The contribution of town functions to the development of rural areas: Empirical analyses for Ethiopia

Tewodros Tadesse

Thesis committee

Thesis supervisor

Prof. dr. ir. Arie J. Oskam
Professor of Agricultural Economics and Rural Policy
Wageningen University

Other members

Prof. dr. ir. Erwin H. Bulte, Wageningen University
Prof. dr. Arthur H. O. van Soest, Tilburg University
Dr. Remco H. Oostendorp, University of Amsterdam
Dr. Cecilia Tacoli, International Institute for Environment and Development (IIED), London, UK

This research was conducted under the auspices of Wageningen School of Social Sciences (WASS).

The contribution of town functions to the development of rural areas: Empirical analyses for Ethiopia

Tewodros Tadesse

Thesis

Submitted in fulfillment of the requirements for the degree of doctor
at Wageningen University
by the authority of the Rector Magnificus
Prof. dr. M. J. Kropff,
in the presence of the
Thesis Committee appointed by the Academic Board
to be defended in public
on Wednesday April 11, 2012
at 4 p.m. in the Aula.

Tewodros Tadesse
The contribution of town functions to the development of rural areas: Empirical analyses for Ethiopia, 213 pages
PhD Thesis, Wageningen University, Wageningen, NL (2012)
With references, with summaries in Dutch and English
ISBN 978-94-6173-188-3

ACKNOWLEDGEMENTS

After 5 long years, this thesis brings an end to what has been a good learning period. I spent the best part of these years behind a computer screen; and most of it alone. Yet, many people kept me going; and others inspired me to work harder. At different levels, lots of people contributed to this thesis but none so more than Prof. Arie Oskam. Prof. Arie initially gave me the benefit of the doubt about my academic credentials, and allowed me to do a PhD under his guidance. I am supremely grateful for that. In connection to this, I am indebted to Dr. Tassew Woldehanna for recommending me to Prof. Arie. I am also equally thankful to Dr. Guush Berhane for facilitating the initial communications with Prof. Arie. I was naïve to the concept of rural-urban linkage before Prof. Arie and Dr. Tassew introduced me, which eventually became the general research area for my PhD. Thank you both for that.

As my daily supervisor, Prof. Arie's meticulous critique and guidance has taught me a lot about how to do scientific research. His straightforward and open approach was instrumental in shaping the contents of this thesis. He gave me the freedom when taking major approaches in my study and encouraged independent work. Every now and then, he asked for more. Yet, when I came up with the next version of chapters or papers, he was equally appreciative, which was encouraging. This whole process effectively changed (for good!) the way I think and do research. Prof. Arie, I am also highly grateful for the level of effort you put in to sort out my future. The least I can do for your commitment and investment in developing my research capabilities and career enhancement is forward my sincere gratitude. Thank you! Apart from academics, Prof. Arie together with his wife, Mirjam Oskam has been extremely kind in inviting me to several dinner nights and Sunday morning 'Brunch' at their home in Bennekom. Thank you, it meant a lot.

A gentle man known by the name Dr. Daan Ooms also made fundamental contribution to my thesis. His stay at Mekelle University has served me well in many ways. He was instrumental in shaping up my econometric approach and was really inspirational and challenging. He wrote the estimation codes for chapters 5 and 6 and I am highly indebted to that. Thank you Daan, you have also inspired me to start learning programming. I am still naïve but it goes without saying that something is better than nothing. I intend to work hard on this and I am confident that what goes around will be coming around!

The whole AEP Group created a suitable environment for me to concentrate on my study. To this end, everybody in the Group has been great but my earnest gratitude goes to Dineke Wemmenhove and Karen van der Heide who had been extremely helpful in everything. Bedankt, Dames! Also, Esther helped me a lot with Dutch translations and layout problems. Thanks for that Esther. In the Group, I took the liberty of appointing myself as the 'coffee master' where I took charge of serving coffee almost every mid-morning, which gave me an extra window of opportunity to get to know my AEP colleagues. That was, most of it, fun. On another note, Prof. Daniel Dela Torre Ugarte (University of Tennessee) created a very enjoyable social environment when I shared office with him at the Group. It was a good experience and I had lots of fun. I am grateful to Daniel and his wife, Jeannine Daniel, for generous Peruvian dinner invitation. Moreover, I have had enjoyable time with fellow PhDs including Merima, Esther, Sabrina, Diana, Mekonnen, Linda and Mekuanint. Thank you all.

I appreciate the econometric support from Dr. Peter Moffatt (University of East Anglia) and Prof. Steven Yen (University of Tennessee). Moreover, I am indebted to Prof. Ken Thomson (University of Aberdeen), Prof. Måns Söderbom (University of Gothenburg), Dr. Marrit van den Berg (WUR), Prof. Thomas Herzfeld (IAMO) and Dr. Marian Rizov (Middlesex University) for useful comments on different parts of the thesis. Equally, I am

indebted to Dr. Tassew and Merima for providing the datasets used for analyses. Kumar Jamdagni edited the English-language of this thesis. Thank you, Kumar.
I owe my home-base in Mekelle University, department of Natural Resources Economics and Management (NREM) for generously providing logistics and for granting me extended period to focus on my study. I appreciate the ubiquitous stimulating discussions and encouragement from my colleague Kinfe Gebreegziabher (PhD candidate). I also thank Dr. Girmay Gebresamuel, Dr. Kiros Meles, Dr. Emiru Berhane, Dr. Girmay Tesfay, Wolde Zewold, Bereket Gebremedhin and Tigist Berhane for providing academic, moral and other forms of support. Likewise, I thank my colleagues at NREM for understanding the situation I was in during my busy days at the department. I must also extend my gratitude to my old friends Kinfe Assefa, Samuel Demissie, Hayelom Tadesse who gave me profound moral support during the course of my study.
My family has been a good Samaritan to me over the years. The list is hardly exhaustive but special note of thanks goes to my mothers (yes, mothers!) ወይና and እሾ, brothers Mihretab, Tsehayu (a.k.a ዓቃ) and Mawcha (a.k.a ዎንጫ), and sisters Etsay (ዒፁ), Girmush (ግርሙሽ), Freyota (ፍረይ) and Melat (ሜላት) for the love and care you gave me throughout. ተንከባኪብኹም ኣብዚ ደረጃ ዘብፃሕኩምኒ ኩሉኹም ስድራይ የቐንየለይ! Social life in Ethiopia, as we know it, may be considered 'surplus to requirements'. Unfortunately, this essential 'commodity' was scarce in Wageningen. Luckily for me, there were Tsehayu and Tafesse giving company and sharing lots of social activities, which helped me ease stress and occasional boredom. Thank you ሲሃይ and ታፈስ; your companionship was comforting.
As a general note, I would like to thank everyone who, one way or another, contributed to the completion of this thesis.
My last but foremost gratitude goes to God for bestowing me full health throughout my life and giving me the strength to carry the rigors of PhD study.

Tewodros Tadesse
Wageningen, April 11 2012

ABSTRACT

Rural areas in many developing countries often lack infrastructure and institutions. However, rural towns and towns possess some of the major functional services that rural and town households can use to advance their economic activities. The study of the contribution that towns and their functions make to different economic activities is still in development. This thesis seeks to add to the literature by addressing the following objectives: conceptually discuss the role of town functions and empirically examine the way they influence income, employment opportunities, rural household crop output marketing and fertilizer adoption and use. We present quantitative results that would help understand and identify the most important functions that contribute to household livelihood activities. The conceptual discussion points out that town functions help households in two ways. One, they bring households closer to employment and income opportunities in towns and further strengthen the linkage through networking. Two, they enable and encourage rural households to participate and intensify crop marketing and fertilizer application.

For the purpose of the empirical analyses, data from households in four major regional states of Ethiopia are used. On the one hand, the role of town functions on income and employment opportunities from productive activities were investigated. Results show that some of the major town functions are instrumental in boosting income from productive activities. One mechanism is that some functions (for example, roads, transport services and telephone) enable commuting to towns where non-farm jobs are often concentrated. These functions in addition facilitate flow of (mainly non-farm) employment information and help households take their products to the market at a lower cost (that can lead to higher profits and income). A second mechanism is the way the functions (like electricity and tap water) contribute to the production process in non-farm home-based enterprises and waged productive activities. They help increase productivity and efficiency that eventually contribute to the sustained operations of productive activities, which increase the probability of employment and income from non-farm productive activities.

This thesis also recognizes that town functions not only influence household *decision* to participate in marketing (for crops or fertilizer) but also the *ability* of accessing markets. Town functions are instrumental in enabling farm households to gain access to the market in towns, which this thesis explicitly considers in modeling crop marketing and fertilizer application. The evidence suggests that shorter road distance is useful for promoting crop marketing and fertilizer adoption and application. The results further highlight that it is not only road proximity that matters but also the quality of the road leading to towns. Institutional elements such as markets and network relations were also found to play a significant role in promoting crop commercialization and fertilizer application. Closer markets help bring higher farm-gate prices for crops while strong networks contribute to learning and faster technology know-how and price information exchange that encourage fertilizer adoption and application. Similarly, results show that better access to telephone facilities contribute to a higher likelihood of crop market participation and fertilizer application through facilitating information exchange. The main results documented in this thesis overall suggest that bringing some of the major functions closer to households can make significant contributions to increasing the probability of non-farm employment, higher income and higher crop marketing and fertilizer application.

Keywords: rural towns, town functions, income, employment, crop output marketing, fertilizer application, network relations, Box-Cox double hurdle, Tigray, Ethiopia

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Many developing countries rely upon the agricultural sector to curb poverty and bring about overall development. It can be argued that overall (economic) development may be unlikely in these countries unless rural development is ensured. This is because while a large proportion of the population depends on agriculture, non-farm income accounts for a good part of rural household income (Reardon, 1997). Some countries such as Ethiopia have recognized this and designed economic policies with agricultural and rural development as the nucleus and engine of economic and social development. However, rural development without parallel and harmonious development of diverse economic activities in rural towns, towns and higher-order urban areas may not be sustainable. This is because rural development depends not only on agriculture but also on local and regional linkages with rural and urban non-farm activities (Reardon, 1997; Lanjouw and Lanjouw, 2001; Jonasson and Helfand, 2010). Even then, investment in transport infrastructure, electrification, communication, water supply and irrigation, agricultural research and services is pivotal to strengthen the linkages (Binswanger and Townsend, 2000; Tacoli, 2003). This is because these infrastructural facilities are vital to the interaction among farm and non-farm activities across different sectors and geography, which is believed to be crucial for rural development (Sadoulet and de Janvry, 1995: 273; Ravallion, 2009).

Rural areas' linkage with economic and social sectors in rural towns, towns and cities can lead to strong rural development and vice versa. This rural-urban linkage manifests itself in many ways. Labor movement, input, output and information flows are among the major linkage elements (Tacoli, 2002; von Braun, 2008). Forward linkages exhibited by the flow of farm and non-farm outputs for consumption and production purposes in rural towns and towns are useful for creating marketing outlets (demand) for rural households. On the other hand, backward linkages enable the flow of inputs, management skills, technologies and information and credit towards the agricultural and rural non-farm sector.

In this regard, rural areas' economy is often closely interwoven with economic activities in rural towns and towns. The linkages with (rural) towns are so pervasive that the structure of the rural economy can vary in response to the economic and social functions in towns. This is because the economic structure of (rural) towns reflects the capacity of local regions to capture forward and backward linkages and their multiplier effects (Douglass, 1998: 15). The combined effect of strong forward and backward linkages can therefore be instrumental in increasing agricultural production and productivity, which eventually helps foster rural development. Moreover, it can help create farm and non-farm employment opportunities and income, which contribute to poverty reduction and development in rural areas.

The contribution of rural-urban linkage (through forward and backward linkages) to poverty reduction and rural development rests on several factors. Land tenure systems, technology of production and management capabilities are some of the factors that determine agricultural production and rural development (Perkins *et al*., 2001; Tacoli, 2002). Markets, credit (and finance) and infrastructure are among the other vital elements that harness forward and backward linkages and contribute to rural welfare improvement (Isgut, 2004; Todaro and Smith, 2009). It is absolutely vital therefore to ensure the functioning of such essential elements for rural development to take hold. This is because the collective effect of ensuring conducive infrastructure and institutional arrangements (such as property rights and markets) can nurture economic activities and facilitate rural development (Start, 2001: 494; Alston, 2002: 12).

Many rural areas however have few or none of the most important functions[1] that contribute to strengthening forward and backward linkages. Missing functions in rural areas can affect economic activities and rural development in many ways. However, (rural) towns situated near to rural areas can contribute to bridging part of that gap and play a significant role in facilitating rural development (Tacoli, 2002; Fan *et al*., 2005; von Braun, 2008). One major contribution that lower-level settlement areas (rural towns and towns) make is that they act as bridges to higher-order towns and cities. In addition, they provide

[1] Functions refer to infrastructures and institutions that are physically connected to, and provided from towns for rural and urban households at a certain level of development. They are discussed in some detail in chapter 2. In the context of institutional economics, institutions refer to 'institutional environment' and 'institutional arrangements'. In this thesis, institutions are meant to represent the informal ones, including network relations and social capital.

various functional services to rural and urban households. These services, which are termed as *town functions* in this thesis, are often physically connected to and located in rural towns and towns. More often than not, they are provided from these towns and households would need to travel to closer towns if they want to make use of the functions. These functions, which can influence employment, income, market accessibility or technology use can therefore be vital for rural development and household welfare improvement. The towns can also act as local centers that households use to establish networks with various economic agents to advance their livelihood strategies and eventually play a role in strengthening rural-urban linkage.

In many developing countries such as Ethiopia, rural areas are situated in a scattered manner and lack vital functions. The development of towns therefore could be a reason to provide the necessary productive infrastructure at a lower cost than normally would be required for scattered rural areas (Haggblade *et al*., 1989). The importance of rural towns and towns that are equipped with the necessary infrastructural facilities is partly highlighted in the literature (Satterthwaite and Tacoli, 2003; Fan and Zhang, 2004; Mukherjee and Zhang, 2007). These studies, among others, indicate that there can be different approaches of studying the ways rural towns and towns contribute to the development of rural areas. Of particular interest in this thesis is the identification of key town functions that contribute to income, employment, fertilizer adoption and use and crop output marketing. For this purpose, this thesis considers a broad spectrum of major town functions. This should contribute to our understanding of the influence of key town functions on rural household livelihood and rural-urban linkage.

1.2 The problem in focus

Rural areas are home to Ethiopia's majority population. The rural population prominently depends on agriculture, and poverty is widespread. The destitute livelihood can be attributed to many things. Traditional farming and poor technology use (Pretty *et al*., 2003); conflict, degrading environment and lacking infrastructure or remoteness (Ahmed *et al*., 2007; Dercon *et al*., 2009); endowments and shocks (Dercon and Krishnan, 2000; Baulch and Hoddinott, 2000) and poorly understood rural non-farm sector and weak rural-urban linkage (Reardon, 1997; Haggblade *et al*., 2002; Tacoli, 2002) are some of the major contributing factors. Given these obstacles, one way of reducing poverty is by bringing rural development (agricultural and rural non-farm growth) in tandem with the more dominant and mainly urban economic activities such as non-farm productive activities (including manufacturing and services) is vital in improving income and living standards of both the rural and urban populations.

Currently, the mantra of economic policy in Ethiopia is Agriculture Development-Led Industrialization (ADLI), where rural development is envisioned to be the hub and engine of overall growth and development (at least in the early stages). Amongst policy makers, there is the question of how to establish or let villages or small towns grow as 'pooling hubs' for the vast rural poor in order to boost off-farm (also non-farm) employment and income (MoFED, 2010). Similarly, there is also the question of how rural towns or towns can help provide several vital functions to rural households and contribute to rural development. In this case, the organic growth of rural towns to local centers of economic activities is seen as a crucial step, which includes provision of functions (services), absorbing labor and serving as marketing outlets. In Ethiopia, several rural towns and towns are located close to rural areas. Comparatively, these towns have some of the major functions that rural and urban households can use to promote their livelihood activities. Of particular interest in this thesis is the question of 'what role do the functions in rural towns or towns play in rural household livelihood opportunities?' Knowing the role of different town functions in the improvement of rural livelihood helps us obtain useful objective information and understand the contribution of each of the key functions, which may contribute to the designation of interventions.

