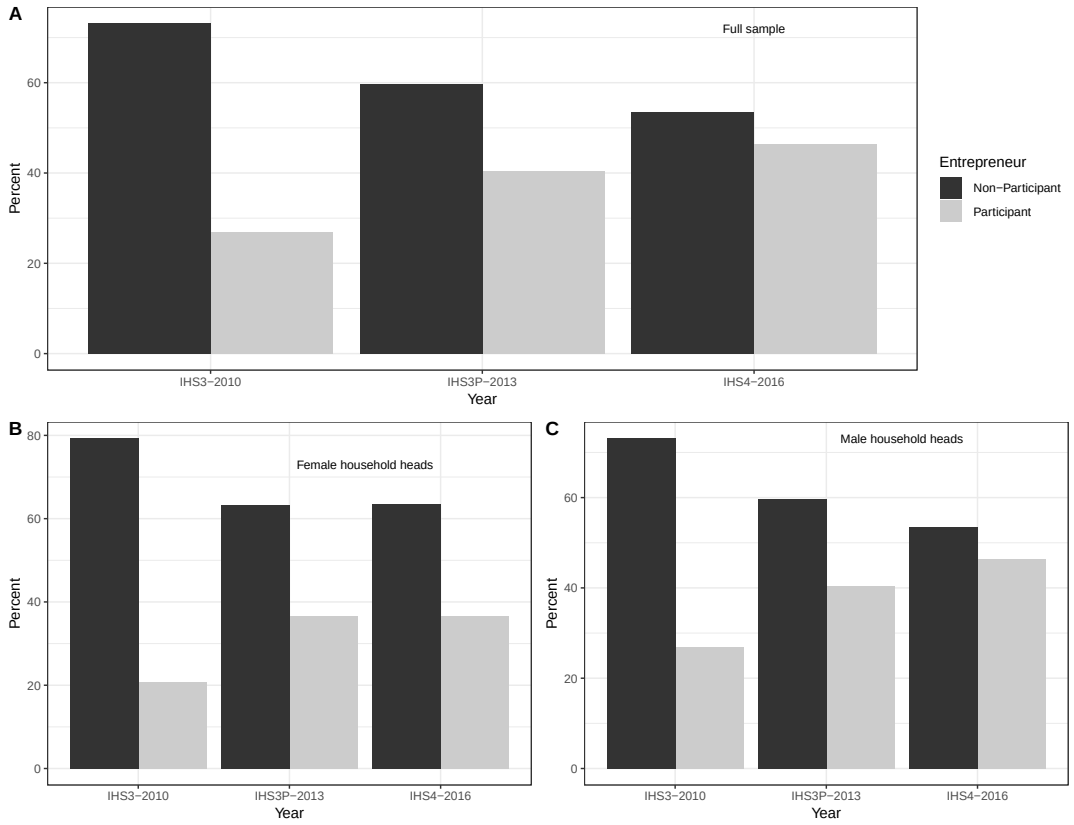
Similarly, we also find few households participating in transport enterprises such as taxis and pickup trucks. With an exception of a surge in the Northern region in 2016 IHS4 of 6%, all regions in the surveys were below 2%. Similar observations are also made with households owning restaurants and bars or drinking joints.

Therefore, we can construct an indicator for off-farm entrepreneurship using these indicators in several ways. The first and simplest way is to check across the indicators if a household participates in one of these activities. If it does, then the household participates in some form of entrepreneurship, otherwise it does not. The second option would be to count how many of these activities the household is involved in. A higher count may mean that the household is more entrepreneurial.

5.3.2 Descriptive statistics of control variables

Table 5.2 summarizes results of the descriptive statistics of the variables used in the study. Dependent variables used in the analysis are presented first. Across all three survey periods, entrepreneurs have significantly higher values of food budgets than non-entrepreneurs. In addition, results show that entrepreneur households have significantly more calorie consumption per capita per day across in the 2013 and 2016

FIGURE 5.2: Distribution of households practising entrepreneurship disaggregated by gender



survey periods. The Berry and Entropy indexes of dietary variety are higher among households that ventured into entrepreneurship. Further, results also show that household that entered into entrepreneurship reported less days of reduced food production. Similarly, households that entered into entrepreneurship experienced higher value of food production.

Non-entrepreneur households had significantly larger household sizes as compared to households that practice entrepreneurship. Across the survey periods, there was 1 male adult in the household. This statistic did not statistically differ between 2010 and 2013 but moved to 2 in 2016. On average, across all three surveys and between participants and non-participants, there were 2 male children per household. Between 2010 and 2013, and between participants and non-participants, there was one female adult in the household. However, in 2016, there were 2 female adults in the household. Further, the household had 2 female children, between participants and non-participants across all survey periods.

Most household heads participating in entrepreneurship were in a monogamous

marital relationship with 75% in 2010, 83% in 2013 and 88%, respectively. About 7% of households were in a polygamous marital relationship. Results for polygamous marital status do not differ significantly between entrepreneur and non-entrepreneur households. About 6% of households were separated. However, there are no statistical differences between entrepreneurs and non-entrepreneurs. About 5% of households are divorced and do not differ significantly between the participants and non-participants across the 3 survey periods. About 13% of households are widowed and do not differ markedly across the survey periods and between entrepreneurs and non-entrepreneurs. The proportion of single and unmarried household heads was 3%. However, the number of participants significantly increased from 2% to 5% and 6% across the survey periods.

About 87% of household heads participating in entrepreneurship in 2010 had no formal schooling. Another 61% and 62% of household heads participating in entrepreneurship had no formal schooling in 2013 and 2016 survey periods, respectively. In 2010, 3% of household heads had attained primary school certificate and participated in entrepreneurship and 12% and 8% had attained primary school. In 2010, about 5% of households participating in entrepreneurship had attained junior secondary education, while in 2013, 16% had attained primary school. Less than 1% of households that participated in entrepreneurship across all surveys.

Land holding sizes and adoption of modern farming technology did not vary substantively across participants and non-participants in all survey periods. Noteworthy, there are statistically significant differences across the covariates which means that in absence of modeling the selection process explicitly, our results would be biased. Thus, based on this assessment, we proceed to model the selection process.

5.3.3 Mechanism of selection into entrepreneurship

Figure 5.3 presents results of a probit model that explicitly models the selection process into entrepreneurship. Results comprise household, socioeconomic, community characteristics, idiosyncratic and covariate shocks that may explain the motivations behind owning an off-farm enterprise. In general, results indicate that the overall probability of venturing into entrepreneurship is 23%.

TABLE 5.2: Descriptive Statistics of variables used

Variable	2010		2013		2016	
	Non-Entre	Entre	Non-Entre	Entre	Non-Entre	Entre
	(1)	(2)	(3)	(4)	(5)	(6)
	A: DEPENDENT VARIABLES					
Food budget	5.591	5.753	8.045	8.360	7.430	7.57
		(3.776)		(5.963)		(9.277)
Total expenditure	7.750	8.04	8.434	10.192	9.26	9.89
		(-7.493***)		(-9.610***)		(-10.623***)
Energy	7.246	7.252	7.283	7.433	7.209	7.338
		(-.162)		(-4.059***)		(-4.210***)
Berry Index	.165	.217	.526	.575	.810	.994
		(-3.985***)		(-1.579*)		(-5.044***)
Entropy Index	.245	.329	.076	.139	.231	.590
		(-4.420***)		(-4.841***)		(-11.626***)
Days without food	.379	.312	.588	.596	1.234	1.217
		(1.399)		(.179)		(.241)
Food Production value	8.323		8.475	9.987	12.510	13.490
		(-0.532)		(.754)		(-1.857*)
	B: DEMOGRAPHIC VARIABLES					
No. Male Adults	1.354	1.440	1.416	1.353	1.730	1.913
		(-1.831*)		(1.553*)		(-3.441***)
No. Male Children	1.692	1.791	1.624	1.441	1.859	1.730
		(-1.445)		(3.722**)		(2.333***)
No. Female Adults	1.339	1.374	1.417	1.324	1.707	1.957
		(-.869)		(2.427***)		(-4.954***)
No. Female Children	1.715	1.699	1.662	1.466	1.848	1.829
		(.243)		(3.631***)		(.331)
Household size	4.635	5.649	6.255	7.656	7.274	10.987
		(-2.778***)		(-4.123***)		(-13.2679***)
Marital status						
Married Monogamous	.697	.749	.744	.830	.755	.880
		(-1.895*)		(-4.023***)		(-6.244***)
Married Polygamous	.066	.075	.054	.080	.086	.075
		(-.616)		(-2.048***)		(.764)
Separated	.051	.027	.059	.057	.081	.092
		(1.943**)		(.175)		(-.804)
Divorced	.050	.019	.051	.060	.065	.066
		(2.597***)		(-.814)		(-0.052)
Widowed/ Widower	.096	.099	.155	.113	.176	.161
		(-.163)		(-2.343**)		(.749)
Never Married	.028	.024	.021	.047	.027	.063
		(.375)		(-2.897***)		(-3.419***)
Adult Equivalence Scale	57.216	49.736	68.808	56.676	11.934	11.932
		(2.277***)		(3.607***)		(.003)
Education status						
No schooling	78.45	86.49	63.50	61.29	77.86	62.89
Primary School (PSLC)	9.44	2.70	9.50	11.83	7.05	7.86
Junior Secondary (JCE)	4.01	5.41	11.14	16.13	4.31	8.49
Senior Secondary (MSCE)	5.77	5.41	10.39	7.53	7.71	14.15
Tertiary (Diploma)	.99	.00	3.21	3.23	1.82	3.77
Tertiary (Degree)	1.06	.00	1.64	.00	1.16	2.52
Tertiary (Graduate level)	.28	.00	.62	.00	.08	.31
		(3.102)		(5.259)		(36.289***)
	C: AGRICULTURAL AND OTHER VARIABLES					
Total cultivated land	4.116	1.202	.360	.233	.392	.372
		(.680)		(3.197***)		(.709)
Adoption of modern technology	.563	.489	.617	.542	.597	.607
		(2.479***)		(2.904***)		(-.382)
Ease of doing business (Rank/190)		141		171		133
Extent of corruption (Rank/190)		85		91		120
Consumer price index (base = 2014)		320		500		80
Food inflation		9.6		38		28

NOTE: t-statistics and χ^2 values in parentheses,for continuous and categorical variables, respectively.
*Significantly different from zero at 90 percent confidence
**Significantly different from zero at 95 percent confidence
***Significantly different from zero at 99 percent confidence

Results indicate that household characteristics significantly affect the entrepreneurship decision. For instance, an additional male adult in the household increases the probability of venturing into entrepreneurship by 2% ($p < .05$). Of note, if a household head is in a monogamous marriage in comparison to a single non-married head, the probability of venturing into entrepreneurship increases by 17% ($p < .05$). Asset holdings, represented by the asset index, increased the probability of venturing into entrepreneurship by 2%.