In the rural-urban linkage literature and role of functions, some studies (notably Isgut, 2004; Dercon and Hoddinott, 2005; and more recently Jonasson and Helfand, 2010; Dillon *et al.*, 2011) have empirically assessed the effect (or impact) of functions on different rural economic activities. These and other studies however focused on a limited number of town functions. This may not lend itself to showing the effect of some of the major town functions on employment and income or input-output marketing. It also makes it difficult to obtain a full picture of the role of major town functions when studies focus on one or two functions. This thesis considers a number of functions that are physically connected to and located in towns in order to examine their effect on specific economic activities. In addition, this thesis considers network relations that may partly compensate for missing functions in trying to study their influence on economic (livelihood) activities. In sum then, this thesis considers a relatively broad spectrum of town functions in order to identify and understand the role of major town functions on economic activities and livelihood strategies. This approach should allow us to see how big the role of towns and their functions is; and help us identify key functions that are useful to rural (town) household livelihood improvement.

1.3 Objectives and research questions

This thesis has a general objective of examining the role of town functions on household economic (livelihood) activities. The focus lies on the empirical investigation of the effect of town functions on household income and employment opportunities; and the influence of town functions on household behavior related to crop output marketing and fertilizer application. In light of this, the following specific objectives are designed to contribute to the general objective. The core theme of each of the specific objectives is to

1. Conceptually discuss the contribution of major town functions to household economic (livelihood) activities and rural-urban linkage
2. Examine the role of town functions on income from productive activities
3. Estimate and analyze the effect of major town functions and network relations on rural household crop output marketing
4. Estimate and analyze the contribution of major town functions and network relations to rural household fertilizer adoption and use
5. Investigate the role of town functions on household choice of employment opportunities

Given the specific objectives, this thesis aims at shedding some light on the following research questions.

1. In what ways do town functions influence income, employment opportunities and input-output marketing?
2. What are the major town functions that influence income from productive activities?
3. Which major town functions influence crop output marketing by rural households? What is the role of network relations in crop marketing?
4. Which major town functions contribute to rural household fertilizer adoption and use? How does the strength of network relations influence fertilizer application behavior?
5. What are the major town functions that influence choice of non-farm employment over farm work?

1.4 Outline of the thesis

The thesis comprises eight chapters, subdivided into three parts. *Part one* comprises the first three chapters. *Part two* consists of four empirical chapters, each of which is written in a standardized journal article format. However, the book-format nature of this thesis necessitated the use of cross-referencing in some chapters so as to avoid repetition. On the other hand, existing models from the literature are replicated in some of the empirical chapters since the thesis can be used as a study material in developing countries, such as Ethiopia. *Part three* comprises the last chapter that discusses the main results and presents future research areas.

In part one, chapter one presents and discusses the background to the thesis and presents the research problem and objectives (including, the research questions). Chapter two provides the conceptual framework of town functions and the relationship with income, employment, fertilizer use and crop output marketing. In this chapter, towns and town functions are defined and specified. Then, conceptual discussion of the contribution of town functions to rural-urban linkage and household economic (livelihood) activities is presented. In addition, the way in which town functions are accounted for in the empirical chapters is discussed. Next to this, chapter three presents the study areas and discusses the datasets in some detail. In this chapter, the setting of the study areas, sampling and sampling procedure of the two major data sets used in the thesis are discussed. In addition, the distribution of sample households *vis-à-vis* access to town functions and study areas is presented. Some preliminary descriptive statistics is also presented in this chapter.

In part two, chapter four empirically examines the relationship between town functions and income from productive activities. This chapter explores and identifies the most important town functions that influence income from productive activities. Town functions are believed to influence the *ability* and *choice* of participation in crop marketing and fertilizer adoption and use. It is essential therefore to examine and identify the major town functions that contribute to enabling households and encouraging them to adopt fertilizer or sell crop outputs. For this purpose, we used the Box-Cox double hurdle model that takes this phenomenon (*ability*, *choice* and *rate* of participation) into account in chapters five and six. Based on this, chapter five aims at estimating the effect of town functions on participation ability and intensity of rural household crop output marketing. On the other hand, chapter six focuses on the way town functions influence fertilizer adoption and use. In chapter seven, the role of town functions on the choice of alternative farm and non-farm employment opportunities is examined and discussed. This chapter attempts to identify town functions that increase employment opportunities in non-farm activities as compared to farm employment opportunities.

In part three, chapter eight discusses the general results of the thesis and draws conclusions and implications. Issues for further research are also presented in this chapter.

CHAPTER 2

CONCEPTUAL FRAMEWORK OF THE ROLE OF TOWN FUNCTIONS

2.1 Introduction

This chapter lays the conceptual background of the relationship between town functions and income, crop output marketing, fertilizer adoption and choice for alternative employment opportunities. Section 2.2 starts by defining the geographical hierarchy of settlements in Ethiopia (the rural-urban interface of rural towns, towns and cities). Next, we place town functions in context by defining them and explaining why they are termed as *town functions*. Section 2.3 revisits the concept of rural-urban linkage to explore how town functions contribute to strengthen interaction among rural and urban areas. Section 2.4 presents the way town functions are accounted for in the empirical analyses. Finally, a diagrammatic sketch that illustrates the overview of chapters in relation to the core theme of each empirical chapter is presented.

2.2 Rural towns, towns and town functions

Ethiopia is a federal country divided into nine regional states and two city administrations where each regional state has a mandate over the designation, proclamation and implementation of non-federal strategies and policies. Each regional state may present a proclamation of a different rural-urban demarcations (different definitions of rural areas, rural towns, towns and cities). However, FDRE (2008) presents three criteria in defining 'urban areas'. It states that 1) localities with established municipalities, 2) having a population size of at least 2,000, and 3) with at least 50 percent of the labor force primarily engaged in non-agricultural activities are considered as *urban centers*, which can include rural towns, towns and cities (FDRE, 2008: 4069).

Some regions in Ethiopia present the rural town-town-cities interface more clearly. For instance, the latest proclamation of the government of the regional state of Tigray categorize non-rural settlements into three distinct areas (GRST, 2006). According to this proclamation, the categorization is based on population size and density, settlement area, types of economic activities and availability and variety of infrastructure. Accordingly, the proclamation states that a geographical settlement is considered as an *emerging town* if it has a population size of at least 2,000; and if the livelihood of the largest proportion of the population is based on trade, manufacturing and/or service provision. In addition, these emerging towns should have a basic level of administrative institutions and social and economic infrastructure. These facilities include police, markets, schools, roads and transport and telephone services.

The proclamation does not mention rural towns; but the requirements stated above for emerging towns also refer to what we refer to in this thesis as *rural towns*. In addition, we reckon that settlements that lie between emerging towns and towns (see below) are considered as rural towns. Regardless of official definitions therefore, localities with a population size of between 2,000 and 5,000 (and sometimes, less than 10,000) are considered in this thesis as rural towns. In addition, the population is expected to be largely engaged in non-agricultural activities and these settlements should possess some of the major infrastructural and institutional facilities (see figure 2.1). There are many geographical settlements of rural town types in Tigray as well as the whole of Ethiopia. These rural towns are important for the livelihood of rural and town households. They provide employment opportunities, are used as market outlets and farm input sources for households and fulfill vital infrastructural and institutional functions.

Similarly, the proclamation of the regional state of Tigray states that a settlement is considered to be a *town* if it meets the following three conditions: a population size of at least 20,000; the existence of relatively more complex economic activities such as trade, service and manufacturing; and possession of better and expanded infrastructure and institutional services. These *towns* serve as bridges between the large number of rural towns and urban areas of the higher hierarchy such as cities (including metropolitan cities). In these towns, agricultural activities are limited and household livelihoods are based on employment in non-farm productive activities (such as manufacturing and services), trade and self-employment in household enterprises. Directly and indirectly, these towns also provide employment, input and output market opportunities and provision of infrastructural and institutional services to households.

Other regional states in Ethiopia provide less than distinctly clear definitions of rural and urban areas. The Amhara regional state for instance categorizes geographical settlements into three localities: amalgamated towns, towns, and metropolitan. *Amalgamated towns* are rural areas and towns within a certain radial distance that do not have their own (town) development administration. On the other hand, the Amhara regional state proclamation defines localities with established municipalities that possess their own development administration as *towns* (GRSA, 2004). This proclamation does not specify the population size and type and complexity of economic activities in categorizing the settlements. GRSA (2004: 403) also talks about *emerging towns* where they are defined as localities that do not have a municipality yet but transform themselves into town administration by detaching themselves from the surrounding rural areas. These are closer to what are termed rural towns in this thesis. A clearer definition is provided by CSA (2007), where in the regional state of Amhara, small towns are related to rural towns and are defined by settlements with less than 10,000 inhabitants and often serve as rural trading centers. In general, the rural-urban categorization from different regional states in Ethiopia does not look to be consistent, though FDRE (2008) presents the same rural-urban categorization for all regions in the country.

It has been argued that availability of competitive infrastructure in rural areas would lead to strong economic activities (Fox and Porca, 2001; Barrett, 2008). Among the many factors that facilitate development in rural areas are markets, credit supply, rural infrastructure and extension services (Dercon and Hoddinott, 2005; Todaro and Smith, 2009; Dillon *et al*., 2011). The argument is that transport and roads, communication infrastructure, water, electricity and finance would allow productive activities[1] to be more productive. This may include the expansion of productive activities, expanding market opportunities, creating non-farm and farm-related employment and income opportunities that eventually contributes to development.

---

[1] Productive activities denote activities that involve the production of goods and/or services for marketing (aiming at generating income) and own consumption. They may include non-farm home-based, non-farm private and public, agricultural (farm) activities and other productive activities. Specific examples of productive activities may include all sorts of cottage industries, household enterprises, farming and livestock rearing, formal and informal firms (construction, mining, transport, food processing, restaurant and hotel services, finance and health, etc.).

In this thesis, *town functions* are those infrastructures, institutions and productive activities that are physically connected to (located in) towns and provide services to rural and urban households in a certain level of development. The town functions considered in this thesis are major markets for agricultural and household inputs (such as fertilizer and improved seeds) markets for agricultural and non-farm outputs, telephone services, electricity and tap water utilities, higher educational centers (junior-secondary and above), postal services, financial institutions (credit and saving institutions and banks) and roads and road transport services that connect households to higher-order settlements. Some of the social and economic infrastructures (such as primary schools and extension centers) are not considered as town functions since they are also physically located in rural areas (village communities). However, they are considered for analysis partly in the empirical chapters since they provide useful services to rural and town households. Other functions such as advanced health facilities (hospitals), advanced communication services (mobile phone and internet), warehousing and administration functions (police, partly governance services) were not included either because data are not available or the functions were non-existent (for instance mobile phone services). Social institutions such as churches, mosques and traditional associations considered as functions (not necessarily as town functions) were considered for analysis via network relations and social capital.

Towns represent settlements where the necessary productive infrastructure and institutions are provided at a lower cost than normally would be required for scattered rural areas, and the development of towns can be a reason to provide feasible functions (Haggblade *et al*., 1989). Towns are important to the development of rural and urban areas through the functions they possess to promote employment and income opportunities by connecting and taking households closer to urban areas where most of the non-farm employment opportunities and productive activities are concentrated (see Fafchamps and Shilpi, 2003). While both rural and town households benefit from the functions, some major functions such as roads and transport services, fixed telephone facilities and markets can be instrumental in taking rural households closer to towns and urban areas where there are more non-farm employment, income and marketing opportunities. Overall, the functions facilitate and strengthen forward and backward linkages (see sections 2.3 and 2.4 for more) that are important to the development of a locally-interwoven (rural-urban) economy.

Many rural households needed to travel to the nearby towns if they wanted to make use of the functions. At times, a good proportion of the urban[2] households needed to travel beyond rural towns and towns if they wanted to make use of some of the town functions such as schools, major markets and banks (see table 3.5 in chapter 3). Other vital infrastructure such as roads that cross rural areas can be partly considered as town functions as they connect rural households to towns, thereby assisting them in various livelihood activities. Transport services (such as taxi and bus), however, were limited to rural towns or towns, in which case they complement the functional services provided by roads that connect rural households to towns. Some other functions that were available in rural areas, such as primary schools, extension and agricultural cooperative centers, also had higher and complex setups in rural towns and towns.

One of the notable microfinance institutions in Ethiopia, Dedebit Credit and Saving Institution (DECSI) for instance is expanding its credit distribution ventures to rural households from mainly rural towns (Berhane, 2009). With Agricultural Development Led Industrialization (ADLI) receiving strong political support as the engine of economic growth and poverty reduction in Ethiopia, functional services such as agricultural credit and input-output marketing have strong connections to rural towns and towns (Gebremedhin *et al*., 2009). The role of towns and urban areas is also highlighted by the fact that non-farm employment opportunities for rural and town households are concentrated in these localities (Fafchamps and Shilpi, 2003).

Currently, road construction and rural electrification in Ethiopia by the federal government is primarily meant to serve towns and rural towns. Roads may pass through several rural areas; but many others are located far away from these road networks. This road network however still provides an important function to nearby and distant rural areas in reducing the transaction cost for input and output marketing and non-farm employment and income opportunities (Dorosh *et al*., 2010). These road networks alone however may not contribute to

---

[2] Based on the Welfare Monitoring Survey (WMS) dataset used in this thesis, 'Urban settlements' include rural towns, towns and higher-order urban centers (such as cities). A broader description of the dataset is presented in Chapter 3. Moreover, a detailed description of the urban-rural definition in the WMS dataset can be obtained in CSA (2005).

higher non-farm employment, income and better linkage if they are not supplemented by transport systems or if the roads are of poor quality.

Other town functions that are particularly important for powering the production process are electricity and tap water (Isgut, 2004). These functional services also have a strong physical connection with rural towns and towns. Many small-scale or large-scale, formal or informal (non-farm) productive activities are situated in rural towns and towns. Together with markets and communication infrastructure, these functions can be instrumental for the profitability of productive activities and development of towns (Tacoli, 2002; Wandschneider, 2004).

Rural towns, towns and other urban centers also provide vital network functions to households in rural areas. In this regard, households can create and maintain network relations with households and productive activities in towns. Networks established contribute to households' options of credit sources, market outlets, input sources, information sources (related to marketing and employment) and employment opportunities. These networks and social capital are also vital as they act as 'rules of the game' in the production and consumption activities and enable positive rural-urban interactions (Start, 2001: 494; Matuschke and Qaim, 2009). In this regard, functions that exist in different settlements (higher-order settlements like towns and cities) can be useful to economic activities and livelihood opportunities in rural areas.

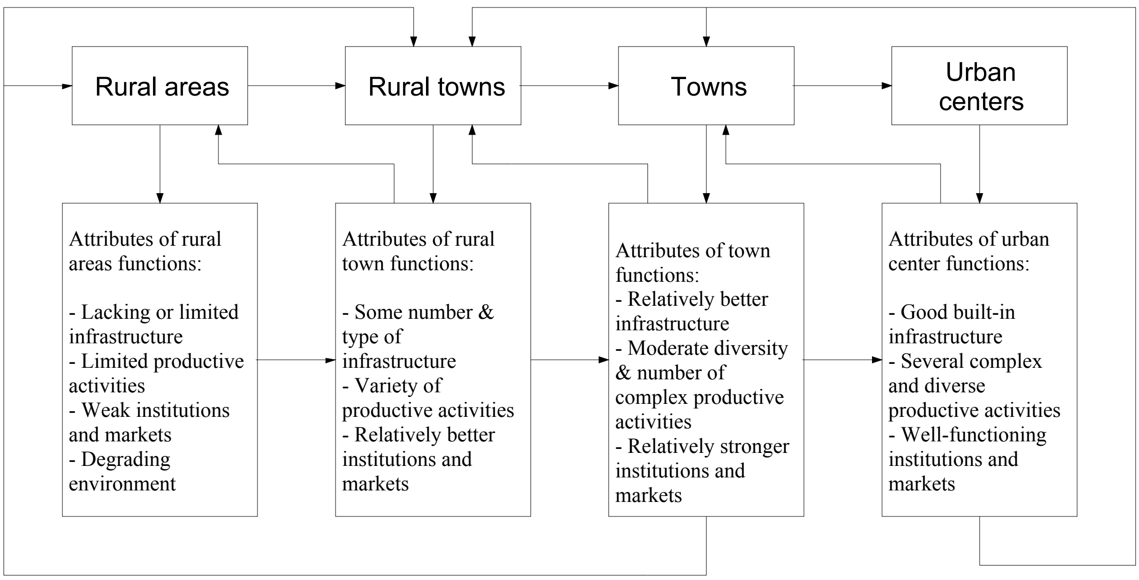

Figure 2.1: Availability and diversity of town functions in different settlements

The existence of the number and variety of town functions, diversity and complexity of productive activities and functioning of markets and institutions varies among the different settlements. In many rural areas of developing countries such as Ethiopia, access to infrastructure is limited or even non-existent. In addition, the diversity and number of productive activities is limited. Rural towns possess some infrastructure and less diversified productive activities than higher-order settlements. These rural towns can be expected to provide the missing functions in rural areas. This eventually facilitates rural-urban interaction and opens up opportunities for rural and town households.