In addition, entrepreneurial training through formal education significantly affects selection into entrepreneurship. Compared to household heads that had never attended formal schooling, primary school attendance is associated with 19% increase in the probability of venturing into entrepreneurship. Household heads that attended junior secondary school and college degree education had 7% higher probabilities of venturing into entrepreneurship, respectively.

However, results show that agricultural variables such as land holding size and the commercialization indicator deter entry into entrepreneurship.

5.3.4 Balancing tests for participants and non-participants

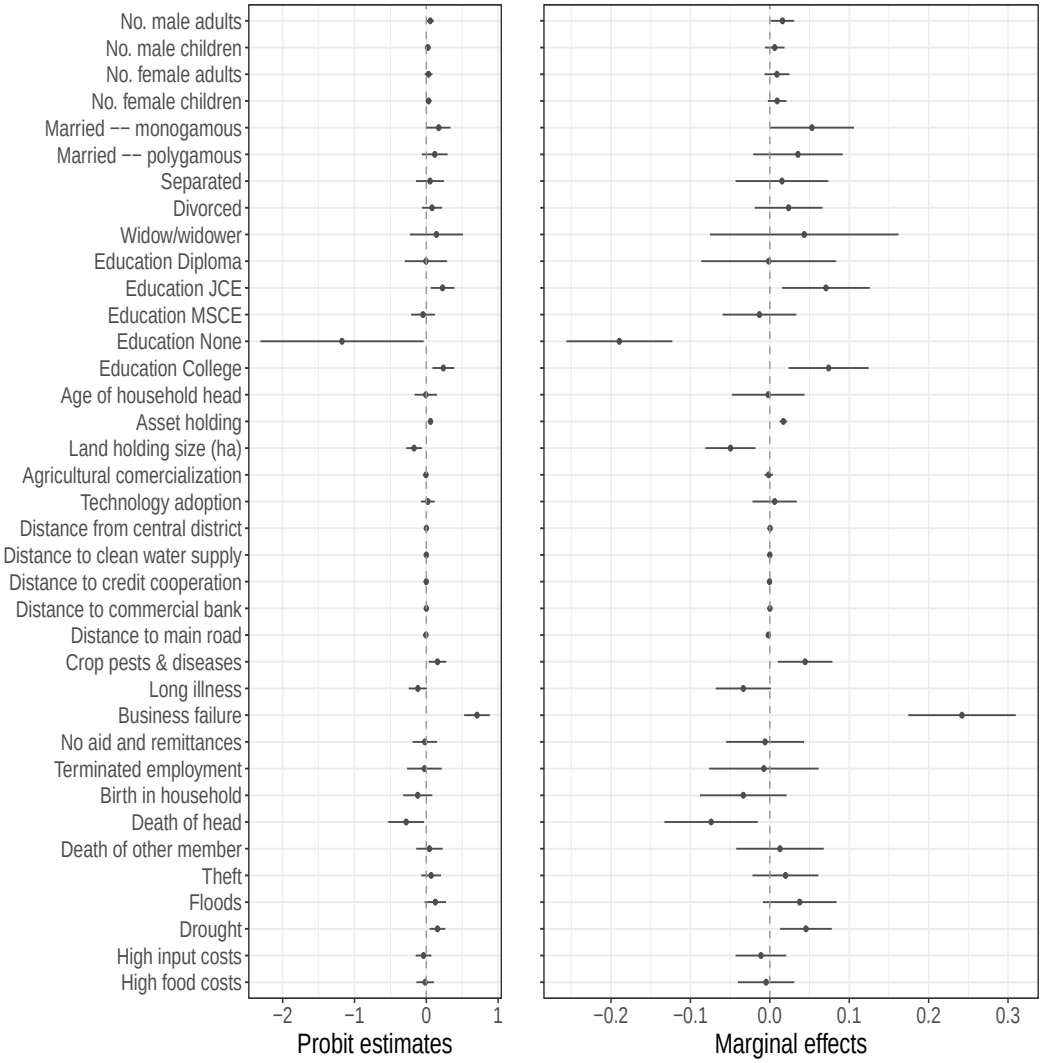
In order to control for selection bias, we used propensity score analysis. Table 5.3 summarizes results of balancing t-tests after propensity score analysis. Given that none of the control variables are statistically different between participants and non-participants, we can assume that the covariates have been well balanced to mimic a randomized control trial. Figure 5.4 summarizes households on support and those not after propensity score matching. Hence, assuming that we have controlled for a sufficient number of covariates, we can now use conventional fixed effects regression analysis to assess effects of entrepreneurship of welfare variables.

5.3.5 Impact of entrepreneurship on food security

Average treatment effects on the treated

After adjusting our sample for selection bias, we estimate the impact of participating in entrepreneurship on food security using inverse-probability-weighted regression adjustment (IPWRA) and nearest neighbour propensity score matching (PSM-NNM)

FIGURE 5.3: Selection mechanism into entrepreneurship



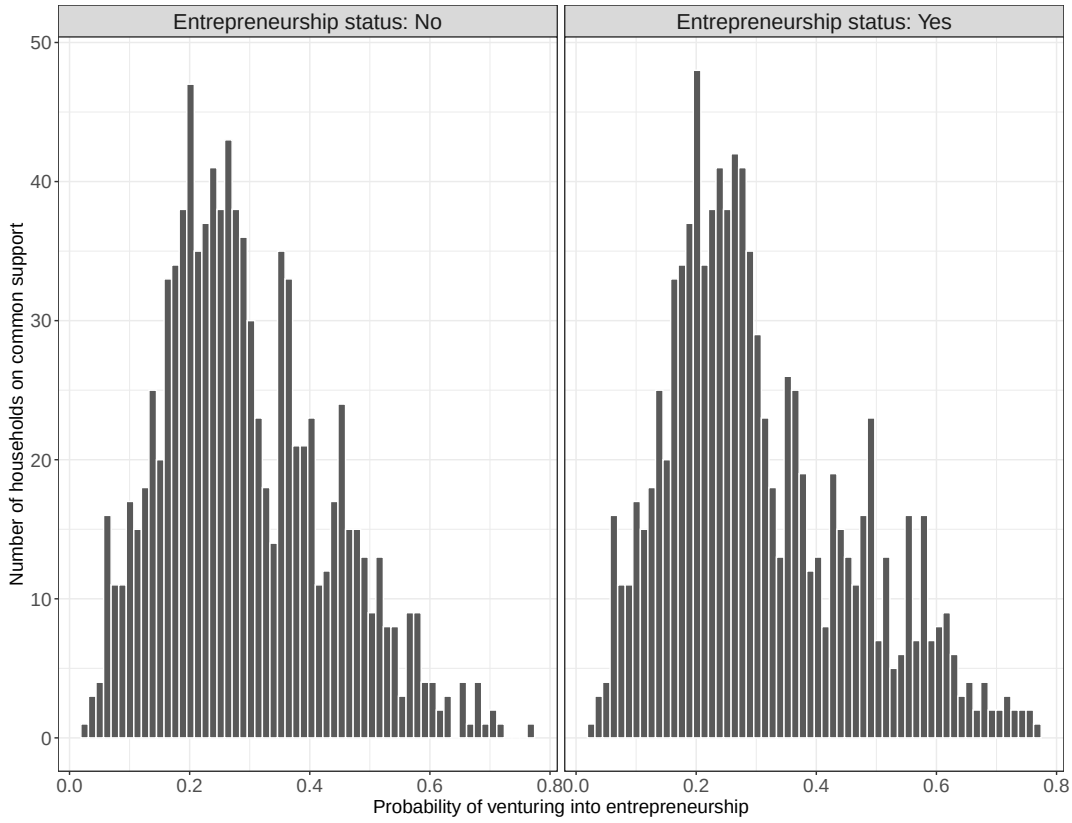
A dot and whisker plot showing probit model estimates of selection into entrepreneurship. The dependent variable $W = 1$ if $D = \{W : E_1 \cup E_2 \cup \ldots \cup E_m\}$ and 0 otherwise and E_i are all off-farm enterprises in Figure 5.1.

TABLE 5.3: Balancing tests for participants and non-participants

VARIABLE	Treated (1)	Control (2)	%bias (3)	t (4)	p>t (5)
No. male adult	1.524	1.529	-.600	-.160	.873
No. female adult	1.562	1.527	4.000	1.110	.268
No. male child	1.248	1.215	3.100	.900	.370
No. female child	1.301	1.298	.300	.090	.925
Married – Monogamous	.832	.830	.500	.150	.882
Married – polygamous	.076	.076	.300	.080	.937
Separated	.064	.067	-1.000	-.280	.779
Divorced	.053	.060	-3.400	-.940	.345
Widowed/Widower	.127	.130	-.700	-.200	.844
Primary school	.109	.106	1.000	.260	.797
Junior secondary	.097	.099	-1.000	-.240	.807
Senior secondary	.109	.118	-2.800	-.730	.464
Tertiary (Diploma)	.035	.032	1.900	.460	.643
Tertiary (Degree)	.019	.024	-3.600	-.860	.389
Tertiary (Post-Graduate)	.004	.003	1.900	.560	.573
Distance to the main road	6.526	6.711	-2.000	-.640	.525
Distance to the next population center	25.531	25.795	-1.300	-.380	.706
Distance to the auction	51.856	52.669	-1.600	-.490	.621
Distance to the border post	52.200	52.415	-.700	-.190	.846
Member of microfinance org.	38.882	39.146	-.500	-.140	.892
Distance to the nearest bank	45.337	54.297	-5.500	-1.120	.265
Agricultural household	.453	.460	-1.300	-.370	.712

NOTE: Robust standard errors in parentheses
*Significantly different from zero at 90 percent confidence
**Significantly different from zero at 95 percent confidence
***Significantly different from zero at 99 percent confidence

FIGURE 5.4: Participant and non-participant households after propensity score matching



at household level. In all models, demographic characteristics of households, district fixed effects and stratum fixed effects i.e. rural, urban, northern, central and southern region interacted dummies were used. Results generally indicate that entry into entrepreneurship increases the value of food consumed by 70% using the IPWRA doubly robust technique. Using PSM-NNM, the impact of entrepreneurship on the value of the food budget was 88%. Further, the IPWRA results indicate that entrepreneurship has 5% impact on dietary variety while PSM-NNM found 6% impact. For the calories indicator, IPWRA shows that venturing into entrepreneurship increases calorific intake per capita per day by 8% while PSM-NNM also indicates 8%. In all results, we find that IPWRA is the most conservative while the PSM-NNM overestimates the results. However, all results fall within the same 95% confidence interval which implies that results from the two models consistently point towards positive impacts of entrepreneurship on food security.