However, there may still be functions that rural towns cannot provide to rural and town households. In this case, towns can act as a bridge for households to reach settlements of the higher hierarchy. This is where towns and urban centers (cities) become important. Towns and higher-order urban centers have much better infrastructures and institutions. In addition, several complex productive activities exist in these geographical settlements. The sheer existence of major functions and productive activities in these settlements create demand for rural products (market outlets) and open up opportunities for employment (and income) and input sources.

2.3 Rural-urban linkage and town functions

For almost two decades now, ADLI has been earmarked as the engine of economic growth and poverty reduction in Ethiopia. One of the key goals of ADLI is to strengthen agricultural commercializing and the forward and backward linkage of the agricultural sector with economic activities commonly practiced in rural towns and towns such as agro-industry and services (FDRE, 2000). In the development process of an economy, the linkage and interaction between various sectors of the economy is a crucial factor (Sadoulet and de Janvry, 1995: 273; Valdés and Foster, 2010). Complementary and interlinked development of the various sectors of an economy could lead to the sustained and integrated development of rural and urban areas. These interactions involve sectoral economic and spatial linkages. The ‘Big Push’ theory of Rosenstein-Rodan (1943), the ‘Balanced Growth’ of Nurkse (1953), and modern development thinking by Hoff and Stiglitz (2001), Perkins *et al*. (2001) and Todaro and Smith (2009) recognize the integrated development of rural and urban areas as the key for growth.

Rural towns and towns in this case possess the functional services that can be pivotal for integrated development. This is because towns (including rural towns) and their surrounding rural areas are usually part of the same functional economic system. Additionally, rural areas that have little or no access to town functions can exploit those functions that are physically connected to and provided from (rural) towns. Rural households may rely on neighboring towns for agricultural inputs, markets, schools, health care and even farm labor. Town functions like roads and transport on the one hand and communication infrastructure such as telephone on the other can support rural and town households' effort for market access, transport of inputs and outputs, employment in productive activities and access to other town functions. Similarly, households and productive activities in towns depend on rural areas for part of their consumption needs (such as, food) and production activities (such as, inputs and outputs). In this case, town functions such as roads and transport, telephone and networks help strengthen the economic linkage among agents between rural areas and towns.

The Ethiopian rural economy is largely agrarian, with households mostly dependent on the environment nearby and its natural resources. Inadequate (and in many cases non-existent) infrastructure and backward technology used in the rural production regimes are some of the major causes of the low production and productivity levels in rural areas (Diao and Pratt, 2005). One way to improve rural production and productivity is to strengthen the linkage with (rural) towns. Rural households in this case can exploit the infrastructure, technology (improved inputs and management skills) and markets in towns in order to improve production, productivity and marketing. The collective effect of this can have a multiplier effect on the rural economy that will ultimately fuel development in towns and urban areas. These linkages can be so pervasive that the structure of the rural economy can vary in response to the economic and social functions in towns. This is because rural towns' economic structure reflects local regions' capacity to capture forward and backward linkages and their multiplier effects (Douglass, 1998: 15; Kammeier, 2002). Furthermore, the surplus, linkages and market contributions of agriculture in rural areas and associated multiplier effects can lead to overall economic growth (de Janvry, 2010: 19).

The diversity in rural-urban linkage presented in figure 2.2 can be conceptualized by labor movement, finance and remittances, and inputs and outputs of the production process between rural areas and towns (Tacoli 1998b, 2002; Satterthwaite and Tacoli, 2003). The flow of factor endowments and commodities (outputs) is largely determined by the overall economic system, such as socioeconomic structure, production regimes, infrastructure and the environment. In addition, functions and activities in (rural) towns and urban centers could also affect the flow of the various elements in either direction.

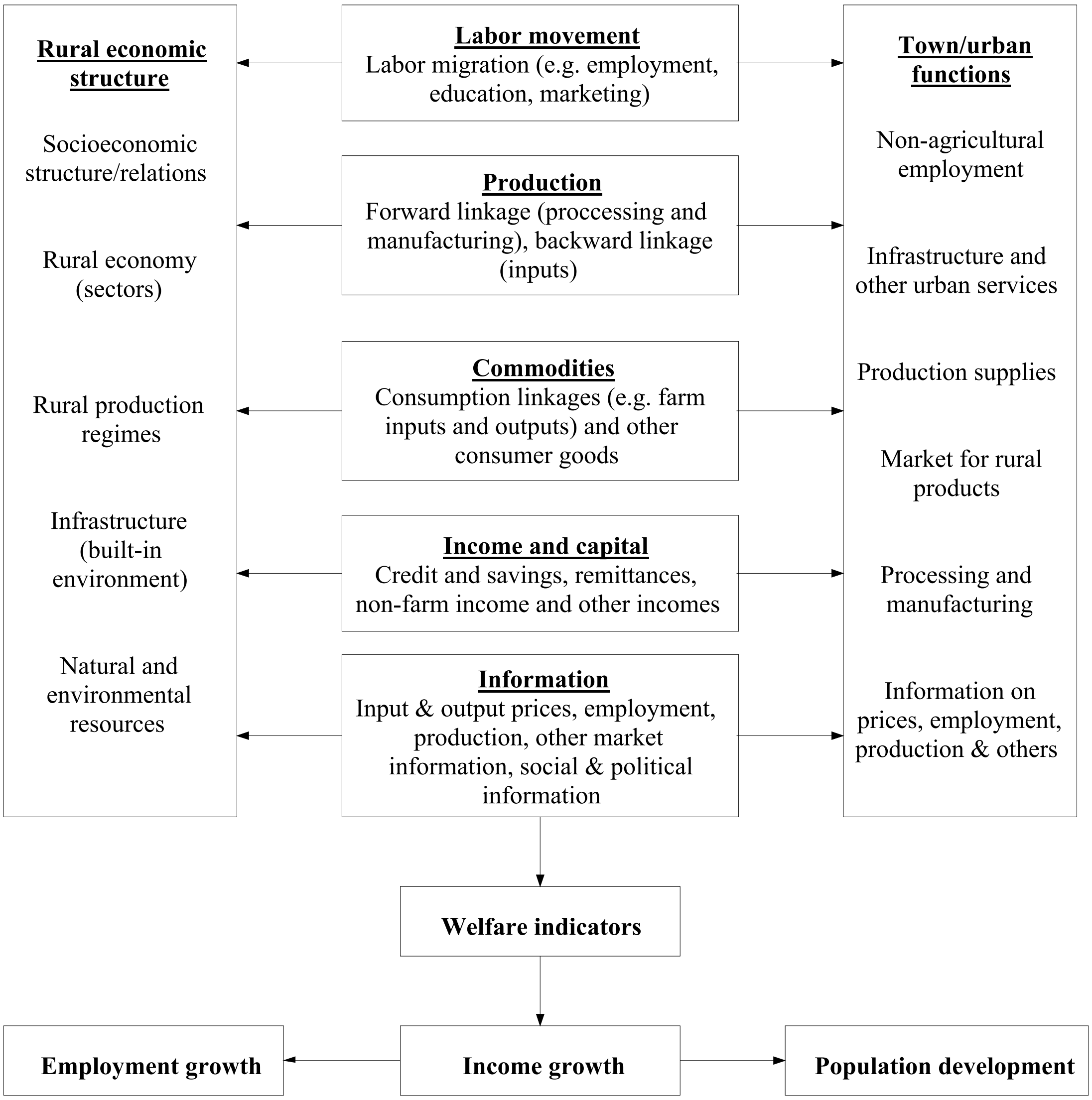

Figure 2.2: Rural-urban linkages, town functions and welfare effects
Source: adapted from Douglass (1998)

In summary, there are situations whereby a smallholder production regime (farm households), as is the case in many developing countries, may depend to a greater extent on towns for input and output supplies, market outlets and cooperative institutions (Satterthwaite and Tacoli, 2003; Gebremedhin *et al.*, 2009). In this case, conditions of the built-in environment (infrastructure and institutions) profoundly affect rural-urban flows of labor, goods and services (Hinderink and Titus, 2002; Barrett, 2008). Rural road networks, electricity, communication and information technology services, and other linkages add to the physical development of markets in town and village economies. Not only can these built-in environments transform the nature, scale and magnitude of rural-urban interaction but also open up economic opportunities by creating linkages to the larger spatial network of higher order settlements like big towns and cities (Douglass, 1998; Barrett, 2008).

2.4 Income, employment and input-output marketing: Account of town functions

This section presents the practical consideration of the relationship between town functions and the main theme of each empirical chapter. In this section, we mainly discuss the way town functions are accounted for. The concept framework in figure 2.3 attempts to show the major relationships between town functions and income, employment choice, crop marketing and fertilizer application. In doing so, the schematic representation shows the approach by which the empirical research questions in this thesis are addressed.

This thesis uses non-separable farm household models (based on, Singh *et al.*, 1986; Taylor and Adelman, 2003) as the basis to explicitly consider the influence of town functions, among other factors, on farm household decision-making. In this framework, the household[3] is considered as the unit of analysis. It is assumed to be a complex entity making non-separable production, consumption, labor (and output) supply and input demand decisions. The behavioral objective of the household is to maximize household utility. The household maximizes utility by allocating labor time to farm and non-farm activities, subjected to time endowment, full income, commodity resource balance and production technology. As we shall see in chapter 5, town functions are incorporated into the household model to illustrate how they influence output supply and input demand decisions by the household.

Taking into account the objectives of this thesis, one issue that requires attention is the causality link among town functions and income, employment and input-output marketing. Do growth or improvements in town functions lead to income or employment growth? Or, is growth or improvement in town functions a response to more income or crop output? Does

[3] The term 'household' is used interchangeably with the term 'farm or rural household' and 'non-farm households' in this thesis. However, the exact nature of the term can be understood from the context.

household behavior and decision-making related to fertilizer adoption or crop marketing influence town function placement or expansion? In this thesis, we assume town functions as exogenously determined factors. This may be a strong assumption for some town functions (such as the possibility of virtual markets developing in transport facilities by local traders, processors, local gathering stations, but also totally new markets for new products in response to income or output). Nevertheless, the assumption is based on the definition of town functions in the Ethiopian setting where households often travel to nearby towns to sell crop outputs, buy farm inputs or in search of non-farm employment opportunities.

2.4.1 Role in income and employment choice

A high degree of market imperfection in rural areas of developing countries leads to inter-related household decision-making in input demand and output supply. Limited or a total lack of the major functions is one of the main factors that influence labor supply decisions at household level and hence employment and income. Two of the research questions in this thesis are related to the analysis of the influence that town functions have on income and employment choice.

First, household income through employment on different productive activities is expected to vary with access to town functions. For instance, many of the non-farm employment opportunities are concentrated in rural towns and towns (Fafchamps and Shilpi, 2003). The income that households earn from these employment opportunities is dependent on the access that they have to these geographical settlements. In this regard, the town functions influence household likelihood of participating in different activities through facilitating information diffusion and reducing the cost of travel to working places in towns. Therefore, analysis of the factors determining income from different activities requires careful investigation through considering the functions that have the ability of increasing the likelihood of employment in the non-farm jobs located in rural towns or towns.

Similarly, farm income can also be significantly determined by some of the functions. Markets or roads and transport can be useful to farm income for instance through enabling households to earn higher farm-gate prices or easily (or at lower cost) take crop outputs to markets in towns where they can bargain for higher prices. Studies that do not take into account these functions may introduce bias through omitting relevant variables (i.e., the functions) that can have significant influence on income (see for instance, Fan and Zhang, 2004).

With the focus lying on the analysis of income versus town functions, the data-generating process should be carefully understood to appropriately model relationships. Variation in income can be due to either participation or non-participation, depending on the accessibility to jobs in a given activity. It can also be due to households opting themselves out of participating in an income earning activity. These cases can lead to zero income[4] earning. As we shall see in chapter 4, we take into account the data generating process that results in zero income by using Heckman models to examine the role of town functions on income.

Second, town functions can influence household choice of employment opportunities, depending on the nature and location of the employment opportunities. While the transport infrastructure has been considered as vital for rural non-farm employment (Lanjouw, 1999), other studies (such as, Isgut, 2004; Gibson and Olivia, 2010) emphasize the role of communication infrastructure in allowing faster and less expensive exchange of information on non-farm employment. In this case, town functions can have varying effects on different employment alternatives. For instance, Escobal (2005) asserts that households may react to changes in the allocation of factor endowments such as labor supply in response to access to different functions. This in turn would lead to varying choice (i.e., labor allocation) among alternative jobs.

However, the relative importance of town functions on alternative employment opportunities has not been widely investigated. As we shall see in chapter 7, we explicitly focus on investigating the relative effect of town functions on alternative employment choices based on a random utility model. In this framework, households choose the alternative employment opportunity that maximizes expected utility. Access to different employment opportunities can vary with access to town functions. For instance, the likelihood of employment in high-earning non-farm activities can be significantly related to the existence of a road and transport services leading to towns where these employment alternatives are often concentrated. Therefore, the expected utility and hence employment in different alternatives can be related to access to functions. As a result, the systematic study of the relative effect of town functions

[4] Zero income earning is assumed to be the result of non-participation (i.e., self-selection or lack of jobs) rather than censoring. This outcome can be explained by both economic (such as wage expectation) and non-economic factors (for example, access to functions). The Heckman model that incorporates these factors is therefore argued to fit the data-generating process that explains the relationship among income and town functions.

on employment choice is useful because it helps us to identify and understand the most important functions that affect employment choice from different alternatives.

2.4.2 Role in crop marketing and fertilizer application

de Janvry *et al*. (1991) and Key *et al*. (2000) present compelling evidence of the significant influence that transaction costs have on the supply of agricultural outputs and farm household decision-making behavior. Transaction costs (fixed or variable) are thought to be influenced by various factors. Among these, town functions are usually associated with their vital contribution in reducing transaction costs. In many rural areas of developing countries, non-existent or limited town functions (like roads, transport, major markets or communication infrastructure) may lead to prohibitive transaction costs. In response to access to town functions, households may react to changes in the allocation of factor endowments such as crop output sales share (Escobal, 2005). This may also in turn have significant effects on decision-making (such as crop marketing or fertilizer adoption and use) by rural households. Therefore, it is important to examine the direct or indirect effects that town functions have on crop output sales and fertilizer adoption and application.

There are two major ways town functions can influence rural household decision-making with regard to crop sales or fertilizer adoption and application. First, households may decide not to sell crop outputs, for instance, just because they are not able to access the market. The lack of access to information and transport infrastructure can contribute to this decision-making. Before deciding about whether or not to participate in crop sales or fertilizer adoption therefore, rural households should have the ability to access the market. In the literature however, this phenomenon has often been ignored. This practice does not give the opportunity to understand the role that town functions play in enabling rural households to access the market. For households living in a remote rural area, a road close by or the existence of transport services for instance increases the ability of households to visit the market. In this thesis, we explicitly consider the 'enabling' factor of town functions in modeling crop marketing and fertilizer adoption decisions by rural households.

Secondly, town functions can have a significant influence on rural household decision concerning whether or not to sell crops or buy and apply fertilizer. Even if households have the ability to participate in crop sales or fertilizer adoption, they may decide not to sell or adopt. Town functions can contribute to this decision-making. Roads lower costs of travel for instance, or help increase farm-gate prices by bringing households closer to the market. Communication services (telephone or social networks) can facilitate information flow about crop prices or attributes of fertilizer technology, which may in the end encourage households to sell crops or apply fertilizer. Understanding the potentially strong influence of town functions on rural household crop marketing and fertilizer application therefore requires careful modeling. As we shall see in chapters 5 and 6, we take into account the effect of town functions not only on enabling households to access the market but also on actually deciding about participation and rate of participation (in crop sales and fertilizer application). This would help us identify and understand the most relevant functions that determine ability to access the market on the one hand, and actual participation on the other.

A farm household model with transaction costs is used as a starting point. Town functions are then integrated to explain transaction costs. Close proximity to town functions is expected to influence household decision-making through the effect on fixed and variable transaction costs. Some of the functions are expected to contribute to enabling farm households to participate in crop marketing or fertilizer application. These may include functions that help facilitate information exchange through lowering fixed transaction costs (mainly telephone, extension centers, roads, transport, even schools). Town functions can also encourage households to go to the market and even participate more (say, take more crop output to the market). Being closer to market and having better access to the transport infrastructure are the major functions that are expected to contribute to lowering variable transaction costs and encouraging farm households to go to the market or increase the intensity of participation (such as sales share or fertilizer application).

In the end, the effect of town functions is captured through the distance that (rural) households need to travel to the town functions, many of which are physically located or connected to rural towns or towns. Each town function is represented by the distance (or indices computed from distances) from the center of the village where the sample households live. The overview of chapters in figure 2.3 portrays the major discussion themes of the chapters in relation to the broad spectrum of town functions.

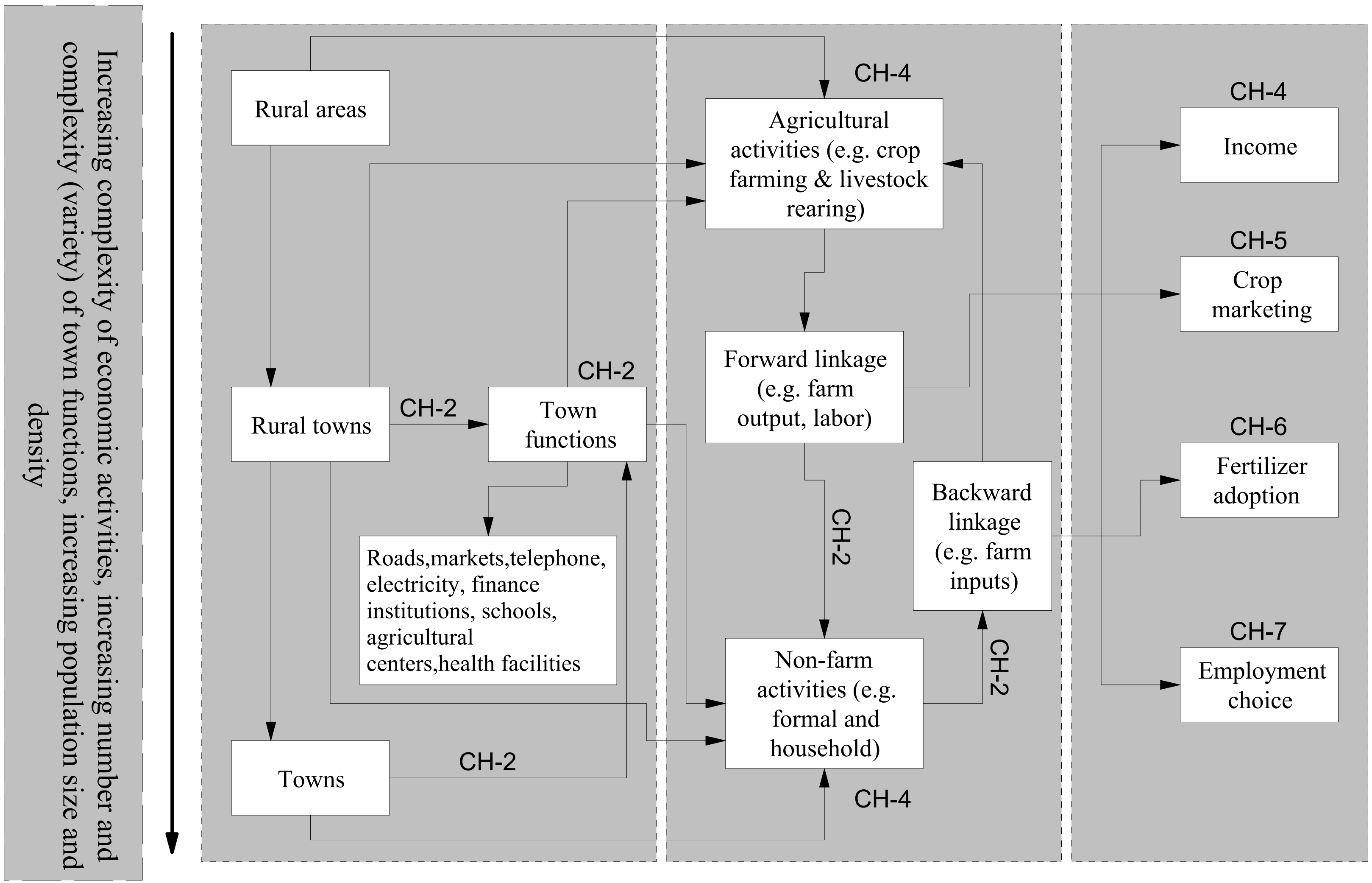

Figure 2.3: Overview of chapters [CH = Chapter]

CHAPTER 3

STUDY AREAS AND DATA

3.1 Introduction

In this chapter, we describe the survey settings and datasets. Some general descriptive statistics are also presented. The survey settings constitute a number of major regional states across Ethiopia on the one hand, and the Tigray regional state on the other. As a result, data used in this thesis come from two broad types of datasets. One the one hand, part of the Ethiopian Rural Household Survey (ERHS) is used to answer two of the research questions related to crop output marketing and fertilizer adoption. This dataset was collected by Addis Ababa University in collaboration with the International Food Policy Research Institute (IFPRI) and Centre for the Study of African Economies, Oxford University. On the other hand, part of the Welfare Monitoring Survey (WMS) dataset collected by the Ethiopian Central Statistical Authority (CSA) was used to examine the research questions related to income and choice among employment alternatives. In section 3.2, a brief description of the survey settings is presented. In section 3.3, a detailed discussion of the datasets (both the ERHS and WMS) used is provided.

3.2 Survey settings: Ethiopia and Tigray regional state

Ethiopia is situated between 3 and 15 degrees North latitude and 33 and 48 degrees East longitude in the Horn of Africa. Topographically, rugged terrains dominate lowland areas, where most of the population lives as mixed farm households in the highlands. Ethiopia has a total landmass of 1.1 million square km, where neighboring border countries include Kenya, Sudan, Djibouti, Eritrea and Somalia (CSA, 2008). Ethiopia is a federal country constituting nine regional states and two city administrations. Among these is Tigray regional state, situated in the northern edge of Ethiopia. Tigray is located between 12 and 15 degrees North latitude and 36 and 39 East longitude, bordered by fellow regional states of Amhara and Afar to the south and east, Sudan to the west and Eritrea to the north. Tigray is a semi-arid are with diverse topography and agro-ecological conditions (Hagos *et al*., 1999). The latest (2007) Population and Housing Census puts Ethiopia's population at about 74 million, where 16.1 percent is urban and 83.9 percent is rural (CSA, 2008). Among Ethiopia's regional states, Tigray has the fifth largest population with a total population size of 4.5 million. Of this total number, urban and rural population sizes account for 19.5 and 80.5 percent, respectively (CSA, 2008).

Many of the urban centers in Ethiopia are situated in highland areas where the rugged terrains that characterize the topography of Ethiopia tend to prohibit strong rural-urban linkage and rural development (Dorosh and Schmidt, 2010). This situation also makes the expansion of infrastructure networks much more difficult and expensive in various regions of the country. A result of this could be a variation in infrastructure endowment across Ethiopia. Before the turn of the Millennium for instance, the infrastructure in Tigray was not well developed. Road density in Tigray was only 10.3 km per 1000 square km (which was below the national average) and it was only in 1998 that most of the towns located on the highway obtained 24-hour electricity (Woldehanna, 2000). Although improvements had been registered in infrastructure provision since the fall of the Derg regime in 1991, the level was not high enough to make a meaningful contribution to rural development (Pender and Gebremedhin, 2004).

Recently however, the economy in general and infrastructure expansion in particular have seen respectable growth, opening up opportunities for diversified rural livelihood and rural-urban linkages. In urban areas, the construction sector has seen a boom, which has been supported by a significant push in private sector investment expansion and increased public investment in infrastructure such as roads, telecom, power and irrigation development (MoFED, 2008; Dorosh and Schmidt, 2010). All over the country, the expansion of educational and health institutions, transport, credit and agricultural extension services in the last decade have been remarkable (Tesfay, 2006). By 2006, national road density had increased to 38.6 km per 1000 square km. Similarly, the proportion of the population with access to electricity within a 5-km radius was 22 percent. The distribution of telecom centers was higher, with 49.3 percent of the population living within a 5-km radius of telephone centers. On the other hand, the national coverage of access to clean drinking water in 2006 was 52.2 percent, in which the coverage is as high as 82 percent in urban areas and 46.4 in rural areas (MoFED, 2008).

This expansion trend has played a significant role in opening up and enhancing income-earning opportunities for both the rural and urban poor. In addition, farm households' market access and bargaining power, on-farm and off-farm diversification have been improved through improved infrastructure (roads) and rural connectivity (telecom) and the development of cooperatives. Expansion of roads, communication infrastructure, educational and health facilities were the focus of the first five-year (2005-2010) development plan. As part of the Growth and Transformation Plan (GTP), the second five-year development plan aims to further expand communication and transport infrastructure (rail and roads); energy (hydropower and wind) and irrigation infrastructure (MoFED, 2010).

3.3 Datasets: the ERHS and WMS datasets

The analytical part of the thesis is based on two separate household-level cross-section survey datasets. One of the datasets covers many rural areas from major regional states of Ethiopia. The other dataset covers rural and urban areas from the regional state of Tigray. In the following subsections, we describe the design of each survey and datasets in some detail.

3.3.1 The Ethiopian Rural Household Survey (ERHS) dataset

The first of the two datasets used in this thesis come from the Ethiopian Rural Household Survey (ERHS)[1] collected in 2004. For the purpose of this thesis, we used part of this dataset for analysis in chapters 5 and 6. The cross-section analysis in these chapters is based on data from 1290 sample households[2] in 15 rural areas in four major regional states of Ethiopia. The major regional states covered in the dataset are Tigray, Amhara, Oromiya and Southern Nations, Nationalities and Peoples (SNNP). A three-stage sampling procedure was used to obtain the required data based on geographical location, varying farming systems and varying agro-ecology across rural Ethiopia (Kebede, 2002). Major regional states were selected in the

[1] The ERHS dataset is a panel dataset that contains data collected so far on seven rounds from the same sample of rural households (with a low attrition rate, see Dercon *et al.*, 2009). As variables of main concern in this thesis, data about town functions were not collected in the earlier panel periods (before 2004).

[2] The original sample size was larger but we considered only those sample households that yielded complete information (for the purpose of this thesis).

first stage. Next, the varying farming systems in different regions of the country were purposively considered as a stratum to select *woredas*[3] from each region. Then, specific rural areas (villages or peasant associations - PAs) were selected from these *woredas*. And from each peasant association, a proportional number of farm households (in relation to the population size of each *woreda*) were randomly selected.

The farm households were selected randomly using the peasant association registers, in which case households surveyed in each rural area reflect the size of the PA in relation to the total size of all PAs surveyed. The sample was stratified in such a way that female-headed households and landless households could be proportionally represented (Dercon and Hoddinott, 2005). Data collection was carried out using structured questionnaires. Well-trained enumerators were employed to conduct face-to-face interviews with the sample households and fill out the questionnaire. A wide range of issues affecting rural households' livelihood and living standard were covered in the questionnaire, including marketing of inputs and outputs, adoption and use of production inputs, land use practices, labor sharing arrangements, off-farm participation and income, business activities, agricultural credit, networking and social capital, asset ownership and access to town functions.

The rural areas cover a wide range of agro-ecological variability and agricultural practices. These areas lie at different altitudes ranging between 1000 and 3000 meters above sea level (see Kebede, 2002). The rainy season in these generally highland[4] areas is between June and August, with an average annual rainfall varying from 504 to 2205 millimeters in the study areas (see Dercon *et al*., 2009). In these study areas, mixed farming (crop farming and livestock husbandry) is the major livelihood strategy.

---

[3] In Ethiopia, *woreda* is an administrative unit that is equivalent to a 'district'. *Tabia* (in Tigray) and *Kebele* (in other parts of Ethiopia) represent the smallest administrative units in Ethiopia.

[4] The dataset represents those rural farm households whose mainstay is mainly mixed farming (commonly practiced in highland Ethiopia). The dataset does not incorporate pastoral households.

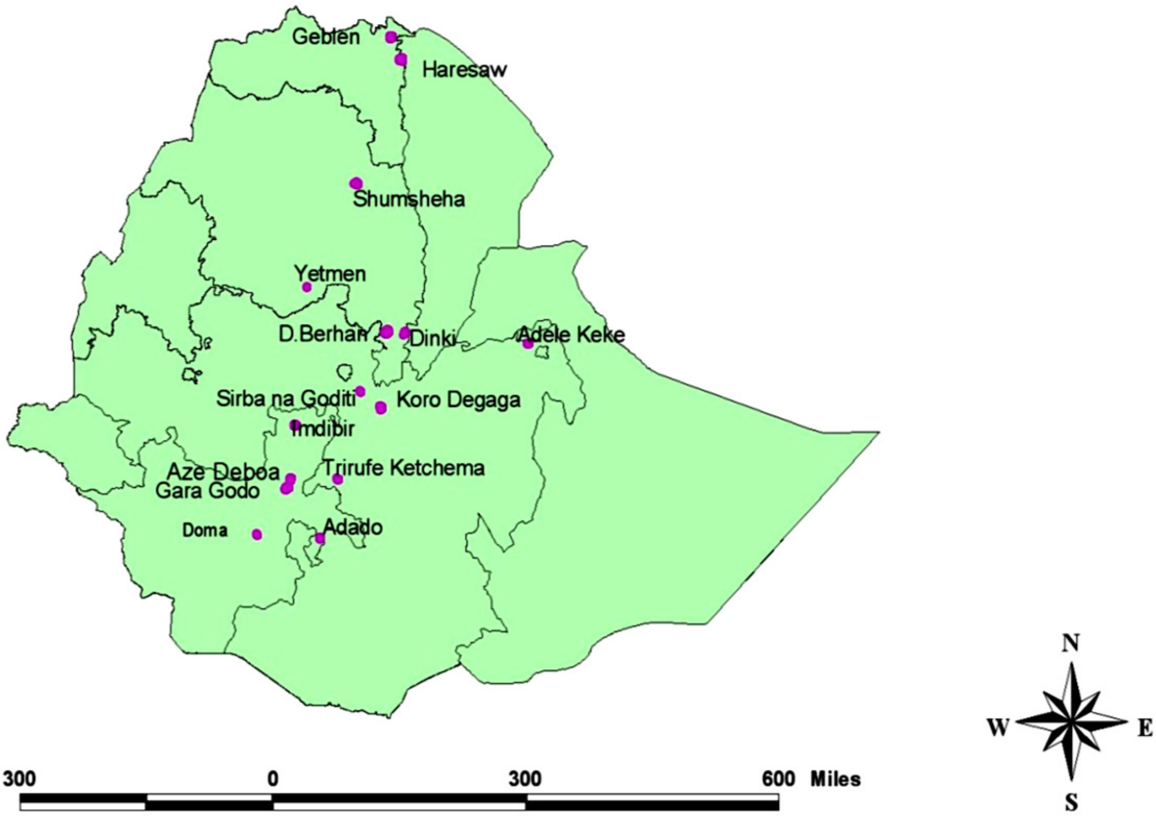

Figure 3.1: The ERHS study villages

Source: Dercon and Hoddinott (2011)