Figure 5.5 presents results of the IPWRA and PSM-NNM on household expenditure adjusted for adult equivalence units. Results generally, indicate that when a

household starts an off-farm enterprise, the average effect on household welfare presented by total household expenditure increases by 21% $\pm$ 0.073 under PSM-NNM and by 0.22 $\pm$ 0.059 under IPWRA. This implies that entrepreneurship increases household welfare.

TABLE 5.4: Impact of entrepreneurship on food security

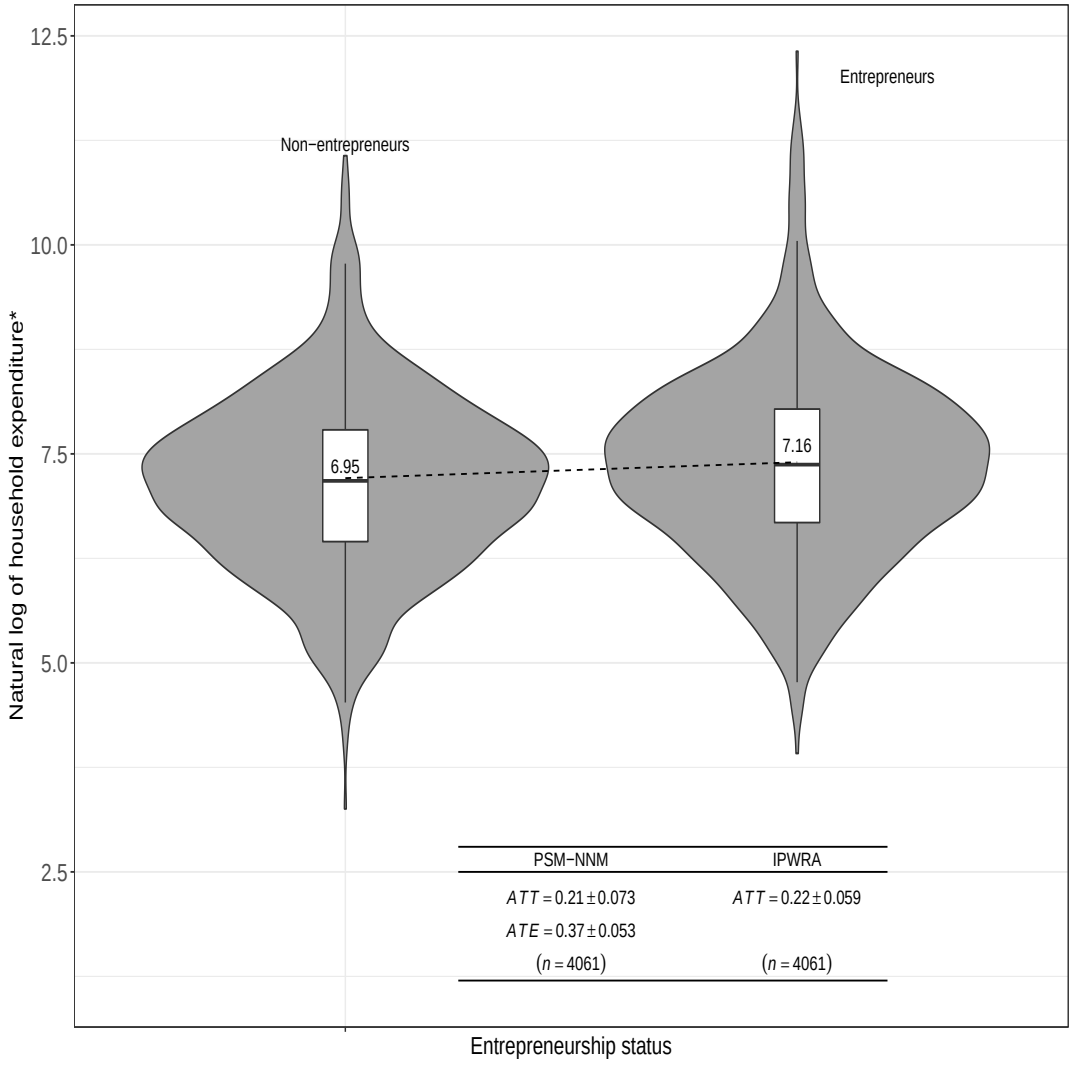
	ln(Value of food)		Berry Index		Calories per capita	
	IPWRA	PSM-NNM	IPWRA	PSM-NNM	IPWRA	PSM-NNM
VARIABLE	(1)	(2)	(3)	(4)	(5)	(6)
Entrepreneurship	.699***	.883***	.047 **	.064**	.078***	.076***
	(.084)	(.120)	(.021)	(.027)	(.021)	(.029)
Demographics	YES	YES	YES	YES	YES	YES
District FE	YES	YES	YES	YES	YES	YES
District FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

NOTE: Average Treatment Effects on the Treated reported.
Outcome model controls presented in the appendix.
Robust standard errors in parentheses
*Significantly different from zero at 90 percent confidence
**Significantly different from zero at 95 percent confidence
***Significantly different from zero at 99 percent confidence

Quantile treatment effects

Apart from assessing average treatment effects, it is important to examine the distribution of the impacts. Examining the distribution effects would help identify whether a policy strategy to encourage entrepreneurship helps poor households' incomes to rise faster than the richest. Table 5.5 presents results of the quantile treatment effects regression of the effects of entrepreneurship on food security. We present results for the 20^{th}, 40^{th}, 50^{th}, 60^{th}, 80^{th} and 95^{th} quantiles. The hypothesis of equality of parameters across the quantiles was resoundingly rejected at level $(p = .01)$. Under the assumption that the individual remains in the same quantile of the distribution after the change, results indicate a general positive effect of entrepreneurship on the value of food consumption. The conditional quantile treatment effects are highest – 87% – in the 20^{th} quantile and 79% for the 95^{th} quantile but are between 49% and 67% between the 40^{th}, 50^{th}, $60^{th}$and 80^{th} quantiles.Noteworthy, our bootstrapped standard errors are smallest in the middle quantiles indicating higher precision as compared to the upper and lower parts of the distribution.

FIGURE 5.5: Impact of entrepreneurship on welfare



* The total household expenditure was adjusted for adult equivalence units. The dependent variable for entrepreneurship $W = 1$ if $W = \{W : E_1 \cup E_2 \cup \ldots \cup E_m\}$ and 0 otherwise where E_i is off-farm enterprise i in Figure 5.5.

TABLE 5.5: Quantile regression model results showing distributional impacts of entrepreneurship on food security

VARIABLES	q20	q40	q50	q60	q80	q95
	(1)	(2)	(3)	(4)	(5)	(6)
Entrepreneurship	.870***	.567***	.556***	.490***	.566***	.798***
	(.125)	(.071)	(.035)	(.059)	(.060)	(.125)
Constant	-4.869	3.135*	4.671***	6.705***	6.343***	8.188***
	(3.330)	(1.687)	(1.658)	(1.779)	(2.299)	(2.613)
Observations	4,537	4,537	4,537	4,537	4,537	4,537
R-Squared	.21	.21	.21	.22	.26	.30
Demographics	YES	YES	YES	YES	YES	YES
District FE	YES	YES	YES	YES	YES	YES
District FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

NOTE: Robust standard errors in parentheses
*Significantly different from zero at 90 percent confidence
**Significantly different from zero at 95 percent confidence
***Significantly different from zero at 99 percent confidence

5.4 Discussion

In this study we evaluated the impact of entrepreneurship on household food security and welfare in Malawi using two distinct methods namely inverse probability weighting regression analysis and propensity score matching using nearest neighbour matching techniques. Second, we assessed distributional impacts of entrepreneurship on food security using quantile regression techniques. In second method we used a novel quantile regression model that adjusts for selection bias. A combination of techniques ensures that our results are robust to measurement and specification errors.

5.4.1 Patterns and drivers of entry into entrepreurship

Using a series of indicators of food security such as the value of the food budget, Berry index of dietary variety and calories consumed per day per capita, we find four key results. First, entrepreneurship is low despite government efforts and investments. Second, various factors, chief among which are household composition and resources, idiosyncratic and covariate shocks, and community characteristics

affect entry into entrepreneurship. Third, entrepreneurship significantly increases economic access to food, variety and calories consumed at household level. Fourth, we find positive distributional impacts of entrepreneurship on food security.

We discuss the first finding, that entrepreneurship is low but steadily increasing, using a number of reasons. The lower levels of entrepreneurship are a direct result of worsening indicators of doing business, corruption and living standards. Although there are efforts to increase entrepreneurship, we also find that they are thwarted by worsening governance indicators. As (Sriram and Mersha, 2010) observed, an enabling environment plays a larger role in stimulating entry into entrepreneurship.

Nevertheless, the steady increase in the number of households getting into entrepreneurship after 2011 is a direct results of the government's shift in its trade facilitating strategy by investing into entrepreneurship. The MGDS II specifically outlined some strategies, such as youth and women empowerment and school curriculum changes, to encourage entrepreneurship. Of note, in support of the country's development strategy, other institutions also embarked on the campaign to encourage entrepreneurship endeavours among the youth. For instance, the United States of America's Embassy, through its Young African Leaders' Initiative (YALI), has been training the youth in entrepreneurial skill development. Most YALI members have been deployed to further the campaign across the country (US Department of State, 2019). Our results are consistent with Mwatsika (2015) who found that Malawians have positive attitudes towards entrepreneurship but lack of supportive environments impede development. Therefore, any effort to nudge individuals to venture into entrepreneurship would yield significant positive outcomes.

Entrepreneurship is affected by demographic and institutional factors. Consistent with Nagler and Naudé (2017), we found that household composition positively affected entry into entrepreneurship. Larger household sizes were invariably associated with entrepreneurship activities. Further, household heads that were more educated were associated with entry into entrepreneurship. This finding corroborates De Gobbi (2014) who also found that highly educated, youthful individuals with access to credit are more likely to venture into entrepreneurship. This observation augurs well with Leibenstein (1987)'s idea that while an individual ventures into entrepreneurship when they find a gap for innovation in the market, what he terms

n-achievement theory, the study found that even average individuals may venture into entrepreneurship when given the necessary training to build their skills. Thus, as more individuals enter the market by starting off-farm enterprises, there remain no more incentives to alter behavior of traders due to lack of competition. This gain in welfare from improved market performance is termed x-efficiency by Leibenstein (1987).