Table 3.1: General characteristics of the ERHS study villages

Survey site	Regional state	Mean rainfall (mm)	General description of the study sites	Availability of functions
Haresaw	Tigray	558	Poor and vulnerable area	Primary school and health center; no market
Geblen	Tigray	504	Poor and vulnerable area; used to be quite wealthy	No school, health center, market
Dinki	Amhara	1664	Not easily accessible even though near Debre Berhan	No school, health center, market
Yetmen	Amhara	1241	Near Bichena; Ox-plough system; cereal production; highland area	Junior secondary, health center and main market
Shumsheha	Amhara	654	Poor area near the town of Lalibela	Primary school; no health center or market
Sirba na Goditi	Oromiya	672	Near Debre Zeit; rich area; much targeted by agricultural policy; cereal production; Ox-plough system	Access to facilities from nearby towns of Debre Zeit (Bishoftu) and Mojo
Adele Keke	Oromiya	748	Highland site; hit by drought in 1985/86	Primary school; access to other facilities from nearby towns
Koro Degaga	Oromiya	874	Poor cropping area in neighborhood of rich valley	Primary (4 grades) school; no clinic and market
Trirufe Ketchema	Oromiya	812	Near Shashemene; Ox-plough system, rich cereal area; highland site	Access to facilities from nearby town of Shashemene
Imdibir	SNNP	2205	Densely populated *enset*-farming area	Access to facilities from nearby Imdibir town
Aze Deboa	SNNP	1509	Densely populated; long tradition of substantial seasonal and temporary migration	No school, health center and market but access to these from the town of Durame
Adado	SNNP	1417	Densely populated; rich coffee producing area	Primary school; no clinic and market
Gara Godo	SNNP	1245	Densely packed *enset*-farming area	Primary school, clinic and market
Doma	SNNP	1150	Remote and semi-arid area; resettlement Area (1985); experienced droughts in the 1980s	Primary school; but access to clinic and market in nearby Wacha town

The following peasant associations: Milki, Kormaragefia, Karafino and Bokafia from nearby Debre Berhan (Amhara region) are also part of the dataset (survey). These peasant associations obtain most of the services (town functions) from the nearby town of Debre Berhan.
SNNP is an abbreviation for Southern Nations, Nationalities and People
Sources: Kebede (2002) and Dercon *et al*. (2009)

Table 3.2: Distribution of ERHS sample households by study villages

Regional state	Zone	Woreda	Villages (rural areas)	Sample[a]
Tigray	Kilte Awlaélo	Atsbi	Haresaw	84
	Saésé Tsaéda Emba	Subha	Geblen	64
Amhara	North Shewa	Ankober	Dinki	84
	Eastern Gojam	Enemay	Yetmen	59
	North Wollo	Bugna	Shumsheha	131
	North Shewa	Debre Berhan	Milki	33
			Kormaragefia	29
			Karafino	19
			Bokafiya	13
Oromiya	East Hareghe	Kersa	Adele Keke	95
	Shewa	Adaa	Sirba na Goditi	87
	Arssi	Dodota	Koro Degaga	100
	Eastern Shewa	Shashemene	Trirufe Ketchema	88
SNNP	Gurage	Cheha	Imdibir	64
	Kembata, Alaba and Tembaro	Kedida Gamela	Aze Deboa	72
	Gadeo	Bule	Adado	109
	North Omo (Wolayitta)	Bolosso	Gara Godo	94
	North Omo (Gamogofa)	Darmalo	Doma	65
Total				1290

[a] Original size of sample households is larger but only these provided complete information for the purpose of this thesis.

The ERHS rural areas studied are characterized by different endowments of town functions (infrastructure and institutions). Almost all of them had a primary school. Some had a health clinic and market. Others had only a school and a clinic but no market. A few of them did not possess any of the aforementioned functions. In addition, some of the major functions were not available in the villages. In these cases, households needed to travel to closest rural towns or towns (or cities) to use the functions. Based on the sample of households we considered, it is shown that all of the villages had a primary school in their village or within 5 km (table 3.3). Junior schools, extension centers and agricultural cooperatives are among the functions that are readily available within 5 km. Markets (both daily and periodic) are also relatively readily accessible (35.5 % of the sample households had markets within 5km). Rural towns and towns situated within 10 to 20 km of the rural areas however were also vital in providing such vital functions as telephone services, schools, markets, banks and credit services and health centers (see table 3.3).

Table 3.3: Distribution of ERHS households by distance to nearest town functions (2004)

Functions	Distance in km			
	(0-5]	(5-10]	(10-20]	(20+]
Markets	35.5	29.5	35.0	0
Post office	17.4	31.8	44.3	6.5
Primary school	100	0	0	0
Junior school	85.7	0	14.3	0
Secondary school	24.7	24.5	35.8	15.0
Telephone centers	21.7	31.8	46.5	0
Electricity	46.1	12.4	35.0	6.5
Bank and credit services	23.9	21.4	19.4	35.3
Clinics	40.5	36.8	14.3	8.4
Hospitals	11.8	24.4	15.8	48.0
Extension centers	61.6	22.7	15.7	0
Agricultural cooperatives	74.6	10.4	15.0	0

3.3.2 The Welfare Monitoring Survey (WMS) dataset

The Welfare Monitoring Survey (WMS) constitutes a cross-section dataset (repeated cross-section, usually yearly) collected by the Ethiopian Central Statistical Authority. The major objectives of the Welfare Monitoring Survey were to provide baseline data on poverty, identify poor and vulnerable groups of households for targeted policy interventions, evaluate targeted programs through periodic surveys and assess the short- and medium-term macroeconomic effects (CSA, 2005). Covering both sedentary rural and urban areas, the survey dataset focuses on a wide range issues from socioeconomic indicators to access to different town functions that assist the process of monitoring and evaluation of policies.

The Welfare Monitoring Survey dataset covers the majority of Ethiopia except for six zones in Somali regional state and two zones in Afar regional state, where the population is largely nomadic (CSA, 2005). For the purpose of this thesis, we used the third round Welfare Monitoring Survey conducted in 2000. Despite the fact that the survey covered different regions of the country, we considered data collected from the Tigray regional state for our analysis.[5] Empirical analyses in chapters 4 and 7 are based on data obtained from this dataset. From this region, rural and urban settlements were considered for data collection. Urban areas

[5] Data from Tigray region were available and the fact that the WMS dataset is immense makes the focus on Tigray manageable.

considered in the Welfare Monitoring Survey include those geographical settlements with a population of at least 1,000, and predominantly non-agricultural livelihood and economic activities. The urban definition in the Welfare Monitoring dataset includes cities, towns and rural towns. On the other hand, settlements with a population of less than 1,000 and predominantly agricultural, but also certain non-agricultural activities, are specified as rural areas in WMS (CSA, 2001).

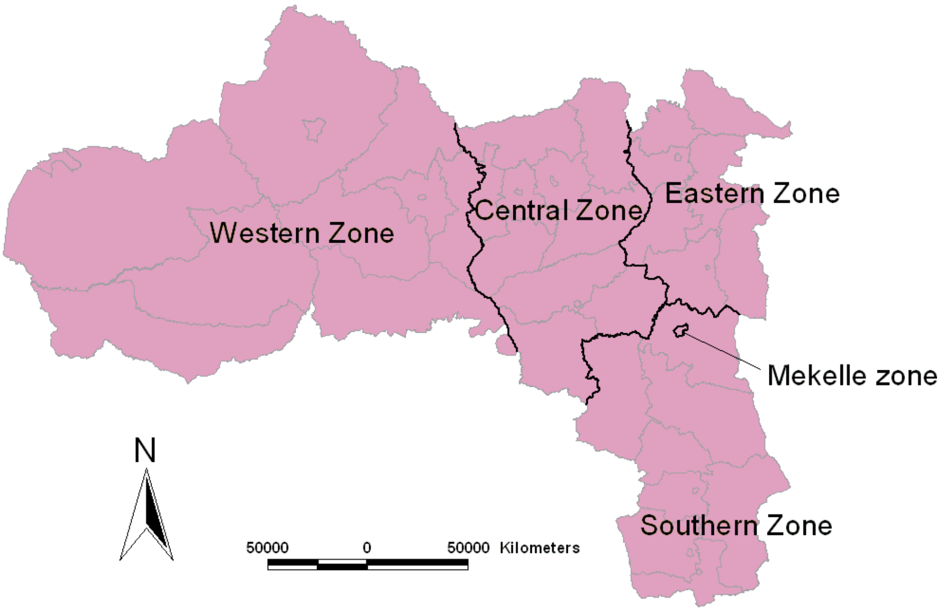

Figure 3.2: Map of Tigray region and zones

In order to select the sample of rural households, two-stage stratified sampling design was used. First, enumeration areas (EAs)[6] which are the primary sampling units were selected systematically from each rural area, proportional to the number of households obtained from the 1994 population and housing census. Then, sample households were systematically selected based on a list of households in each enumeration area obtained from the local

[6] An enumeration area is an area of land that is delineated for the purpose of enumerating housing units and population without omission or duplication (CSA, 2001: 7). An enumeration area usually consists of 150-200 households in rural areas and 150-200 housing units in towns. In rural areas, a peasant association or village can be equal to or part of an enumeration area depending upon the size of the households in the village.

administration. From this, a total of 1196 rural households were selected from four zones of the regional state of Tigray.

The urban data included information collected from rural towns, towns and the regional state capital. In order to select the sample households from the regional state capital, a two-stage stratified sampling design was used. Sample enumeration areas from the regional state capital considered as strata were used as primary sampling units. These enumeration areas were then selected from each stratum using systematic sampling in a proportional manner using the size of households obtained from the 1994 population and housing census. Finally, sample households were selected based on systematic sampling from a list of households prepared for this purpose. In order to select the sample households from towns and rural towns,[7] a three-stage stratified sampling was used. In this case, towns and rural towns as primary sampling units were selected using systematic sampling in a proportional manner using the size of households obtained from the 1994 population and housing census. Next, enumeration areas as secondary sampling units from towns and rural towns were selected proportionally (in a systematic way) based on household size obtained from the same census. Finally, sample households were selected from the list of households prepared for this purpose. Based on this, 687 households were selected from the regional capital, towns and rural towns of Tigray.

Overall, data from a total of 1883 rural and urban sample households were collected through structured questionnaires using well-trained enumerators and supervisors (CSA, 2005). From the total sample households however, only 1710 households[8] yielded complete information for the purpose of this thesis. In this regard, 628 urban and 1082 rural sample households from the Tigray region were considered for analysis. Specific information (data) collected includes issues related to participation in farm and non-farm productive work (household enterprises and wage employment), employment and employment types, access and distance to town functions (roads, transport, schools, telephone, water, markets), housing status (including access to electricity), asset ownership, different sources and level of income and demographic features.

---

[7] A detailed description of the survey setting, sampling procedure and urban-rural definition can be obtained in CSA (2005).

[8] For analysis in chapter 7, about 1660 sample households yielded complete information for the purpose of the chapter (these sample households are used for analysis in chapter 7).

Table 3.4: Distribution of WMS sample households by study zones (Tigray)

	Zones in Tigray	Enumeration areas	Sample households
Rural areas	Eastern	25	300
	Western	25	296
	Central	25	300
	Southern	25	300
Towns	Mekelle zone	23	367
	Other towns	20	320
Total			1883

Source: CSA (2001)

The distribution of town functions in the WMS rural areas and towns on the one hand and the zones on the other shows some variation. This situation can be seen from figures in table 3.5 that indicate the distance that households would need to travel to make use of (town) functional services. Primary schools, roads and water utilities are some of the functions that are available in close proximity (up to 4 km) to a large proportion of rural and urban households. Some of the other vital functions were located farther away from households (especially rural households). Secondary schools, postal services, telephone centers and transport services (taxi and bus) are located relatively farther away from rural households. For instance, 41 percent of the sample households from rural areas needed to travel more than 20 km for a secondary school. Similarly, 26.4 percent of the sample households in rural areas needed to travel more than 20 km for telephone services.

In the WMS dataset, rural towns are considered as 'urban' settlements and household members (living in villages or rural areas) often travel to these nearby localities for different purposes. These settlements play crucial roles in providing rural households with marketing outlets and other vital functions such as educational, health, transport and communication services. Yet, it can be seen from table 3.5 that many rural households travel farther to reach some of the functional services. Also, even those households categorized under 'urban' settlement (such as those who live in rural towns) would be required to travel to higher-order localities to make use of some of the functions. Many rural towns may not have some of the major functions, which may explain the observation that some households categorized under the ‘urban’ settlement travel more than 20 km to reach some of the functions (for instance, 13.2% for secondary schools and 16.2% for telephone services).

Table 3.5: Distribution of WMS sample households by distance to town functions (Tigray, 2000)

Functions	Distance in km to the nearest function					
	(0-1)	[1-4]	[5-9]	[10-14]	[15-19]	[20+)
Full sample						
Markets	17.1	29.1	21.5	15.4	11.1	5.8
Post office	8.2	29.6	11.0	13.0	15.6	22.6
Primary school	24.5	50.9	19.6	4.0	0.8	0.2
Secondary school	6.9	31.5	9.5	10.3	11.0	30.8
Telephone centers	11.3	28.0	11.3	12.9	13.9	22.6
Health centers	11.2	40.0	24.9	14.6	6.3	3.0
Taxi and bus transport	21.7	25.8	12.2	12.5	11.1	16.7
Dry-weather roads	40.4	23.0	15.3	8.7	4.5	8.1
All-weather roads	45.5	15.9	12.1	9.1	6.3	10.1
Water-dry season	69.8	27.1	2.7	0.2	0.1	0.1
Water-rainy season	75.4	23.1	1.2	0.1	0.1	0
Rural						
Markets	13.1	21.1	23.2	20.9	13.4	8.3
Post office	4.7	18.8	12.9	16.6	19.3	27.7
Primary school	14.2	52.6	26.1	5.8	1.1	0.2
Secondary school	2.0	22.0	9.6	12.5	12.9	41.0
Telephone centers	5.5	19.7	12.5	17.2	18.7	26.4
Health centers	6.9	33.0	30.7	18.6	6.7	4.1
Taxi and bus transport	12.4	23.9	14.0	16.5	13.7	19.5
Dry-weather roads	34.5	20.3	19.5	11.2	4.8	9.7
All-weather roads	35.3	16.6	15.8	11.9	7.6	12.8
Water-dry season	63.8	32.5	3.3	0.1	0.1	0.2
Water-rainy season	69.9	28.1	1.5	0.2	0.2	0.1
Urban[a]						
Markets	84.6	15.4	0	0	0	0
Post office	14.2	48.6	7.6	6.8	9.1	13.7
Primary school	42.7	47.9	8.4	1.0	0	0
Secondary school	15.4	47.9	9.4	6.5	7.6	13.2
Telephone centers	21.3	42.3	9.1	5.5	5.6	16.2
Health centers	18.8	52.1	14.9	7.8	5.4	1.0
Taxi and bus transport	37.9	29.1	8.8	5.5	6.6	12.1
Dry-weather roads	50.6	27.6	7.9	4.6	3.8	5.5
All-weather roads	63.3	17.2	5.6	4.3	4.1	5.5
Water-dry season	80.3	17.7	1.7	0.3	0	0
Water-rainy season	85.0	14.4	0.6	0	0	0

[a] Figures in this table for ‘urban’ settlements include that of rural towns, towns and higher-order urban localities.

At this point, we briefly present a comparison of the distribution of town functions (in terms of distance from rural households) in the ERHS and WMS datasets. This gives some insight into the variation in access to functions for rural households across rural Ethiopia. About 34.2 percent of the rural households from the Tigray region can access markets, on average within 4 km. This average is close to the proportion of sample rural households (35.5%) in the ERHS dataset who travel 5 km to reach a market. Rural sample households from the WMS dataset (for Tigray) travel farther than 4 km to reach a primary school. Only 66.8 percent of the rural households in Tigray can get access to primary schools within 4 km (see table 3.5). In this case, there is a notable difference between the two datasets in the proportion of sample households that can get a primary school within 5 km.

On the other hand, the proportion of sample households that travel less than 5 km to reach a secondary school is roughly similar (24.7% in the ERHS dataset and 24% in the WMS dataset). Roughly, between 22 percent (ERHS) and 25 percent (WMS) of the rural sample households obtain telephone services within 5 km (see tables 3.3 and 3.5). Furthermore, notable difference in access to electricity and clean tap water can also be observed among rural and urban households in the WMS dataset for Tigray (see table 3.6). The distance to major town functions from rural households in the two major datasets considered is observed to be roughly similar. But there is indication that many rural households still travel farther to reach major functions such as telephone, electricity, major markets and banks that are located in towns and higher-order urban centers.

For the empirical models in chapters 4 and 7, the summary statistics of variables is presented in table 3.6 (based on the WMS dataset). Due to a smaller sample size, mean values of independent variables used for analysis in chapter 7 vary slightly. The details of these summary statistics for the variables used in chapter 7 are presented in appendix 7.1A. The summary statistics of the variables from the ERHS dataset are presented within the empirical chapters (of 5 and 6).