The effect of education on welfare through entrepreneurship can also be easily traced through Mincer and Polachek (1974)'s finding, that education of a head and other family members – a spouse in particular – affects earnings, by raising a household's human capital. Since one of the explanations of the low entrepreneurship levels can also be traced to low education levels of household heads.

Chowdhury, Amin, and Farah (2016) and Becker (1974) and Wong (1986) proved that, within the household, specialization and cooperation in marriage could lead to better welfare outcomes through increased marginal value productivity of labour. As our results show, in both monogamous and polygamous marriages, there are higher probabilities –5%– of venturing into entrepreneurship compared to single unmarried household heads. In line with Wong (1986), we argue that members benefit from a set of skills distributed across the household such that others could specialize in skills that are honed particularly for entrepreneurship while others may specialize in subsistence oriented activities. The net cross-productivity gains from different human capital endowments of individuals within the household are benignly shared aggregated for overall welfare gain. This theory further explains the results that consistently show that additional members of the household have a significant positive change in the probability of venturing into entrepreneurship. Additional members of the household also mean increase in the supply of labour. Given aforementioned factors could raise marginal value productivity of the household labour. These results are also consistent with Doss (2013).

Given the cross-productivity gains in human capital, it can be inferred that any valuable skills gained by household members from, say, training in form of schooling or apprenticeship that the MGDS II advocated (Government of Malawi, 2011b) can be shared effortlessly across the household. Thus, it cannot be far-fetched to reason that entrepreneurship skills taught in schools, incubation centers, and technical

and vocational centers can easily spillover within the household and could lead to a surge in entrepreneurship.

The study findings are consistent with (Sriram and Mersha, 2010) who found that most African entrepreneurs are not only influenced by socioeconomic factors such as family structure and education but also external market structure and the business environment regulated by government. Our finding about doing business in Malawi is consistent with the authors that when complex procedures of doing business are not well streamlined, entrepreneurship levels would be low.

5.4.2 Impact of entrepreneurship on food security

Our second finding, that participating in entrepreneurship improves the value, variety and amount of calories and micro-nutrients consumed per capita per day, is not only consistent with what economic theory predicts but also has pro-poor implications. After correcting for selection bias, a disruption into the household budget caused by entrepreneurship would shift the budget set upwards. A higher budget set implies that the household would have access to varied quantities of high value foods – in income effect from entrepreneurship. A change in preferences, moving from a lower indifference curve to a higher affordable one, implies that the household can substitute lower value, less desirable commodities such as starchy foods to more lucrative high value foods such as mean products.

Results show that households in lower quantiles are very sensitive to changes in the budget line. We find corroborating evidence from Bonney et al. (2013) who – in a general qualitative study on trends in entrepreneurship in Africa recommended that, as an alternate logic to solving food security problems, governments should encourage entrepreneurship. The study reported that an increase in collective entrepreneurship among farm households would increase food security by strengthening food value chains since it would leverage the farm households to have a larger say in their businesses, thereby, reconceptualizing distribution of resources by reducing market chains through removal of unwanted actors such as middlemen. Efficient, farm household driven entrepreneurship would lead to efficient market outcomes and welfare (Bonney et al., 2013). We also argue, though, that the largest

benefits would result from direct marginal changes in household incomes from entrepreneurial activities regardless of their position in the value chain. Our results also corroborate Otoo et al. (2011), who – in West African countries of Ghana and Sierra Leone – found that entrepreneurship contributes to food security and overall welfare by a magnitude of over 16%.

While the positive impact derives directly from economic theory, not all entrepreneurs benefit equally. All things being equal, results from quantile regression indicate that venturing into entrepreneurship benefits the poorest more than any other group of households. We notice a greater than 30 percentage point difference in average effects of entrepreneurship from the poorest to the median impact. Despite making the richest group of households richer, impacts on the losers – those on which entrepreneurship had the least impact – are still above 50%. To all intents and purposes, entrepreneurship is welfare improving. Thus, any policy geared towards increasing the level of entrepreneurship will be Pareto optimal. This finding is consistent with pro-poor growth literature which suggests that incomes of the poor have to grow faster than the richer households (Kakwani, Pernia, et al., 2000; Rogerson, 2018; Asongu, 2016; Dorward et al., 2004).

5.5 Conclusion

The study econometrically assessed patterns and causal effects of entrepreneurship on food security and welfare using representative panel data from Malawi. The study also assessed implications of entrepreneurship on the quantity, variety and value of food consumed per capita per day.

Results generally indicate that entrepreneurship is lower but has been steadily increasing over the survey periods. The mechanisms driving entry into entrepreneurship were demographic factors such as education, marital status and household size.

The study found that entrepreneurship has a positive effect on the value, variety and quantity of food consumed per capita per day at household level. The study also found that the poorest households benefitted the greatest from venturing into entrepreneurship. The household specific and heterogeneous impacts imply that

investing in entrepreneurship is not only a good strategy for economic development but is also a pro-poor policy strategy.

Since government assignment of treatment was non-ignorable, the study recommends that delivery of investments to increase entrepreneurship levels should be designed in such a way that attribution can be easily identified. While randomization might be unethical, sequential delivery of investments across districts or regions can ensure cleaner difference-in-difference assessment of impacts.

The finding that entrepreneurship levels are still low calls for focused and increased efforts to encourage entrepreneurship through streamlining and reducing costs associated with doing business in the country and improving governance efforts such as fighting corruption.

Chapter 6

General conclusions and policy implications

6.1 Introduction

This chapter summarizes key results from the thesis and provides implications for food policy. Although each chapter provides its own summary and conclusions, this chapter unifies the results and provides resolutions in line with the general concept presented in Chapter I and tying it to development policy of countries such as Malawi. We revisit how we have answered the key questions and draw insights from economic theory to inform policy.

6.2 Infrastructure, extreme weather events and food security

6.2.1 Background

Economic disruptions in form of covariate and idiosyncratic shocks have important food and nutrition implications. Malawi has for the past six years experienced a number of covariate shocks with varying impacts. This study assessed assessed the impact of extreme weather events, price shocks, pest and diseases and miscellaneous idiosyncratic shocks on food and nutrition security. The study also assesses the impact infrastructure investment on mitigating the impact of economic disruptions.

6.2.2 Methods

The study used multiple data sets to triangulate identification of shocks. First the study used three waves of Integrated Household Survey panel data sets from Malawi of sample sizes up to 2500 collected between 2010, 2013 and 2016 by the National Statistical Office. These data sets are geo-referenced and representative at household and national level. The data contains demographic, production, consumption and incidence of shocks experienced by the households.

The study used high resolution weather data with a 0.5×0.5 latitude by longitude and monthly time resolution of drought incidences during the study time period. This data is used to objectively triangulate self reported data by households.

The study also used Night Time Light data obtained from the National Oceanic and Atmospheric Administration of the United States as a proxy for infrastructure. Another proxy of infrastructure used was the roads GIS shape file obtained from the World Bank.

Closely following microeconomic theoretic foundations, we exploited a natural experiment of infrastructure assignment, occurrence of extreme weather events and time to come up with a triple difference fixed effects regression combined with propensity matching to assess the impacts. Key dependent variables were food consumption expenditure per day and the Berry dietary diversity index while independent variables were Standardized Precipitation - Evapotranspiration Index and indicator variables for pests and diseases, and price related shocks. We reduced the dimensionality of the shocks using principal component analysis.

6.2.3 Key results

Results generally indicate that shocks were highly correlated but the major shocks were extreme weather shocks which were experienced by 56% of the households and made the principle component. Price related shocks were also widely reported and made the second component. Results show that extreme weather events have negative food and nutrition security implications. A standard deviation change in the mean SPEI in the middle of the agricultural season would reduce food consumption

expenditure shares by 17% . Noteworthy, a standard deviation increase in infrastructure has a food and nutrition security mitigating effect of 9% on food consumption expenditure .

6.2.4 Implications

An economic disruption such as a drought – the highly significant shock in the study – reduces market supply i.e. shift the food supply function backwards. Given that price elasticities of supply are larger than price elasticities of demand, as is the case in Malawi *see* (Govindan and Babu, 2001) and (Ecker and Qaim, 2011), in general welfare reduces due to the shock and consumers are hurt the most. However, net sellers of food commodities benefit the most due to higher prices.

Infrastructure investments would reduce transaction costs and bring more traders and commodities to the deficit region under the law of one price such that the negative effects of the shocks are mitigated. The effects of infrastructure suggest low endowments and high marginal productivity of social overhead capital.

6.2.5 Recommendations

We find that weather related shocks have negative impacts on food consumption expenditure shares, significantly reduce dietary diversity and micronutrient consumption. In addition, households that sell a larger proportion of their farm produce to markets and held less assets also experienced higher levels of food insecurity. We therefore recommend that farmers must ensure that they keep sufficient stocks of their produce to ensure continued availability of food at household level. Further, we advocate that households hold tangible assets that could cushion them against shocks.

Results have shown that infrastructure improves food and nutrition security by improving access to socioeconomic amenities and also reduces impacts of weather related shocks. In the construction of the index, results indicated that electricity availability, proximity to main roads, credit facilities had significant explanatory power and magnitude. We recommend that policy makers consider increasing investments towards these forms of infrastructure.

Results of low dietary diversity may also signal lack of nutrition education. The study therefore recommends focused nutrition messages for rural households for dietary behavioural change. During crises, key messages about dietary diversity and nutrient rich foods should be widely disseminated.

6.3 Social capital and food market performance

6.3.1 Background

Chapters III and IV analyze different aspects of market structure, conduct and performance of staple food markets using maize as a case study. Considering that formal contracts in food markets are hard to come by, most contracts, interactions and transactions are based on trust. As such, we use New Institutional Economics embedded with Rational Expectations Equilibrium assumptions and evolutionary game theory to assess the conduct and performance of maize markets. Chapter III assesses the effect of industry structure, institutional and social capital on maize trader behaviour, business resilience and profitability. Chapter IV assesses whether business registration leads to more efficient firms.

6.3.2 Methods

Chapters III and IV use a randomly sampled trader survey of size 172. In Chapter II we used the Herfindahl Index and key informant interviews to measure market concentration and Bayes Model Averaging regression techniques with both informative and reference priors to analyze key success correlates for business performance and resilience. Chapter IV uses instrumental variable triangulated with control function techniques to assess effects of business registration on trader performance.

6.3.3 Key results

Results not only indicate that markets are concentrated but also highly informal with only 24% of the traders formally registered. Key correlates of business performance as indicated by profitability were business registration, possession of export licences, whether the trader performs multiple market functions, number of family members

engaged in maize trading, number of contacts with distant traders. Results of causal effects of business registration on business performance show that registering a business reduces performance.