Table 3.6: Summary statistics of variables (WMS, Tigray 2000)

Specification of variables	Full sample		Urban		Rural		t-ratio
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Household and farm-specific characteristics							
Age (age of household head in years)	47.2	15.6	45.7	16.1	48.1	15.3	
Female (gender of household head: 1= female; 0= male)	0.42	0.49	0.54	0.50	0.35	0.48	
Household size (number of household members)	4.55	2.23	4.32	2.33	4.68	2.16	
Adult members (number)	2.65	1.36	2.72	1.44	2.61	1.32	
Dependent members (number)	1.95	1.54	1.85	1.46	2.01	1.59	
Married (1= yes; 0= otherwise)	0.62	0.49	0.50	0.50	0.69	0.46	
Level of household head education (1=yes; 0= otherwise)							
Illiterate	0.79	0.40	0.57	0.49	0.92	0.27	
Primary education	0.14	0.34	0.25	0.43	0.07	0.26	
Secondary education	0.04	0.19	0.10	0.29	0.01	0.05	
College and above education	0.03	0.18	0.09	0.28	0.01	0.06	
Health status (1= has had health problems; 0= no)	0.42	0.49	0.33	0.49	0.56	0.47	
Access to land (1= yes; 0= otherwise)	0.80	0.39	0.68	0.47	0.87	0.33	
Home ownership (1= yes; 0= otherwise)	0.73	0.44	0.64	0.48	0.78	0.41	
Access to electricity (1= yes; 0= no)	0.31	0.46	0.55	0.50	0.17	0.38	
Access to piped water (1= yes; 0= no)	0.36	0.48	0.60	0.49	0.22	0.41	
Cattle ownership (TLU)	2.23	3.10	1.42	2.36	2.70	3.35	
Access to town functions (distance in km)							
Markets	7.48	7.13	4.31	4.98	9.32	7.54	13.3***
Primary schools	3.24	3.35	1.94	2.17	3.98	3.67	12.5***
Secondary schools	16.2	17.1	8.96	13.1	20.4	17.7	13.8***
Taxi and bus for transport	10.5	12.5	7.16	10.9	12.4	12.9	8.40***
All-weather road	7.32	11.6	3.99	8.50	9.25	12.7	7.80***
Dry-weather road	6.10	10.5	4.24	9.05	7.14	11.0	5.50***
Telephone booth	14.0	16.7	9.54	14.1	16.6	17.6	8.50***
Water (dry season)	1.27	1.57	1.06	1.01	1.39	1.81	4.20***
Water (rainy season)	1.11	1.27	0.96	0.64	1.19	1.52	3.60***

~continues (table 3.6)

	Full sample		Urban		Rural	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Dependent variables (in Birr)[a]						
Income from farm productive activities	195	344	118	296	240	362
	(6.13)		(6.01)		(6.16)	
Income from wage employment in non-farm productive activities	414	1290	837	1867	169	667
	(8.10)		(8.25)		(7.98)	
Income from non-farm household productive activities	148	736	273	1078	76	409
	(6.87)		(7.40)		(6.25)	
Total income from productive activities	758	1421	1227	2011	485	802
	(6.63)		(7.11)		(6.18)	
	$n = 1710$		$n = 628$		$n = 1082$	
Dependent variables (category)						
Employment in farming (employment alternative = 1)	0.54	0.50	0.35	0.47	0.65	0.54
Employment in non-farm household enterprises (employment alternative = 2)	0.22	0.27	0.26	0.36	0.20	0.24
Employment in waged non-farm formal activities (employment alternative = 3)	0.18	0.21	0.27	0.32	0.13	0.17
Employment in other non-farm activities (employment alternative = 4)	0.06	0.12	0.09	0.15	0.04	0.08
	$n = 1660$		$n = 605$		$n = 1055$	

[a] Average income also includes zero earnings.
Whereas, the log values in parentheses are based on positive income only (for non-zero income).

From table 3.6, mean comparison of the distance to town functions among sample households from rural and urban areas indicate the varying distribution of town functions. The t-ratio results indicate a significant difference in distance to town functions among households in rural and urban areas. From table 3.5, this variation in distance to functions can be observed from the varying proportion of rural and urban households that travel to reach some of the major town functions. While two-thirds of the urban sample households obtain most of the major functions within 4 km, many rural households travel far beyond 10 km to reach most of the functions.

This varying access to town functions can influence household choice of alternative employment opportunities and income. One major effect of town functions is creating an enabling environment that would increase the likelihood of rural household employment in non-farm jobs, which are often concentrated in towns and urban areas (Fafchamps and Shilpi, 2003). For instance, 27 and 13 percent of the urban and rural sample households respectively depend on non-farm wage jobs as the major employment opportunity (see table 3.6). After controlling for household-specific features, town functions can significantly contribute to this difference in employment (and income) in non-farm activities. The analyses of these relationships are left for the empirical chapters.

CHAPTER 4

CONTRIBUTION OF TOWN FUNCTIONS TO INCOME FROM PRODUCTIVE ACTIVITIES

Abstract

In this chapter, the aim is to investigate the effect of town functions on income from productive activities. Starting from the analysis of total income we distinguish and analyze income from three categories: non-farm household, non-farm wage and farm productive activities. A cross-sectional data of 1710 households from the Tigray region in northern Ethiopia is used for analysis. The empirical evidence suggests that income from the productive activities decreases with distances to markets, transport infrastructure and telephone services. Moreover, results indicate that connection to electricity and tap water contributes to higher income. Results however show that certain functions are more important to some of the income types than others. Therefore, selective investment in expanding road networks with transport systems, establishing and expanding market information systems, electrification and expanding tap water will help increase income from productive activities.

Key words: town functions, non-farm household income, non-farm wage income, farm income, productive activities, Heckman model, Tigray

4.1 Introduction

The vast majority of the rural population in developing countries depends on agriculture, mainly farming and livestock husbandry. However, households still earn a good proportion of their income from non-farm productive activities. For instance, non-agricultural income accounts for 35 percent of total household income in Asia, 40 percent in Latin America and 45 percent in Sub-Saharan Africa (Reardon *et al.*, 2001). These income shares include all sorts of non-farm income and transfers, such as product processing, craftwork, off-farm employment, rents, etc. Nevertheless, a large part of the income share is earned from employment in non-farm productive activities that are often concentrated in nearby rural towns, towns and higher-order urban areas (Fafchamps and Shilpi, 2003; Isgut, 2004).

Often, rural areas in developing countries lack the infrastructures and institutions that are useful for strong rural-urban linkage. However, many of them can be found in nearby rural towns and towns. Though physically located in towns and provided from there, rural and urban households can use these functions, including major markets, telephone centers, higher schools, health facilities, roads, microfinance institutions and banks. In a way, the functions contribute to towns acting as intermediaries along the rural-urban continuum, linking and benefiting both rural and urban areas mainly through production, employment and income patterns (Tacoli, 1998a; Tacoli, 1998b; Satterthwaite and Tacoli, 2003). Moreover, productive activities in rural towns and towns are instrumental in providing income-earning opportunities. In this case, the functions are instrumental in linking households to employment opportunities in productive activities. For instance, Mukherjee and Zhang (2007) argue that China's rural non-farm economic development with active support from public institutions has been largely driven by the continuous growth of township- and rural enterprises (productive activities).

Various studies have investigated the role of functions in income using different approaches, often considering a limited number of functions (notably Escobal, 2001; Lanjouw, 2001; Dercon and Hoddinott, 2005; Jonasson and Helfand, 2010). A large body of these empirical studies focuses on the role of specific components of town functions. However, the approaches so far do not consider other major town functions that rural areas lack but that the rural towns and towns nearby possess. In addition, considering a limited number of functions restricts the opportunity to compare functions and identify the most important ones.

Rural areas in many developing countries such as Ethiopia lack many major functions. An interesting research approach is then to study the contribution that town functions make to income from productive activities. A particular interest of this chapter is to obtain objective and quantitative information about the effect on 1) how distance to town functions influences income, and 2) identify those functions that particularly have strong effects. For this purpose, we use data collected from households in the Tigray region of northern Ethiopia, which presents an opportunity to analyze household income generation from different farm and non-farm productive activities.

The rest of the chapter is organized as follows. In section 4.2, we present the theoretical background that specifies and discusses the conceptual income equations from observed productive activities. Section 4.3 presents the econometric method that is used to estimate the effect of town functions on income from productive activities. In section 4.4, we briefly describe the data used for analysis. In addition, we identify the major productive activities and provide a description of the composition of household income from these activities. In section 4.5, we present the econometric results, with a focus on the effect of town functions on income from productive activities. In addition, we discuss the results in relation to the literature and practical implications. Section 4.6 briefly discusses and summarizes what has been learnt about the contribution of town functions to income from productive activities. Section 4.7 summarizes the main points of the chapter and concludes with issues for further study and consideration.

4.2 Theoretical framework

The complex nature of production and consumption decision-making among households in developing countries has its influence on the allocation of inputs. The interaction between the household's production and consumption decision-making is the major feature of household models. Where there is a market for all inputs and outputs (when there is no market failure as such), production and consumption decisions can be made recursively. However, a typical feature of the great proportion of rural/town households in developing countries is the interrelated decision-making nature of production, consumption and labor supply activities (Sadoulet and de Janvry, 1995).

When households in developing countries decide on labor allocation, they are constrained by different factors. The constraints lead to households' joint production, consumption and labor supply decisions. The non-separable production, consumption and labor supply decision-making by households results from varying preference of working on off- or on-farm activities (Lopez, 1986). This is due to imperfections in input and output markets. Moreover, high transaction costs because of inadequate infrastructures and institutions contribute to the joint (non-separable) decision-making.

With the premise of highly imperfect markets, assume that a producer-consumer-worker household's motive in working in farm and/or non-farm productive activities is to maximize utility. In this framework, the standard consumer and producer theories stacked in the broader household models and their first order conditions can be used to derive important relationships. Consider the following utility function:

$$Max\ U(y, l; \mathbf{z}) \tag{4.1}$$

where y represents income from productive activities; l is leisure time and $\mathbf{z}$ is a vector of characteristics related to individual households. From the utility maximization model provided in equation (4.1), labor time spent in productive activities, denoted by j, can be used to earn income. In this chapter, we consider both non-farm income and farm income earned by supplying labor to non-farm and farm productive activities. In light of this, the role that town functions play in influencing non-farm (farm) income can be presented as:

$$y_{ij} = f_j \{\mathbf{z}_i, \mathbf{z}_i^{\mathbf{q}}, TF_{ik}, \mathbf{A}_i\} \qquad j = 1, \ldots, n \tag{4.2}$$

where income obtained from different productive activities (y) for household i is explained by household characteristics $(\mathbf{z}_i)$, quasi-fixed inputs $(\mathbf{z}_i^{\mathbf{q}})$, household $i's$ access to a particular town function (TF_{ik}) and farm characteristics, $\mathbf{A}_i$ (such as land and home ownership by rural or urban households). Households in rural areas and towns in developing countries considerably differ in their endowment of town functions. This variation in town functions for households can be taken into account as follows:

$$y_{ij} = f_j \{\mathbf{z}_i, \mathbf{z}_i^{\mathbf{q}}, g(d_i, TF_k), \mathbf{A}_i\} \tag{4.3}$$

The approach we followed to see the effect of town functions was to consider the distance that households would need to travel to reach each town function. This is denoted by the distance function $g(\cdot)$, which encompasses the distance (*d*) that households travel to a specific town function (TF_k).

Assuming a linear specification of (4.3) results in

$$y_{ij} = \mathbf{z}_i \boldsymbol{\tau}'_j + \{g(d_i, TF_k)\}\boldsymbol{\theta}'_j + \mathbf{z}_i^{\mathbf{q}} \boldsymbol{\varphi}'_j + \mathbf{A}_i \boldsymbol{\alpha}'_j + \varepsilon_{ij} \tag{4.4}$$

where income (y) for household i from productive activity j is given by the stochastic function of observed household- and farm-specific variables and distance to town functions, $g(d_i, TF_k)$. The vector of parameters $\boldsymbol{\tau}, \boldsymbol{\theta}, \boldsymbol{\varphi}$ and $\boldsymbol{\alpha}$ are specific for each productive activity. The idiosyncratic random component of the model is denoted by ε. The exact influence of town functions, considered in terms of distance, requires some scrutiny. Town functions (such as roads and transport, electricity, education, water, health, markets etc.) can have direct and indirect influence on income from productive activities. In this chapter, we consider income earned through monetary or in-kind wage (w) only from productive activities (transfers are excluded). Given that input and output prices influence income, town functions have direct and indirect (through their effect on prices) impact on farm and/or non-farm income of households. For reasons of parsimony, let us consider the decomposition of the effect of a given town function (TF_k) on income from different productive activities:

$$\frac{dy_{ij}}{dTF_k} = \frac{\partial y_{ij}}{\partial TF_k} + \left(\frac{\partial y_{ij}}{\partial w_j}\right)\left(\frac{dw_j}{dTF_k}\right) \quad (4.5)$$

The main objective in this chapter is to examine the overall effect of town functions on income from productive activities. Therefore, parsing the direct and indirect effects of town functions is not part of this chapter. The total effect of a given town function on non-farm and farm income, in a simplified scenario, is the sum of the direct partial effect of the town function and the indirect partial effect of the town function on wages[1], which indirectly influence non-farm and farm income.

4.3 Method of estimation

To identify the appropriate method of estimation, it is informative first to notice the nature of the data. The data indicate that many households did not earn a given income type. In other words, many households have zero income from non-farm household enterprises or waged productive activities. For instance, only about 57 and 59 percent of the sample households earned non-farm[2] and farm income respectively. This shows that a good proportion of the sample households earned no income from farm and non-farm productive activities.

Zero non-farm income for instance can be due to limited or no access to non-farm jobs or self-selection by households from working in non-farm productive activities. Hence, the use of standard OLS (Ordinary Least Square) technique yields biased estimates (Cameron and Trivedi, 2005; Verbeek, 2008). This is because it does not properly consider the relatively

---

[1] While wages (w) may be considered exogenous in the models, the shadow wage rate (also total wages) depends on household characteristics $(\mathbf{z}_i)$. Wage can enter the model as a function of household labor endowment, productive assets owned by the household and other household characteristics, in equations (4.2) through (4.4) - see Fafchamps and Quisumbing (1999).

[2] This includes income from both non-farm wage employment and home-based enterprises.

large number of sample households that do not have any income from non-farm and/or farm productive activities. Zero farm and/or non-farm income is not usually due to censoring. Rather, zero income is often observed because of non-participation by households in farm or non-farm productive activities (say, because the wage may be below the reservation wage of households, see the pioneer work by Gronau, 1974).

Unlike censored models, the Heckman model attributes zero observations to non-economic factors (non-corner solutions) as well, including lacking or limited infrastructure that leads to prohibitive transaction costs. Our focus is on the outcome equation (income from different productive activities). The appropriate procedure in this case would be to model the data-generating process that produces the zero observations as well. As a result, we use the Heckman model (Heckman, 1979) that is designed to tackle sample selection bias, which arises when interest lies on the relationship between x and y but data are available only for cases in which another latent variable, z^* exceeds a certain value.

The first equation in the Heckman model is a probit model of the probability of having a positive outcome (the selection equation), and the second equation is an OLS estimator of income among the sub-sample with $y > 0$. Based on this therefore, the selection equation can be presented as

$$z_i^* = \mathbf{w}_i'\boldsymbol{\gamma} + u_i \tag{4.6}$$

$$\text{Prob}\left(z_i^* > 0 \middle| \mathbf{w}_i\right) = \text{Prob}\left(u_i > -\mathbf{w}_i'\boldsymbol{\gamma}\right) = \Phi\left(\mathbf{w}_i'\boldsymbol{\gamma}\right) \tag{4.7}$$

where $\mathbf{w}$ is the vector of explanatory variables with corresponding vector of parameters of $\boldsymbol{\gamma}$, u_i is the error term and Φ is the standard normal cumulative distribution function (*cdf*). The outcome equation is observed only when $z_i^* > 0$, and can be specified as

$$y_i = \mathbf{x}_i'\boldsymbol{\theta} + \varepsilon_i \tag{4.8}$$

where $\mathbf{x}$ is the vector of explanatory variables with corresponding vector of parameters of $\boldsymbol{\theta}$, ε_i is the error term of the outcome equation. The error terms u_i and ε_i are independently and jointly normally distributed with $\left(u_i, \varepsilon_i\right) \sim N\left(0, \begin{bmatrix} 1 & \rho\sigma_\varepsilon \\ \rho\sigma_\varepsilon & \sigma_\varepsilon^2 \end{bmatrix}\right)$. While $\rho\sigma_\varepsilon$ denotes the covariance, ρ represents the coefficient of correlation.