6.3.4 Implications

Results suggest that in the market, traders in an oligopoly will tend to cooperate until in the last game someone defects. Results bring out evidence of high levels of interaction and cooperation to fix prices. Such behaviour has welfare reducing implications. At market level, when traders effectively fix prices they act like a monopoly such that their quantities are sold at marginal cost, but they generate revenues at average cost, thereby reducing consumer surplus. Under this arrangement, consumers always buy their staple food at higher than equilibrium price. This is especially concerning when the consumers are also poor smallholder producers – who are cash constrained and sell their output to traders at harvest at below long run equilibrium prices. Due to temporal arbitrage and collusion among genetically close traders, markets do not perform efficiently.

6.4 Recommendations

Following the results, the study makes the following recommendations:

Our results showed that distance to the registration center was negatively correlated with registration. Registration of major businesses is conducted at major cities namely Lilongwe and Blantyre. This creates a disincentive for traders that are far from these areas. When traders do not register the government loses substantial sums in government revenue.

Due to a large presence of collusion and market concentration from the results, the study recommends that government institutions should monitor local staple food markets for anti-competitive behaviour.

A lasting solution for promoting competitive markets would be to ensure continuous entry of traders into the market by incentivising individuals to venture into entrepreneurship. Based on our findings, the study therefore suggests entrepreneurship as a means of achieving food security and increased welfare.

6.5 Study limitations and recommendations for further studies

The study of impacts of idiosyncratic and covariate shocks on food security remains an important area of policy interest. There are some outstanding issues that the study was not able to address. First, the study's use of Living Standards Measurement Surveys takes advantage of its representativeness and ease of achieving external validity. However, some questions were not as detailed to elicit specific adaptation strategies after shocks. Economic disruption focused primary data longitudinal surveys are therefore required.

The study has not addressed the public finance aspects of infrastructure provisioning due to data unavailability. Therefore a study building on this quantifying benefit cost aspects of various infrastructure financing needs is required. Regarding the same manner, public policy design incorporating infrastructure investments decisions should include baseline socioeconomic surveys and studies where impact assessment exercises can be built on.

The study managed to assess trader characteristics and behavior with regards to entry into business, performance and institutional aspects. However, a study based on laboratory or field games to elicit behavior of traders under given scenarios could elicit informative insights.

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Appendix for Chapter 2

Table A2.1: Impact of extreme weather events on food security conditional on infrastructure. These results replicates Table 2.5.

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.2962                                         min =          1
     between = 0.0656                                         avg =        2.7
     overall = 0.1920                                         max =          3

                                                F(29,1555)        =      39.15
corr(u_i, Xb)  = -0.0332                        Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------
                    |               Robust
          foodShare |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------+---------------------------------------------------------------
              spei03 |  -.0244145   .0069018    -3.54   0.000    -.0379523   -.0108767
                cii1 |   .1160561   .0794994     1.46   0.145    -.0398812    .2719933
                     |
     c.spei03#c.cii1 |  -.0732483   .0455272    -1.61   0.108    -.1625495    .0160528
                year |
                2013  |   .0174596   .0164172     1.06   0.288    -.0147425    .0496618
                2016  |  -.2101705   .0146075   -14.39   0.000    -.2388231    -.181518
       year#c.spei03 |
                2013  |  -.0530344   .0093278    -5.69   0.000    -.0713308   -.0347381
                2016  |   .0094678   .0086929     1.09   0.276    -.0075832    .0265188
         year#c.cii1 |
                2013  |  -.1555728   .0836992    -1.86   0.063     -.319748    .0086025
                2016  |  -.1343166   .0882716    -1.52   0.128    -.3074605    .0388273
year#c.spei03#c.cii1 |
                2013  |   .1011737   .0528941     1.91   0.056    -.0025776     .204925
                2016  |   .1798924   .0619493     2.90   0.004     .0583795    .3014053
           asset_inde |  -.0165036   .0059958    -2.75   0.006    -.0282642    -.004743
                lnage |     .00088   .0231978     0.04   0.970    -.0446223    .0463822
                  sex |  -.0058408   .0151669    -0.39   0.700    -.0355905    .0239089
            maleAdult |  -.0030841   .0052277    -0.59   0.555    -.0133383      .00717
            maleChild |   -.005021   .0047885    -1.05   0.295    -.0144136    .0043717
           femaleAdul |  -.0032732   .0050517    -0.65   0.517    -.0131821    .0066357
           femaleChil |  -.0051264   .0045968    -1.12   0.265     -.014143    .0038902
             marital2 |   -.000649   .0158219    -0.04   0.967    -.0316836    .0303856
             marital3 |  -.0192429   .0155118    -1.24   0.215    -.0496692    .0111835
             marital4 |  -.0076742    .017715    -0.43   0.665     -.042422    .0270737
             marital5 |  -.0231414   .0150132    -1.54   0.123    -.0525897    .0063069
              school1 |  -.0025365   .0317279    -0.08   0.936    -.0647704    .0596974
              school2 |  -.0477302   .0247806    -1.93   0.054    -.0963372    .0008768
              school3 |   .0069297   .0131794     0.53   0.599    -.0189215    .0327809
              school4 |  -.0181888   .0147543    -1.23   0.218    -.0471292    .0107515
              school6 |  -.0382296   .0838249    -0.46   0.648    -.2026514    .1261921
              school7 |  -.0413569   .0123775    -3.34   0.001    -.0656352   -.0170785
               lnland |  -.0019402   .0096284    -0.20   0.840    -.0208262    .0169458
                _cons |    .638741   .0880577     7.25   0.000     .4660167    .8114652
--------------------+---------------------------------------------------------------
              sigma_u |  .12962867
              sigma_e |  .16589853
                  rho |  .37909185   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.0462                                         min =          1
     between = 0.1392                                         avg =        2.7
     overall = 0.0805                                         max =          3

                                                F(29,1555)        =       5.09
corr(u_i, Xb)  = 0.1359                         Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------------
                    |               Robust
             BBerry |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------+---------------------------------------------------------------
              spei03 |  -.0104898   .0078193    -1.34   0.180    -.0258273    .0048476
                cii1 |  -.0712566   .0824907    -0.86   0.388    -.2330614    .0905482
     c.spei03#c.cii1 |   .0817082   .0493734     1.65   0.098    -.0151372    .1785536
                year |
                2013  |  -.0080102   .0227841    -0.35   0.725    -.0527009    .0366806
                2016  |  -.0826928   .0172363    -4.80   0.000    -.1165017   -.0488839
       year#c.spei03 |
                2013  |    -.00057   .0137137    -0.04   0.967    -.0274692    .0263293
                2016  |   .0135553   .0100061     1.35   0.176    -.0060717    .0331822
         year#c.cii1 |
                2013  |  -.0841634   .1004599    -0.84   0.402    -.2812145    .1128878
                2016  |   .0503627   .0968682     0.52   0.603    -.1396434    .2403687
year#c.spei03#c.cii1 |
                2013  |   .0222945   .0653063     0.34   0.733    -.1058033    .1503923
                2016  |  -.0973292    .071852    -1.35   0.176    -.2382662    .0436078
          asset_inde |   .0132114   .0052977     2.49   0.013       .00282    .0236029
               lnage |   -.009678   .0334887    -0.29   0.773    -.0753659    .0560098
                 sex |     .02321   .0203375     1.14   0.254    -.0166818    .0631018
           maleAdult |   .0140389   .0059576     2.36   0.019     .0023531    .0257246
           maleChild |    .012814    .005504     2.33   0.020      .002018     .02361
          femaleAdul |  -.0089241   .0057211    -1.56   0.119    -.0201461    .0022978
          femaleChil |  -.0014618   .0057252    -0.26   0.799    -.0126917     .009768
            marital2 |   .0007483   .0202924     0.04   0.971     -.039055    .0405516
            marital3 |   .0401557   .0182072     2.21   0.028     .0044424    .0758689
            marital4 |   .0329367   .0215788     1.53   0.127    -.0093899    .0752634
            marital5 |   .0182584   .0184544     0.99   0.323    -.0179398    .0544566
             school1 |   .0409777   .0175256     2.34   0.020     .0066014    .0753539
             school2 |   .0428321   .0149897     2.86   0.004       .01343    .0722343
             school3 |   .0348761   .0130961     2.66   0.008     .0091883     .060564
             school4 |   .0428661    .012002     3.57   0.000     .0193242     .066408
             school6 |  -.0076793      .0497    -0.15   0.877    -.1051653    .0898067
             school7 |   .0293432   .0126368     2.32   0.020     .0045562    .0541301
              lnland |   .0096533   .0099155     0.97   0.330    -.0097959    .0291025
               _cons |   .6340103   .1251706     5.07   0.000     .3884893    .8795314
--------------------+---------------------------------------------------------------
             sigma_u |  .16445931
             sigma_e |  .20072328
                 rho |  .40166604   (fraction of variance due to u_i)
```

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.0759                                         min =          1
     between = 0.1441                                         avg =        2.7
     overall = 0.1031                                         max =          3

                                                F(29,1555)        =       8.16
corr(u_i, Xb)  = 0.1388                         Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------------
                    |               Robust
                 EE |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------+---------------------------------------------------------------
              spei03 |  -.0172309    .014501    -1.19   0.235    -.0456744    .0112126
                cii1 |   .0471169   .1648491     0.29   0.775    -.2762332     .370467
                     |
     c.spei03#c.cii1 |   .0704964   .0924103     0.76   0.446    -.1107654    .2517583
                     |
                year |
                2013 |  -.1307311   .0408005    -3.20   0.001    -.2107609   -.0507014
                2016 |   -.186802   .0325129    -5.75   0.000    -.2505758   -.1230282
                     |
       year#c.spei03 |
                2013 |  -.0004806   .0241682    -0.02   0.984    -.0478863     .046925
                2016 |   .0575362   .0179888     3.20   0.001     .0222514    .0928211
                     |
         year#c.cii1 |
                2013 |  -.4900846   .1906531    -2.57   0.010    -.8640489   -.1161202
                2016 |  -.0580108   .1751596    -0.33   0.741    -.4015847    .2855632
                     |
year#c.spei03#c.cii1 |
                2013 |   .1247767   .1220192     1.02   0.307    -.1145628    .3641162
                2016 |   -.079078   .1270939    -0.62   0.534    -.3283716    .1702155
                     |
          asset_inde |   .0270957   .0118607     2.28   0.022      .003831    .0503604
               lnage |   .0117387   .0666069     0.18   0.860      -.11891    .1423874
                 sex |  -.0129292     .03722    -0.35   0.728    -.0859359    .0600776
           maleAdult |   .0160272   .0122466     1.31   0.191    -.0079943    .0400488
           maleChild |   .0212818   .0115428     1.84   0.065    -.0013593    .0439229
          femaleAdul |  -.0278636   .0115744    -2.41   0.016    -.0505666   -.0051606
          femaleChil |  -.0177047   .0116786    -1.52   0.130    -.0406122    .0052029
            marital2 |   .0072636   .0371669     0.20   0.845    -.0656388     .080166
            marital3 |   .0822321   .0362337     2.27   0.023     .0111601    .1533041
            marital4 |   .0756194   .0391258     1.93   0.053    -.0011255    .1523643
            marital5 |   .0151772    .034918     0.43   0.664    -.0533142    .0836686
             school1 |   .2006522   .0604131     3.32   0.001     .0821524     .319152
             school2 |   .2136506   .0432306     4.94   0.000     .1288543     .298447
             school3 |   .1092678   .0287011     3.81   0.000     .0529709    .1655648
             school4 |   .1623918   .0293346     5.54   0.000     .1048523    .2199313
             school6 |   .0880682   .1340859     0.66   0.511    -.1749401    .3510764
             school7 |   .0657791   .0274811     2.39   0.017     .0118751    .1196831
              lnland |   .0551618   .0202486     2.72   0.007     .0154444    .0948792
               _cons |   1.663803   .2458777     6.77   0.000     1.181517     2.14609
--------------------+---------------------------------------------------------------
             sigma_u |  .39213171
             sigma_e |  .38324186
                 rho |  .51146375   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