The conditional and unconditional expectations of this outcome model, respectively can then be presented as

$$\mathrm{E}(y_i|y_i > 0, \mathbf{x_i}) = \mathbf{x_i'\theta} + \mathrm{E}(\varepsilon_i|y_i > 0, \mathbf{x_i}) = \mathbf{x_i'\theta} + \rho\sigma_\varepsilon\lambda(\alpha_u) \tag{4.9}$$

$$\begin{aligned}\mathrm{E}(y_i|\mathbf{x_i}) &= \mathrm{Prob}(y_i > 0|\mathbf{x_i})\cdot \mathrm{E}(y_i|y_i > 0, \mathbf{x_i}) \\ &= [\mathbf{x_i'\theta} + \beta_\lambda\lambda(\alpha_u)]\Phi(-\alpha_u)\end{aligned} \tag{4.10}$$

The term $\lambda(\alpha_u)$ denotes the inverse Mills ratio (IMR), which is equal to the expression $\frac{\phi(\alpha_u)}{1-\Phi(\alpha_u)} = \frac{\phi(-\alpha_u)}{1-\Phi(-\alpha_u)} = \frac{\phi(\mathbf{w_i'\gamma}/\sigma_u)}{\Phi(\mathbf{w_i'\gamma}/\sigma_u)}$, where ϕ is the standard normal probability distribution function (*pdf*). The IMR captures the correlation between the unobservables in the selection and outcome equations. One approach to capture this correlation is by estimating the probit model in (4.6) first, using all observations. The estimates from this model are then used to generate the IMR, which is included in equation (4.8) as an additional regressor. If the coefficient associated with the IMR is significantly different from zero, it indicates that the use of the Heckman model yields consistent estimates, as opposed to OLS (Verbeek, 2008).

Interpreting the results of the Heckman model is not straightforward. The situation is complicated by the inclusion of variables both in the selection and outcome equations. In such cases, attention usually centers on the observed y (outcome equation) and the marginal effect of kth element of $\mathbf{x}$ on the conditional (or unconditional) expectation. Conditional marginal effect shows the effect of a given continuous explanatory variable on income on the condition that the household head participates in a productive activity. It specifically refer to the effect on household heads that actually worked in productive activities. Continuous explanatory variables are specified in level form. But when the dependent variable is specified as the natural logarithm of income, the conditional marginal effect corresponds to a relative change in income. This should therefore be considered when interpreting the marginal effects. Following Hoffmann and Kassouf (2005), the estimated percentage change in income due to a unit change (increase or decrease) in x_k can be computed from [exp(c)-1]×100, where c is the estimated value of the conditional[3] marginal effects.[4]

---

[3] The full derivation of the conditional marginal effects of continuous and binary independent variables can be obtained from Hoffmann and Kassouf (2005), part of which goes with the notations in this

4.4 Data description

The data for this chapter come from the Welfare Monitoring Survey dataset collected by the Ethiopian Central Statistical Authority (CSA). The dataset includes information obtained from household surveys in different regions of Ethiopia. For the purpose of this chapter however, we focus on the data collected from the regional state of Tigray in northern Ethiopia. The original dataset contains a randomly selected sample of 1882 households for the regional state of Tigray. However, we consider only 1710 sample households (628 urban[5] and 1082 rural) that yielded complete information. The survey gathered detailed information about household employment and income using recall questions in different formal and informal sectors, self-run farm and formal non-farm productive activities. The dataset includes data related to participation in farm and non-farm productive activities, employment status and employment alternatives, access and distance to town functions (roads, transport, schools, telephone, water, markets), housing status (including access to electricity and tap water) and demographic features.

Households earned their income from a wide variety of activities. Income from farm productive activities[6] includes income earned from crop farming, livestock husbandry and other agricultural productive activities (such as forestry and other off-farm activities including off-farm labor income through wage employment in farm or agricultural[7] activities). Income from non-farm productive activities consisted of income obtained from non-farm household enterprises[8] and non-farm waged productive activities. Non-farm household productive activities include many sorts of in-house production activities, for example handicraft work, cottage industries, in-house services and small-scale manufacturing activities based at household level. The income that comes from these productive activities mainly constitutes

---

chapter is presented in Appendix 4.1A. An alternative derivation of probability, conditional and unconditional marginal effects of log-transformed sample selection models is also presented in Yen and Rosinski (2008).

[4] In the formula $[\exp(c)-1]\times 100$, $\exp(c)$ represents the exponent of the scalar c.

[5] The description of 'urban' and 'rural' settlements in the Welfare Monitoring Survey dataset is presented in chapter 3.

[6] Income from farm production that is used for own consumption was not included as it was not recorded.

[7] Income earned from agricultural activities is considered as farm income.

[8] Home-based enterprises and household productive activities are interchangeably used in this chapter.

sales profit (of goods and services), wages, bonuses and allowances from the household enterprises.

On the other hand, non-farm waged productive activities constitute formally established non-farm public and private productive activities. Formal manufacturing, transport, services (such as tourism, hotels, banking and legal, education and health, etc.), construction and registered small-scale manufacturing enterprises are among the waged productive activities. Income from non-farm waged productive activities can include wages, salaries, bonuses, overtime and allowances. Transfer income does not belong to productive activities and comprises rent from capital assets (buildings, tools and machinery), income from gifts and remittances and income from pensions and insurance. Other non-farm income sources constitute income earned from brokerage, daily labor and freelance work. Average income of different activities over a six-month period are provided in table 4.1.

Major town functions such as roads, transport and telephone services that take households closer to employment opportunities are among the variables of main concern. These functions can be particularly useful for households to reach non-farm jobs that are often concentrated in towns. Roads are often useful to household income from farm and home-based activities. Income from these activities is usually dependent upon accessing the market for products of farm and home-based enterprises. With larger distance to roads, accessing the market becomes difficult. This limits market outlets for products from home-based enterprises and farm output, the sales of which contribute to total income.

Shorter distance to telephone services is expected to boost employment opportunities and income. This may be due to facilitated information exchange about employment opportunities. Furthermore, these functions enable affordable commuting to working places by lowering travel costs. Major markets in towns can also be a source of employment or market (prices, supply and demand) information that can contribute to output sales from home-based enterprises and farm activities, which can boost income.

Table 4.1: Average income of households from various activities

Income from various activities (Birr)[a]	Full sample (n=1710)	Rural (n=1082)	Urban (n=628)
Farm (agricultural) productive activities			
Crop farming (735)	230.4	236.8	216.7
Livestock-related and other agricultural activities (723)	227.8	235.7	213.8
Non-farm (non-agricultural) productive activities			
Household productive activities (275)	921.7	519.5	1614.7
Wage employment in private sector (206)	1342.5	1198.7	1588.6
Wage employment in public sector (225)	1923.1	1733.9	2247.7
Total income from productive activities (1441)	899.1	564.6	1475.4
Income from transfers			
Income from house rent and other capital assets (120)	1020.1	807.4	1390.0
Gifts and remittance income (372)	413.2	337.5	543.0
Pension and insurance income (58)	572.5	505.5	688.0
Income from other activities (80)	484.6	403.8	623.7

[a] Income is over a six-month period and these average earnings are computed for households that registered non-zero income. At the time of data collection for this chapter, 1 Euro was equivalent to 10.6 (1USD to 7.54) Birr, the Ethiopian currency.

Numbers in parentheses represent the number of sample households (for each income sub-category) that registered non-zero income.

Schools that households can use to gain knowledge and skills can also influence income. Shorter distances to schools can mean lower costs of building the knowledge and skills required to obtain high-earning jobs that can lead to higher income. Schools in closer proximity are therefore hypothesized to boost income, especially from non-farm wage employment. Connections to electricity and tap water that are useful in powering the production process in both non-farm formal productive activities and home-based enterprises can also lead to higher efficiency and productivity, which may encourage the payment of higher wages. Thus, such connections to electricity and tap water are hypothesized to increase income from non-farm home-based enterprises and waged activities.

Educational achievement is among the major factors that influence labor market choice. Hence, acquired knowledge and skills are expected to increase the likelihood of obtaining high-paying non-farm jobs. Another element of human capital is the health status of workers, which can influence productivity and thereby wage earnings that contribute to income. Experiencing health problems is therefore hypothesized to lead to lower income. Farm-specific assets such as land and houses are instrumental for the operations of especially farm and home-based activities. Hence, access to land is hypothesized to have an inverse relationship with non-farm wage income. On the other hand, land is a factor of production that farming cannot do without. As a result, farm income is hypothesized to increase with access to land. Similarly, home-ownership can be useful to the operations and profitability of home-based enterprises. Access to buildings that can house home-based enterprises is therefore hypothesized to increase income from home-based enterprises. The summary statistics of variables used in the empirical models are presented in table 3.6 in chapter 3.

4.5 Estimation results

Models of total income and income from the three specific productive activities are estimated using the Heckman procedure. All regression results reported are for the full sample (both rural and urban households). We start by presenting results related to the relationships among total income and town functions in section 4.5.1. The results for income from non-farm household and waged productive activities are presented and discussed in section 4.5.2. Finally, section 4.5.3 presents the results of income from farm productive activities. For the purpose of interpretation, we present the marginal effects of the major predictors for each income model. Standard errors are estimated after accounting for within cluster (village or town) correlations and possible heteroskedasticity.

One thing that should be emphasized when estimating Heckman models is the specification of the selection criteria. This is because coefficient estimates of the Heckman model are effectively determined by the selection criteria (Cameron and Trivedi, 2005). Choosing variables that have nothing to do with selection would lead to estimates that do not differ from OLS estimates (which can be biased). In this chapter, we consider dependent household members as the selection variable. It can be argued that the number of dependent household members can influence decision-making related to employment of adult members. Research into fertility and wage employment shows that the number of children discourages wage employment (Bianchi, 2000). However, given employment dependent household members are not expected to influence income from employment in productive activities.

Four income models are estimated. These are total income and income from each of the observed productive activities: income from non-farm home-based activities, income from non-farm wage employment and farm income. The inverse Mills ratio (λ) estimated for the four income models are statistically significant at the 1% level, indicating that the models appear to show selection bias. The positive and significant coefficient of the inverse Mills ratios for income from non-farm home-based activities and income from non-farm wage employment models suggest that household heads who are employed in these non-farm productive activities are very likely receive higher income. On the other hand, the significantly negative coefficient of the inverse Mills ratio for income from farm productive activities indicates that household heads who are employed as farm workers are likely receive lower earnings from farm productive activities. The Wald tests for the independence of equations in all of the income models yielded a chi-square value that is significantly different from zero (see tables 4.2, 4.3, 4.4 and 4.5). The indication is that the error terms in the selection and outcome equations are correlated, which requires the use of the Heckman procedure to consistently estimate the parameters.

4.5.1 Effect of town functions on total income from productive activities

Some of the most important town functions have a significant effect on total income[9] earnings from productive activities. This is particularly the case with access to markets, roads, secondary schools, electricity and clean water infrastructural facilities (see table 4.2). The results suggest that longer distance to dry-weather roads is associated with lower income from productive activities. The effect of roads[10] is particularly strong, as depicted by the reduction in total income by 2.8 ([exp(0.028)-1]×100) percent,[11] for each 1 km increase in distance to dry-weather roads (see table 4.8).

Although transport services are expected to complement roads in boosting income, findings do not support this hypothesis. Nevertheless, this does not mean that the contribution of transport services is negligible. It could be that the contribution of closer roads may be impaired by their poor quality or a lack of transport services. In fact, other studies have emphasized the important role that transport services play in increasing household income. For instance, Lanjouw *et al*. (2001) argue that proximity (shorter distance) *per se* may not lead to higher

[9] Total income in this chapter is meant to include income from productive activities only (i.e., excluding transfer income). Though not the goal of this chapter, a brief analysis was made to examine how income from transfers varies in response to access to town functions. Distance to roads and schools was observed to have a negative influence on transfer income. Also, access to electricity was found to be associated with lower transfer income.

[10] Whenever the term 'roads' is used in this chapter, it refers to 'dry-weather roads'.

[11] For continuous variables, the elasticities in table 4.8 show the effect of 1 km change on the percentage change of income from productive activities. For the effect on total income, the elasticities (and discrete effects) given in table 4.8 are computed from the marginal effects presented in table 4.6.

income if transport services are lacking; and/or the quality of the roads leading to towns is poor (Lanjouw, 1999; Corral and Reardon, 2001). Therefore, although a shorter distance to (dry-weather) roads is useful to boosting total income, its contribution can be further enhanced by improved road quality and accessible transport services.

Distance to market is similarly found to influence total income in a significantly negative manner, though the effect is weaker than that of roads. Elasticities suggest that total income decreases by 0.7 percent when market distance increases by 1 km, *ceteris paribus* (see table 4.8). In effect, bringing markets closer to households would usefully to contribute to income. Closer markets can help reduce the cost of travel (such as transporting farm or non-farm home-produced goods to the market) and bring higher farm-gate prices that increase profitability and income. Markets can lead to establishing networks and secure input sources that may encourage technology use, which contribute to higher agricultural yields, sales and income. They can also be the source of employment information that may increase the likelihood of obtaining high-earning jobs and higher income.

After controlling for educational achievement, distance to secondary schools is found to have a significant negative influence on total income from productive activities. The implication is that significant reductions in distance to secondary schools would make a tangible contribution to higher total income (1.2% more for each 1 km reduction). This is expected *a priori* where a shorter distance to educational centers can lead to lower costs of developing human capital (lower investment cost for skills and knowledge) that is useful for obtaining better jobs and increasing income. The higher income can also be due to the opportunities created for developing medium-level and higher management skills from closer secondary schools.

Other important functions that are observed to have a positive influence on total income include electricity and tap (piped) water connections. The results show that with access to electricity and clean drinking water, total income from productive activities increases. These two functions are instrumental to the productivity and profitability (and perhaps sustainability) of especially non-farm productive activities. This can lead to productive activities to generate (higher) income for employed heads. Many non-farm home-based and formal productive activities often use electricity and clean water as input for production process. Continuous access to these functions can therefore lead to a difference in productivity and profitability, on which income depend.

Table 4.2: Estimates of total income from productive activities

	Selection equation		Outcome equation	
Variables	Coefficient	Std. error	Coefficient	Std. error
Age	0.068	0.005***	-0.149	0.001***
Age-squared	-0.001	4.2×10^{-6}***	-0.001	4.9×10^{-5}***
Female	0.091	0.028**	-0.271	0.069***
Adult members	0.019	0.015	0.434	0.003***
Dependent members	0.004	0.005		
Married	0.016	0.022	0.434	0.046***
Primary education	0.445	0.051***	0.467	0.003***
Secondary education	0.329	0.130**	0.782	0.343**
College and above education	0.258	0.125**	1.228	0.380***
Health status	-0.069	0.006***	-0.005	0.065
Access to land	-0.026	0.045	-0.007	0.023
Home ownership	0.190	0.007***	0.445	0.068***
Access to electricity	0.241	0.072**	0.865	0.204***
Tapped (piped) water	-0.144	0.193	0.768	0.150***
Access to town functions (distance in km)				
Markets	-0.030	0.014**	-0.017	0.001***
Primary schools	-0.032	0.012**	-0.001	0.014
Secondary schools	-0.005	0.002**	-0.014	0.002***
Taxi and bus for transport	-0.007	0.007	-0.002	0.006
Dry weather road	-0.011	0.001***	-0.025	0.004***
Telephone booth	-0.010	0.005**	-0.001	0.005
Constant	1.258	0.253***	5.814	0.280***
λ (IMR)			0.782	0.072***
Wald $\chi^2\ (\rho = 0)$			57.1***	

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: robust standard errors are reported.

Furthermore, some household and farm-specific characteristics are found to significantly influence total income from productive activities. Results related to the role of education confirm the positive and powerful effect of human capital in earning a higher income. Skill and knowledge obtained from higher schooling can lead to employment in high-earnings jobs that contribute to higher total income. Results related to adult members in a household used as proxy for labor supply indicate that more adult labor means higher income. This relationship is expected *a priori* as it can also be seen from the negative sign of dependent household members (though not statistically significant). Income variation is also observed among gender of household heads. In this case, female-headed households are found to earn less income as compared to male-headed households. This may be, amongst other things, attributed to unequal ownership of resources.