```
Fixed-effects (within) regression               Number of obs     =      4,061
Group variable: HHID                            Number of groups  =      1,554

R-sq:                                           Obs per group:
     within  = 0.5582                                         min =          1
     between = 0.1717                                         avg =        2.6
     overall = 0.4066                                         max =          3

                                                F(29,1553)        =     185.73
corr(u_i, Xb)  = -0.0264                        Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,554 clusters in HHID)
------------------------------------------------------------------------------------
                   |               Robust
                lfexp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------------+-------------------------------------------------------------
              spei03 |   -.196031   .0625985    -3.13   0.002    -.3188176   -.0732445
                cii1 |  -.4470444   .5538891    -0.81   0.420    -1.533494    .6394052
                     |
     c.spei03#c.cii1 |   .2447544    .290719     0.84   0.400    -.3254888    .8149976
                     |
                year |
                2013 |   1.868665    .090666    20.61   0.000     1.690824    2.046505
                2016 |   1.504333   .0983714    15.29   0.000     1.311379    1.697288
                     |
       year#c.spei03 |
                2013 |  -.1457401   .0541972    -2.69   0.007    -.2520474   -.0394328
                2016 |   .1497241   .0549135     2.73   0.006     .0420116    .2574366
                     |
         year#c.cii1 |
                2013 |   .0279246   .4085498     0.07   0.946    -.7734429    .8292921
                2016 |   .3846365    .691917     0.56   0.578    -.9725536    1.741827
                     |
year#c.spei03#c.cii1 |
                2013 |  -.0483849    .241185    -0.20   0.841    -.5214675    .4246977
                2016 |  -.1091524   .4487119    -0.24   0.808    -.9892974    .7709927
                     |
          asset_inde |   .0125094   .0090312     1.39   0.166    -.0052052     .030224
               lnage |   .1203506   .1039805     1.16   0.247    -.0836064    .3243075
                 sex |  -.1059274   .0749773    -1.41   0.158    -.2529949      .04114
            maleAdult |   .0732144   .0309565     2.37   0.018     .0124935    .1339352
            maleChild |   -.015483     .03054    -0.51   0.612    -.0753869    .0444209
           femaleAdul |   .0973482   .0230459     4.22   0.000     .0521439    .1425525
           femaleChil |  -.0967142    .031452    -3.07   0.002     -.158407   -.0350213
             marital2 |    .016411   .0862486     0.19   0.849     -.152765    .185587
             marital3 |   .0133544   .0614885     0.22   0.828    -.1072547    .1339636
             marital4 |   .0852389   .0968742     0.88   0.379    -.1047791    .2752569
             marital5 |   -.199272     .09312    -2.14   0.033    -.3819263   -.0166177
              school1 |   .1611549   .1005465     1.60   0.109    -.0360664    .3583762
              school2 |   .1734335   .0912912     1.90   0.058    -.0056335    .3525005
              school3 |   .1773274   .0657137     2.70   0.007     .0484305    .3062242
              school4 |   .0992062   .0634687     1.56   0.118    -.0252871    .2236995
              school6 |   .0908656   .2921857     0.31   0.756    -.4822544    .6639857
              school7 |  -.0626036   .0766883    -0.82   0.414    -.2130272    .0878199
               lnland |   .0540427   .0405635     1.33   0.183    -.0255223    .1336077
                _cons |   9.488953    .393086    24.14   0.000     8.717918    10.25999
----------------------+-------------------------------------------------------------
              sigma_u |  .76361558
              sigma_e |   .8511498
                  rho |   .4459502   (fraction of variance due to u_i)
------------------------------------------------------------------------------------
```

Table A2.2: Impact of floods on food security conditional on infrastructure. These results replicates Table 2.6.

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.2915                                         min =          1
     between = 0.0938                                         avg =        2.7
     overall = 0.2017                                         max =          3

                                                F(29,1555)        =      36.09
corr(u_i, Xb)  = 0.0021                         Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------
                   |               Robust
         foodShare |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
             flood |  -.0187755   .0095627    -1.96   0.050    -.0375327   -.0000183
              cii1 |   .1802122   .0850294     2.12   0.034     .0134279    .3469965
                   |
    c.flood#c.cii1 |  -.1110274   .0485481    -2.29   0.022    -.2062541   -.0158008
                   |
              year |
              2013 |  -.0178211   .0159771    -1.12   0.265    -.0491601    .0135179
              2016 |  -.2103811   .0167271   -12.58   0.000    -.2431912   -.1775711
                   |
      year#c.flood |
              2013 |  -.0315378   .0088851    -3.55   0.000    -.0489659   -.0141098
              2016 |   .0118374   .0097919     1.21   0.227    -.0073694    .0310441
                   |
       year#c.cii1 |
              2013 |  -.1778877   .0777229    -2.29   0.022    -.3303404    -.025435
              2016 |  -.1627498   .0916056    -1.78   0.076    -.3424333    .0169338
                   |
year#c.flood#c.cii1 |
              2013 |    .105748    .047717     2.22   0.027     .0121515    .1993445
              2016 |   .1784789   .0638056     2.80   0.005     .0533247    .3036331
                   |
        asset_inde |  -.0171902   .0060526    -2.84   0.005    -.0290624    -.005318
             lnage |   -.000586   .0231783    -0.03   0.980      -.04605     .044878
               sex |  -.0052652   .0151482    -0.35   0.728    -.0349784    .0244479
         maleAdult |  -.0028861   .0052499    -0.55   0.583    -.0131837    .0074116
         maleChild |  -.0049644   .0048226    -1.03   0.303     -.014424    .0044952
        femaleAdul |  -.0035437   .0050803    -0.70   0.486    -.0135086    .0064212
        femaleChil |   -.004791   .0046138    -1.04   0.299     -.013841    .0042591
          marital2 |   .0001389   .0158343     0.01   0.993      -.03092    .0311978
          marital3 |    -.02006   .0155468    -1.29   0.197    -.0505549    .0104348
          marital4 |  -.0096218   .0177402    -0.54   0.588    -.0444192    .0251755
          marital5 |  -.0241147   .0152611    -1.58   0.114    -.0540491    .0058197
           school1 |  -.0018705   .0320164    -0.06   0.953    -.0646703    .0609294
           school2 |  -.0473203   .0251943    -1.88   0.061    -.0967387    .0020981
           school3 |   .0059672    .013133     0.45   0.650    -.0197931    .0317275
           school4 |  -.0191224   .0148898    -1.28   0.199    -.0483286    .0100837
           school6 |  -.0400456   .0838755    -0.48   0.633    -.2045667    .1244755
           school7 |  -.0419299   .0123455    -3.40   0.001    -.0661454   -.0177144
            lnland |   -.005181   .0096775    -0.54   0.592    -.0241634    .0138013
             _cons |    .638019   .0885251     7.21   0.000     .4643778    .8116602
-------------------+----------------------------------------------------------------
           sigma_u |  .12756036
           sigma_e |  .16645039
               rho |  .37000036   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.0452                                         min =          1
     between = 0.1337                                         avg =        2.7
     overall = 0.0777                                         max =          3

                                                F(29,1555)        =       5.02
corr(u_i, Xb)  = 0.1319                         Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------
                   |               Robust
            BBerry |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
             flood |  -.0044496   .0107095    -0.42   0.678    -.0254563     .016557
              cii1 |  -.1094707   .0941793    -1.16   0.245    -.2942026    .0752611
                   |
     c.flood#c.cii1 |   .1012825   .0561693     1.80   0.072    -.0088931     .211458
                   |
              year |
              2013 |  -.0039474   .0195364    -0.20   0.840    -.0422678     .034373
              2016 |  -.0740331   .0199186    -3.72   0.000    -.1131033    -.034963
                   |
       year#c.flood |
              2013 |  -.0038809   .0110627    -0.35   0.726    -.0255802    .0178184
              2016 |   .0067331   .0111882     0.60   0.547    -.0152125    .0286786
                   |
        year#c.cii1 |
              2013 |   .0136172   .0911285     0.15   0.881    -.1651306     .192365
              2016 |   .0482883   .1054952     0.46   0.647    -.1586395    .2552161
                   |
year#c.flood#c.cii1 |
              2013 |  -.0351189   .0574506    -0.61   0.541    -.1478077    .0775698
              2016 |  -.0814981   .0786885    -1.04   0.301    -.2358449    .0728487
                   |
         asset_inde |   .0132849   .0053499     2.48   0.013     .0027911    .0237787
              lnage |   -.010292   .0333655    -0.31   0.758    -.0757381    .0551542
                sex |     .02375   .0203809     1.17   0.244     -.016227     .063727
          maleAdult |   .0137984   .0059557     2.32   0.021     .0021163    .0254805
          maleChild |   .0128504   .0055046     2.33   0.020     .0020531    .0236477
         femaleAdul |  -.0090888   .0057284    -1.59   0.113     -.020325    .0021474
         femaleChil |  -.0016796   .0057274    -0.29   0.769    -.0129138    .0095546
           marital2 |   .0009876   .0202462     0.05   0.961    -.0387252    .0407004
           marital3 |   .0404226   .0182196     2.22   0.027     .0046849    .0761602
           marital4 |   .0330718   .0216099     1.53   0.126    -.0093158    .0754594
           marital5 |    .018213   .0184655     0.99   0.324    -.0180069    .0544329
            school1 |   .0397714   .0176794     2.25   0.025     .0050934    .0744493
            school2 |   .0423736   .0150732     2.81   0.005     .0128076    .0719397
            school3 |   .0344136   .0131415     2.62   0.009     .0086367    .0601905
            school4 |   .0422735   .0120315     3.51   0.000     .0186739    .0658732
            school6 |  -.0102684   .0509639    -0.20   0.840    -.1102336    .0896967
            school7 |   .0295186   .0126055     2.34   0.019      .004793    .0542442
             lnland |     .01085   .0098965     1.10   0.273    -.0085619    .0302619
              _cons |   .6279794   .1249537     5.03   0.000     .3828838    .8730749
-------------------+----------------------------------------------------------------
            sigma_u |  .16476545
            sigma_e |   .2008251
                rho |  .40231636   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.0746                                         min =          1
     between = 0.1361                                         avg =        2.7
     overall = 0.0988                                         max =          3

                                                F(29,1555)        =       8.03
corr(u_i, Xb)  = 0.1324                         Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------
                   |               Robust
                EE |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
             flood |   .0039289   .0207144     0.19   0.850    -.0367021    .0445599
              cii1 |   .0143812   .1884698     0.08   0.939    -.3553006    .3840629
                   |
     c.flood#c.cii1 |   .0776399    .106706     0.73   0.467    -.1316629    .2869428
                   |
              year |
              2013  |  -.0935469   .0382325    -2.45   0.015    -.1685397   -.0185542
              2016  |  -.1402238   .0377079    -3.72   0.000    -.2141874   -.0662602
                   |
       year#c.flood |
              2013  |  -.0271159    .021717    -1.25   0.212    -.0697136    .0154818
              2016  |   .0253972   .0202362     1.26   0.210     -.014296    .0650904
                   |
        year#c.cii1 |
              2013  |  -.3753651    .172383    -2.18   0.030    -.7134927   -.0372375
              2016  |    .007593   .1918408     0.04   0.968     -.368701     .383887
                   |
year#c.flood#c.cii1 |
              2013  |   .0718522   .1068501     0.67   0.501    -.1377333    .2814377
              2016  |  -.1171167   .1414086    -0.83   0.408    -.3944884    .1602549
                   |
         asset_inde |   .0272905   .0120429     2.27   0.024     .0036686    .0509125
              lnage |   .0115654   .0659891     0.18   0.861    -.1178717    .1410025
                sex |  -.0136452   .0372477    -0.37   0.714    -.0867062    .0594157
          maleAdult |   .0155898   .0122272     1.28   0.202    -.0083937    .0395733
          maleChild |   .0212159    .011534     1.84   0.066    -.0014079    .0438397
         femaleAdul |  -.0280769   .0115887    -2.42   0.016     -.050808   -.0053457
         femaleChil |  -.0183987   .0116549    -1.58   0.115    -.0412598    .0044623
           marital2 |   .0073682   .0371925     0.20   0.843    -.0655846     .080321
           marital3 |   .0802814   .0363521     2.21   0.027      .008977    .1515858
           marital4 |   .0758381   .0390976     1.94   0.053    -.0008515    .1525277
           marital5 |   .0157998   .0349164     0.45   0.651    -.0526883     .084288
            school1 |   .2020235   .0597093     3.38   0.001     .0849043    .3191427
            school2 |   .2109884   .0431171     4.89   0.000     .1264147    .2955621
            school3 |   .1071687   .0289632     3.70   0.000     .0503577    .1639796
            school4 |   .1629095   .0294382     5.53   0.000     .1051667    .2206524
            school6 |   .0797263   .1369919     0.58   0.561     -.188982    .3484345
            school7 |    .066751   .0275293     2.42   0.015     .0127526    .1207494
             lnland |   .0602212   .0201738     2.99   0.003     .0206505     .099792
              _cons |   1.634335   .2441334     6.69   0.000     1.155469      2.1132
-------------------+----------------------------------------------------------------
            sigma_u |  .39314135
            sigma_e |  .38350112
                rho |  .51241078   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

```
Fixed-effects (within) regression               Number of obs     =      4,061
Group variable: HHID                            Number of groups  =      1,554

R-sq:                                           Obs per group:
     within  = 0.5544                                         min =          1
     between = 0.1935                                         avg =        2.6
     overall = 0.4142                                         max =          3

                                                F(29,1553)        =     183.95
corr(u_i, Xb)  = -0.0048                        Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,554 clusters in HHID)
------------------------------------------------------------------------------------
                   |               Robust
              lfexp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------+---------------------------------------------------------------
              flood |  -.1674596   .0699633    -2.39   0.017    -.3046922   -.0302271
               cii1 |  -.6734308   .6024526    -1.12   0.264    -1.855137    .5082756
                    |
     c.flood#c.cii1 |   .3697052   .2986977     1.24   0.216    -.2161881    .9555985
                    |
               year |
               2013 |   1.699813    .080419    21.14   0.000     1.542072    1.857555
               2016 |   1.521438   .1154014    13.18   0.000     1.295079    1.747797
                    |
       year#c.flood |
               2013 |  -.0480696   .0410173    -1.17   0.241    -.1285246    .0323855
               2016 |   .1232376   .0597213     2.06   0.039     .0060947    .2403806
                    |
        year#c.cii1 |
               2013 |   .3222689   .4260665     0.76   0.450    -.5134575    1.157995
               2016 |   .4265064   .7154451     0.60   0.551    -.9768339    1.829847
                    |
year#c.flood#c.cii1 |
               2013 |  -.2255712   .2248263    -1.00   0.316    -.6665664     .215424
               2016 |  -.0739923   .4945832    -0.15   0.881    -1.044114    .8961291
                    |
         asset_inde |   .0099962   .0091487     1.09   0.275     -.007949    .0279414
              lnage |   .1122901   .1046471     1.07   0.283    -.0929745    .3175547
                sex |  -.1000159    .076125    -1.31   0.189    -.2493344    .0493026
          maleAdult |   .0722676    .031134     2.32   0.020     .0111985    .1333366
          maleChild |   -.016516   .0308198    -0.54   0.592    -.0769689    .0439368
         femaleAdul |   .0976411   .0231724     4.21   0.000     .0521887    .1430936
         femaleChil |  -.0942801   .0314522    -3.00   0.003    -.1559734   -.0325867
           marital2 |   .0232506   .0886416     0.26   0.793    -.1506193    .1971205
           marital3 |    .012448   .0621085     0.20   0.841    -.1093774    .1342735
           marital4 |   .0790902   .0965263     0.82   0.413    -.1102454    .2684258
           marital5 |   -.202527   .0942155    -2.15   0.032      -.38733    -.017724
            school1 |   .1611912   .1013577     1.59   0.112    -.0376212    .3600035
            school2 |   .1759165   .0930886     1.89   0.059     -.006676     .358509
            school3 |   .1731801   .0659219     2.63   0.009     .0438747    .3024855
            school4 |   .0970286   .0653668     1.48   0.138     -.031188    .2252451
            school6 |   .0825266   .2948541     0.28   0.780    -.4958275    .6608808
            school7 |  -.0602298   .0771419    -0.78   0.435     -.211543    .0910834
             lnland |   .0498402   .0411155     1.21   0.226    -.0308075     .130488
              _cons |   9.485715   .3970297    23.89   0.000     8.706944    10.26449
--------------------+---------------------------------------------------------------
            sigma_u |  .75298367
            sigma_e |  .85478146
                rho |  .43693649   (fraction of variance due to u_i)
------------------------------------------------------------------------------------
```

Table A2.3: Impact of drought weather events on food security conditional on infrastructure. These results replicates Table 2.7.

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.2861                                         min =          1
     between = 0.1146                                         avg =        2.7
     overall = 0.2068                                         max =          3

                                                F(29,1555)        =      37.79
corr(u_i, Xb)  = 0.0198                         Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------------
                    |               Robust
          foodShare |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------+---------------------------------------------------------------
            drought |  -.0324033   .0153987    -2.10   0.036    -.0626077    -.002199
               cii1 |   .0309397   .0388417     0.80   0.426     -.045248    .1071273
                    |
     c.drought#c.cii1 |  -.0514534   .1829776    -0.28   0.779    -.4103623    .3074555
                    |
               year |
               2013 |  -.0509637   .0102549    -4.97   0.000    -.0710786   -.0308488
               2016 |  -.1883179   .0109277   -17.23   0.000    -.2097525   -.1668833
                    |
       year#c.drought |
               2013 |  -.2590587   .0535961    -4.83   0.000     -.364187   -.1539305
               2016 |   .0539896   .0416195     1.30   0.195    -.0276467    .1356259
                    |
          year#c.cii1 |
               2013 |  -.0542559   .0395063    -1.37   0.170    -.1317471    .0232352
               2016 |   .1167509   .0477707     2.44   0.015     .0230492    .2104526
                    |
year#c.drought#c.cii1 |
               2013 |  -.4459479    .396816    -1.12   0.261    -1.224299     .332403
               2016 |   .4848113   .3030679     1.60   0.110    -.1096535    1.079276
                    |
           asset_inde |  -.0164514   .0061128    -2.69   0.007    -.0284417   -.0044612
                lnage |  -.0001424   .0234274    -0.01   0.995    -.0460951    .0458103
                  sex |  -.0020303   .0152704    -0.13   0.894     -.031983    .0279224
            maleAdult |  -.0032017   .0052369    -0.61   0.541    -.0134739    .0070705
            maleChild |   -.005075   .0048025    -1.06   0.291     -.014495     .004345
           femaleAdul |  -.0039303   .0051191    -0.77   0.443    -.0139714    .0061107
           femaleChil |  -.0038975   .0046402    -0.84   0.401    -.0129991    .0052042
             marital2 |   .0043501   .0161369     0.27   0.788    -.0273023    .0360025
             marital3 |  -.0179528   .0154735    -1.16   0.246    -.0483039    .0123984
             marital4 |  -.0048061   .0179883    -0.27   0.789      -.04009    .0304777
             marital5 |  -.0226129   .0151358    -1.49   0.135    -.0523016    .0070759
              school1 |  -.0047368   .0315623    -0.15   0.881    -.0666459    .0571723
              school2 |  -.0482069   .0246406    -1.96   0.051    -.0965392    .0001255
              school3 |   .0063435   .0132426     0.48   0.632    -.0196317    .0323187
              school4 |  -.0208775   .0147423    -1.42   0.157    -.0497943    .0080393
              school6 |  -.0318725   .0864289    -0.37   0.712     -.201402     .137657
              school7 |  -.0408211   .0123928    -3.29   0.001    -.0651295   -.0165128
               lnland |  -.0012056   .0095815    -0.13   0.900    -.0199996    .0175884
                _cons |   .5975257   .0888944     6.72   0.000     .4231603    .7718912
--------------------+---------------------------------------------------------------
              sigma_u |  .12633954
              sigma_e |   .1670849
                  rho |  .36376545   (fraction of variance due to u_i)
------------------------------------------------------------------------------------
```

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.0482                                         min =          1
     between = 0.1166                                         avg =        2.7
     overall = 0.0747                                         max =          3

                                                F(29,1555)        =       5.42
corr(u_i, Xb)  = 0.1102                         Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------------
                    |               Robust
                BBerry |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------------------+------------------------------------------------------------
               drought |  -.0617084   .0171718    -3.59   0.000    -.0953907   -.0280261
                  cii1 |   .0770815   .0460555     1.67   0.094    -.0132558    .1674189
                       |
     c.drought#c.cii1 |   .1023015   .1641403     0.62   0.533    -.2196583    .4242612
                       |
                  year |
                  2013 |  -.0008341   .0119035    -0.07   0.944    -.0241828    .0225146
                  2016 |  -.0574639   .0127417    -4.51   0.000    -.0824566   -.0324712
                       |
       year#c.drought |
                  2013 |  -.0437762   .1284255    -0.34   0.733    -.2956815    .2081292
                  2016 |   .0342664   .0506474     0.68   0.499     -.065078    .1336108
                       |
          year#c.cii1 |
                  2013 |  -.0833856   .0467039    -1.79   0.074    -.1749948    .0082237
                  2016 |   -.121347   .0574495    -2.11   0.035    -.2340337   -.0086604
                       |
year#c.drought#c.cii1 |
                  2013 |   .6113085   .7577062     0.81   0.420    -.8749252    2.097542
                  2016 |  -.4607086   .2984125    -1.54   0.123    -1.046042    .1246248
                       |
           asset_inde |   .0130559   .0051858     2.52   0.012     .0028839    .0232279
                lnage |  -.0073106   .0333825    -0.22   0.827    -.0727901    .0581689
                  sex |   .0231944    .020334     1.14   0.254    -.0166906    .0630795
             maleAdult |   .0140718   .0059687     2.36   0.019     .0023642    .0257794
             maleChild |   .0133107   .0055328     2.41   0.016     .0024582    .0241633
            femaleAdul |  -.0091718   .0057452    -1.60   0.111    -.0204408    .0020973
            femaleChil |   -.002042   .0057161    -0.36   0.721    -.0132541    .0091701
              marital2 |   .0010496   .0203094     0.05   0.959    -.0387871    .0408864
              marital3 |   .0386969   .0183268     2.11   0.035     .0027491    .0746447
              marital4 |   .0338749   .0215239     1.57   0.116     -.008344    .0760938
              marital5 |   .0171772   .0185745     0.92   0.355    -.0192565    .0536109
               school1 |    .036607   .0173625     2.11   0.035     .0025505    .0706634
               school2 |   .0435011   .0146928     2.96   0.003     .0146814    .0723209
               school3 |   .0357436   .0130678     2.74   0.006     .0101112     .061376
               school4 |   .0425617   .0119074     3.57   0.000     .0192055     .065918
               school6 |   -.005443   .0468842    -0.12   0.908    -.0974058    .0865198
               school7 |   .0283951   .0125654     2.26   0.024     .0037482     .053042
                lnland |   .0083903   .0098102     0.86   0.393    -.0108524     .027633
                 _cons |   .6052271   .1255443     4.82   0.000     .3589732     .851481
-----------------------+------------------------------------------------------------
               sigma_u |  .16511799
               sigma_e |  .20051054
                   rho |   .4040994   (fraction of variance due to u_i)
------------------------------------------------------------------------------------
```

```
Fixed-effects (within) regression               Number of obs     =      4,205
Group variable: HHID                            Number of groups  =      1,556

R-sq:                                           Obs per group:
     within  = 0.0774                                         min =          1
     between = 0.1444                                         avg =        2.7
     overall = 0.1044                                         max =          3

                                                F(29,1555)        =       9.27
corr(u_i, Xb)  = 0.1342                         Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,556 clusters in HHID)
------------------------------------------------------------------------------------
                    |               Robust
                 EE |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------+---------------------------------------------------------------
            drought |  -.1277087   .0281127    -4.54   0.000    -.1828514    -.072566
               cii1 |    .214089    .092104     2.32   0.020     .0334279    .3947501
                    |
     c.drought#c.cii1 |    .178035   .2652357     0.67   0.502    -.3422224    .6982924
                    |
               year |
               2013  |  -.1073641   .0232031    -4.63   0.000    -.1528767   -.0618514
               2016  |  -.1025051   .0246323    -4.16   0.000    -.1508211    -.054189
                    |
       year#c.drought |
               2013  |   .1745102   .1739542     1.00   0.316    -.1666994    .5157198
               2016  |   .0996524   .0824559     1.21   0.227    -.0620841    .2613889
                    |
          year#c.cii1 |
               2013  |  -.3775884   .0925012    -4.08   0.000    -.5590286   -.1961481
               2016  |  -.2443602   .1088012    -2.25   0.025    -.4577728   -.0309476
                    |
year#c.drought#c.cii1 |
               2013  |    1.18761   1.157156     1.03   0.305     -1.08214    3.457361
               2016  |  -.9702643   .4877929    -1.99   0.047    -1.927066    -.013463
                    |
           asset_inde |   .0262367    .011522     2.28   0.023     .0036364    .0488371
                lnage |   .0116909   .0655097     0.18   0.858    -.1168057    .1401875
                  sex |  -.0132123   .0374035    -0.35   0.724     -.086579    .0601543
            maleAdult |   .0157081   .0122606     1.28   0.200    -.0083409    .0397571
            maleChild |   .0217499    .011565     1.88   0.060    -.0009348    .0444345
           femaleAdul |  -.0275821   .0116014    -2.38   0.018    -.0503381   -.0048262
           femaleChil |  -.0190846   .0115712    -1.65   0.099    -.0417813    .0036122
             marital2 |   .0122393   .0366794     0.33   0.739     -.059707    .0841856
             marital3 |   .0773581   .0363412     2.13   0.033     .0060751    .1486412
             marital4 |   .0770158   .0392595     1.96   0.050     8.69e-06    .1540229
             marital5 |   .0160429   .0351323     0.46   0.648    -.0528688    .0849546
              school1 |   .1990795   .0597121     3.33   0.001     .0819546    .3162043
              school2 |   .2186173   .0432489     5.05   0.000     .1337851    .3034495
              school3 |   .1137759   .0284295     4.00   0.000     .0580117      .16954
              school4 |   .1664079   .0296041     5.62   0.000     .1083397    .2244762
              school6 |   .1002404   .1297286     0.77   0.440     -.154221    .3547019
              school7 |   .0630675   .0273063     2.31   0.021     .0095065    .1166286
               lnland |   .0571887   .0198905     2.88   0.004     .0181736    .0962037
                _cons |   1.623375   .2434228     6.67   0.000     1.145904    2.100847
--------------------+---------------------------------------------------------------
              sigma_u |  .39147056
              sigma_e |  .38292386
                  rho |  .51103528   (fraction of variance due to u_i)
------------------------------------------------------------------------------------
```

```
Fixed-effects (within) regression               Number of obs     =      4,061
Group variable: HHID                            Number of groups  =      1,554

R-sq:                                           Obs per group:
     within  = 0.5597                                         min =          1
     between = 0.1630                                         avg =        2.6
     overall = 0.4031                                         max =          3

                                                F(29,1553)        =     186.11
corr(u_i, Xb)  = -0.0235                        Prob > F          =     0.0000

                                    (Std. Err. adjusted for 1,554 clusters in HHID)
------------------------------------------------------------------------------------
                   |               Robust
              lfexp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
             drought |   -.489794   .1407336    -3.48   0.001    -.7658419   -.2137462
                cii1 |   .2046883   .1874019     1.09   0.275    -.1628991    .5722757
                     |
     c.drought#c.cii1 |   1.591525     1.6235     0.98   0.327    -1.592959    4.776008
                     |
                year |
                2013 |   1.718577   .0436203    39.40   0.000     1.633016    1.804138
                2016 |   1.806431   .0463533    38.97   0.000     1.715509    1.897353
                     |
       year#c.drought |
                2013 |  -1.655554   .7453109    -2.22   0.026    -3.117476   -.1936319
                2016 |   .5144787   .2497491     2.06   0.040     .0245976     1.00436
                     |
          year#c.cii1 |
                2013 |  -.4056324   .1704922    -2.38   0.017    -.7400515   -.0712132
                2016 |  -.1069463   .2791759    -0.38   0.702    -.6545478    .4406551
                     |
year#c.drought#c.cii1 |
                2013 |   .3270179   6.259142     0.05   0.958    -11.95024    12.60428
                2016 |  -2.682883   1.991677    -1.35   0.178    -6.589542    1.223776
                     |
           asset_inde |   .0096517   .0083023     1.16   0.245    -.0066331    .0259366
                lnage |   .1335702   .1049492     1.27   0.203    -.0722868    .3394273
                  sex |  -.0953996   .0742414    -1.28   0.199    -.2410235    .0502244
            maleAdult |   .0737513   .0308555     2.39   0.017     .0132284    .1342742
            maleChild |   -.011017    .030552    -0.36   0.718    -.0709446    .0489106
           femaleAdul |   .0903679   .0231027     3.91   0.000     .0450521    .1356837
           femaleChil |  -.0932806   .0313665    -2.97   0.003    -.1548058   -.0317554
             marital2 |   .0253288    .083696     0.30   0.762    -.1388403    .1894979
             marital3 |   .0065093   .0614388     0.11   0.916    -.1140024     .127021
             marital4 |   .0956854    .098434     0.97   0.331    -.0973922    .2887631
             marital5 |    -.21312   .0946125    -2.25   0.024    -.3987018   -.0275383
              school1 |   .1265599   .1036842     1.22   0.222    -.0768159    .3299357
              school2 |   .1620757   .0911414     1.78   0.076    -.0166974    .3408489
              school3 |    .177103   .0660263     2.68   0.007     .0475928    .3066131
              school4 |   .0865932   .0661878     1.31   0.191    -.0432338    .2164201
              school6 |   .1218855   .3023617     0.40   0.687    -.4711947    .7149658
              school7 |  -.0653449   .0751746    -0.87   0.385    -.2127993    .0821096
               lnland |   .0470799   .0403603     1.17   0.244    -.0320866    .1262463
                _cons |   9.096198   .3916481    23.23   0.000     8.327983    9.864413
---------------------+--------------------------------------------------------------
             sigma_u |  .76739983
             sigma_e |  .84971433
                 rho |  .44922945   (fraction of variance due to u_i)
------------------------------------------------------------------------------------
```