So far, the analysis focused on the role of town functions to total income from productive activities. However, different income categories from productive activities may be influenced differently by town functions. In the subsequent subsections, results related to the effect of town functions on income from two non-farm and farm productive activities are presented.

4.5.2 Income from non-farm household and waged productive activities

Influence of town functions

The transport infrastructure is found to have a significant influence on income from non-farm household and waged productive activities. The results in tables 4.3 and 4.4 show that income from non-farm household and waged productive activities declines with distance to dry-weather roads. For participating heads, the conditional marginal effect of log of income from non-farm household productive activities with respect to distance to dry-weather roads is 0.036, implying that a 1 km increase in distance to dry-weather roads reduces income, *ceteris paribus*, by 3.6 percent (see table 4.8). Similarly, the conditional marginal effect of log of income from waged non-farm productive activities with respect to distance to dry-weather roads implies that a 1 km increase in distance to dry-weather roads reduces income by 2.7 percent among participants of non-farm waged productive activities (*ceteris paribus*).

Roads and transport facilities are among the vital establishments that facilitate interactions among economic agents and can lead to higher income. Lanjouw *et al*. (2001) stress that roads and transport are core infrastructural facilities that significantly contribute to income from non-farm home-based and wage employment. The role they play in improving consumption and welfare through helping households earn higher incomes is particularly emphasized (see also, Decron and Hoddinott, 2005). Closer distance or availability of roads however may not be sufficient as the existence of poor-quality roads may not translate into higher non-farm employment opportunities (Lanjouw, 1999). Though not considered in this chapter, good-quality (such as asphalt or paved) roadways significantly contribute to higher non-farm income from household-based and waged activities (Lanjouw *et al*., 2001; Corral and Reardon, 2001).

Table 4.3: Estimates of income from household non-farm productive activities

Variables	Selection equation		Outcome equation	
	Coefficient	Std. error	Coefficient	Std. error
Age	0.014	0.007	0.043	0.007***
Age-squared	-0.0002	7.9×10^{-5}	-0.0009	2.9×10^{-5}***
Female	-0.029	0.085	0.099	0.221
Adult members	0.011	0.027	0.112	0.037***
Dependent members	0.062	0.009***		
Married	0.017	0.008**	0.058	0.177
Primary education	0.068	0.217	0.856	0.419**
Secondary education	0.266	0.398	1.927	1.101*
College and above education	-0.203	0.097**	0.541	0.296*
Health status	-0.260	0.032***	-0.362	0.002***
Access to land	0.113	0.098	0.226	0.024***
Home ownership	0.194	0.054***	0.096	0.028***
Access to electricity	0.612	0.060***	1.572	0.527***
Tapped (piped) water	0.012	0.002***	1.512	0.177***
Access to town functions (distance in km)				
Markets	-0.010	3.7×10^{-5}***	-0.062	0.001***
Primary schools	0.002	0.006	0.087	0.017***
Secondary schools	0.011	0.0003***	0.033	0.003***
Taxi and bus for transport	-0.020	0.011*	-0.011	0.023
Dry weather road	0.004	0.008	-0.031	0.013**
Telephone booth	-0.230	0.232	-0.007	0.002***
Constant	-1.750	0.486***	3.153	0.530***
λ (IMR)			1.461	0.147***
Wald $\chi^2(\rho=0)$			1100.8***	

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: robust standard errors are reported.

The other important town function that is observed to have a significant influence on income is markets. Results suggest that the farther the market, the lower the probability of participation in non-farm household and waged productive activities (see tables 4.3 and 4.4). In addition to being a source of consumption goods, accessible markets can be a vital outlet for products of household enterprises and formally established firms that can increase income from each productive activity. As the results show, bringing markets closer to households can therefore increase income from non-farm household and waged productive activities.

Findings in tables 4.3 and 4.4 show that distance to a telephone booth plays a significant role in influencing income from non-farm household and waged productive activities. However, the effect is found to be comparatively smaller (a 1 km increase in distance leading to 0.7%

reduction in income from both non-farm household and waged productive activities). Nevertheless, telephone services can play a pivotal role in information exchange about prices, availability of inputs and marketing of outputs of the production process of household enterprises. When the share of households connected to telephone lines increases, distance to telephone services decreases. This would help households gather and process information (related to non-farm employment or output prices) relatively easily and at lower cost. This eventually would contribute to higher employment opportunities and sales from home-based or other non-farm activities leading to higher income (Lanjouw, 1999; Jonasson and Helfand, 2010). Recent expansion of the use of mobile phone services[12] may however render the distance element to fixed telephone booths less significant. This is because distance becomes less influential through the penetration of mobile phones deep into rural areas.

Other town functions that are found to have a significant influence on income from non-farm household and waged productive activities are electricity and piped water facilities (see tables 4.3 and 4.4). The strong effect (in magnitude) of access to electricity can be seen from table 4.8. The discrete effect of a change from 0 to 1 in access to electricity leads to an increase in income from non-farm household enterprises and waged activities by 134 and 84 percent, respectively *ceteris paribus*. It may not be conclusive but a good number of the non-farm household and waged productive activities are powered by electricity, which ensures a continuous production process and attracts employment. This is particularly the case for some household and waged productive activities that use electricity and clean tapped water as the major input of production (for example, restaurants and hotels, barber shops, small-scale industries, some cottage industries, different manufacturing or construction firms, etc.). Electricity is one of the major inputs for the production processes at formally established productive entities. Furthermore, access to electricity and a constant supply of it can lead to significant income from waged productive activities through better efficiency and management of production processes.

---

[12] Mobile phones as 'telephone services' were not considered in part due to the negligible penetration of mobile phones in the study area (during data collection). The reality is totally different currently where mobile phone use is rapidly expanding in Ethiopia.

Table 4.4: Estimates of income from wage employment in non-farm productive activities

	Selection equation		Outcome equation	
Variables	Coefficient	Std. error	Coefficient	Std. error
Age	0.031	0.017*	0.125	0.025***
Age squared	-0.0006	0.0004	-0.002	0.0003***
Female	-0.003	0.118	-0.196	0.216
Adult members	0.015	0.008*	0.094	0.025***
Dependent members	-0.026	0.007***		
Married	-0.078	0.032**	-0.167	0.108
Primary education	0.132	0.152	0.195	0.562
Secondary education	0.574	0.242**	1.160	0.235***
College and above education	0.326	0.126**	2.373	0.200***
Health status	-0.285	0.125**	-0.671	0.302**
Access to land	-0.324	0.045***	0.740	0.354**
Home ownership	-0.193	0.020***	0.010	0.005**
Access to electricity	0.406	0.161***	1.280	0.326***
Tapped (piped) water	0.005	0.050	0.890	0.011***
Access to town functions (distance in km)				
Markets	-0.478	0.037***	-0.572	0.064***
Primary schools	-0.060	0.014***	-0.119	0.014***
Secondary schools	0.007	0.003**	-0.010	0.005**
Taxi and bus for transport	-0.209	0.421	-0.007	0.003**
Dry weather road	-0.001	0.005	-0.025	0.014*
Telephone booth	-0.015	0.001***	-0.033	0.009***
Constant	-0.751	0.896	2.791	0.674***
λ (IMR)			2.105	0.423***
Wald $\chi^2(\rho = 0)$			12.2***	

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: robust standard errors are reported.

Connection to tap water supplies was also found to lead to higher income from non-farm wage employment and household productive activities (indicated in tables 4.3 and 4.4). In this regard, table 4.8 shows the significant difference that access to tap water can bring for income from non-farm household (348% higher) and waged (141% higher) productive activities. One reason might be the health benefits of piped water and thus a higher productivity and better employment opportunities in non-farm activities that entail a mentally and physically strong labor force. A second reason could be the higher number of enterprises that make use of piped water for production purposes, which may lead to higher profits and payment of higher wages. Distance to educational centers presents a contrasting effect on income from non-farm household enterprises and income from non-farm waged productive activities. While income from non-farm waged productive activities was found to decrease with distance to schools, the results indicate that income from non-farm household enterprises tends to increase with distance (to primary and secondary schools). A shorter distance to primary and secondary schools creates better opportunities to learn and accumulate skills, which increases the probability of employment and earning higher non-farm wage income. On the other hand, it may well be the case that a longer distance to educational institutions (primary and secondary educational schools) may result in a higher investment cost of labor. In many cases, however, the nature of non-farm household enterprises is such that highly skilled labor is not required. This in turn may encourage households to concentrate on household productive activities, which require less skill and expertise. On the other hand, it can be argued that skill and knowledge (such as special skills or management techniques) obtained from closer schools may be used to enhance income from home-based enterprises. Nevertheless, we could not clearly establish why income from home-based enterprises increases with distance to secondary schools. However, these results do suggest that access to educational centers may not be as important to employment in, and income from, non-farm household productive activities as it is to employment and income from non-farm waged productive activities. Non-farm employment and income from waged productive activities require better skills and knowledge, which the educational centers at close proximity are helpful in building.

Influence of household and farm-specific characteristics

Factors that are postulated to influence income from productive activities include household- and farm-specific characteristics. The results suggest the tendency of income from non-farm household and waged productive activities to increase with age, but only up to a certain age before eventually declining (see similar empirical evidences in Lanjouw *et al.*, 2001; Isgut, 2004; Jonasson and Helfand, 2010).

Human capital indicators (level of education and good health status) play a particularly significant role in boosting income from non-farm household and waged productive activities. Household heads with a certain level of educational achievement (secondary and college-level) were observed to earn higher income from non-farm household and waged productive activities. Among participants in non-farm household productive activities, the effect of going from being illiterate to being in possession of primary and secondary levels of education respectively are 0.77 and 1.21 (see table 4.7). This in other words means that household heads with primary and secondary levels of education earn 116 and 235 percent more income from non-farm home-based enterprises. Similarly, college-level education also makes significant contribution (120%) to income from household productive activities (as compared to being illiterate).

On the other hand, the effect of education on non-farm wage income can be seen from the coefficients of secondary and college-level education. Household heads who possess secondary and college-level education earned more income from non-farm waged activities as compared to illiterate heads. The conditional marginal effects of going from being illiterate to being in possession of secondary and college-level education, respectively are 239 and 530 percent more income from non-farm wage employment, *ceteris paribus*. This is a powerful indication for the rewarding nature of possessing skills and knowledge (educational competence) for earning higher income from non-farm waged and household productive activities. In this regard, there is sufficient empirical evidence to suggest that educational achievement is vital for earning higher income from non-farm household enterprises and waged productive activities (Isgut, 2004; Matsumoto *et al*., 2006; Jonasson and Helfand, 2010).

Labor input is also found to have a significant positive influence on income from non-farm household and waged activities. The higher the number of labor units (in terms of adult members), the higher the income earned from non-farm household and waged activities. As a physical human capital, the results highlight the importance of labor input for earning higher income from non-farm household enterprises and waged activities. Human capital can be further bolstered by the state of health of the household head and members and can be one of the important factors influencing employment, productivity and income as a result. Results suggest that household heads that experienced health problems had lower income from both non-farm household and waged productive activities.

Table 4.5: Estimates of income from farm productive activities

	Selection equation		Outcome equation	
Variables	Coefficient	Std. error	Coefficient	Std. error
Age	0.005	0.001***	-0.002	0.002
Age-squared	-3.2×10^{-5}	7.8×10^{-5}	4.5×10^{-5}	1.1×10^{-5}
Female	0.217	0.011***	-0.323	0.146**
Adult members	0.061	0.020***	0.051	0.008***
Dependent members	0.031	0.003***		
Married	0.162	0.084*	-0.103	0.216
Primary education	0.145	0.180	0.089	0.097
Secondary education	-0.267	0.234	0.275	0.210
College and above education	-0.223	0.057***	0.125	0.237
Health status	-0.069	0.006***	-0.019	0.133
Cattle ownership	0.010	0.006*	0.023	0.001***
Access to land	0.351	0.018***	0.324	0.017***
Home ownership	0.524	0.054***	0.066	0.127
Access to electricity	-1.564	0.167***	1.660	0.093***
Tapped (piped) water	-0.411	0.228*	0.778	0.051***
Access to town functions (distance in km)				
Markets	-0.500	0.396	-0.015	0.008*
Primary schools	-0.012	0.018	0.018	0.0006***
Secondary schools	0.002	0.0003***	0.002	0.0009***
Taxi and bus for transport	-0.597	0.289**	-0.014	0.002***
Dry weather road	-0.004	0.002**	-0.010	0.001***
Telephone booth	-0.012	0.003***	-0.001	0.0004***
Constant	0.577	0.060***	6.070	0.514***
λ (IMR)			-1.236	0.011***
Wald $\chi^2 (\rho = 0)$			376.4***	

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: robust standard errors are reported.

Finally, the empirical results indicate a significant effect of access to land and home ownership on income from non-farm household and waged productive activities. These physical capital elements are particularly vital for the establishment and profitability of non-farm household enterprises and hence income from them. Better access to land among participants of non-farm waged productive activities may enable them to invest on the land and help diversify economic activities that contribute to higher income (see also Abdulai and CroleRees, 2001). But, there are other studies that report an insignificant effect of land holdings to non-farm income (for instance, Matsumoto *et al*., 2006).

4.5.3 Income from farm productive activities

Town functions' influence on farm income

The transport infrastructure (dry-weather roads and the presence of taxi and/or bus transport) is another vital element of town functions that is observed to significantly influence income from farm productive activities. Estimation results show that with distance to dry weather roads and transport services, income from farm productive activities declines. The conditional marginal effects of log of income with respect to distance to dry-weather roads and transport services are estimated to be 0.013 and 0.014. The implication is that increasing distance to dry-weather roads and transport services each by 1 km reduces income from farm productive activities by 1.3 and 1.4 percent, *ceteris paribus*. This would suggest that if households were to be relocated far away from these functions, their income would be much lower. The indication is that these town functions are particularly important to farm income because more access to these facilities means that households can get useful farming inputs at lower costs and transport their farm products to markets, helping them earn higher farm-gate prices and thus higher farm income. The significant contribution of the transport infrastructure to welfare improvement (through increasing farm income) obtained from our empirical evidence is a consistent finding with previous empirical studies (notably, Dercon and Hoddinott, 2005; Dercon *et al*., 2009; Khandker *et al*., 2009).

Access to electricity and tap water was observed to discourage employment in farm productive activities but tend to help increase farm income (table 4.5). Households with access to electricity and clean drinking water may rather engage themselves in non-farm productive activities, which are more rewarding. However, for households that were employed in farm productive activities access to electricity and tapped water in fact help them earn more farm income. This may happen through wage employment in farming and activities that process farm products. The magnitude of the effect of these functions is less than that of non-farm income but still significant. All other things being constant, access to electricity and clean water increases farm income by 45 and 61 percent, respectively. One reason for this significant effect may be the important nature of electricity and clean water in 'powering' some farm (agricultural) activities that increase productivity (efficiency) and production. The health impacts of access to clean drinking water can help also build the 'human capital' asset of household members, which in turn can have a positive effect on farm productivity and income.

Table 4.6: Marginal and discrete effects for total income

Variables	Non-farm household enterprises income	
	Probability of participation	Conditional marginal effect
Discrete effects		
Female	-0.025 (0.008)**	-0.242 (0.076)**
Married	0.004 (0.006)	0.429 (0.039)***
Primary education	0.106 (0.009)***	0.340 (0.026)***
Secondary education	0.080 (0.026)**	0.686 (0.302)**
College education	0.065 (0.005)***	1.151 (0.320)***
Health status	-0.003 (0.012)	-0.002 (0.051)
Access to land	0.007 (0.013)	0.002 (0.009)
Home ownership	0.055 (0.002)***	0.380 (0.071)***
Access to electricity	0.072 (0.023)***	0.947 (0.223)***
Tapped (piped) water	0.042 (0.057)	0.816 (0.080)***
Marginal effects		
Age	0.019 (0.001)***	0.127 (0.001)***
Adult members	0.005 (0.004)	0.078 (0.002)***
Dependent members	-0.001 (0.001)	-0.001 (0.002)
Markets	-0.008 (0.004)**	-0.007 (0.002)**
Primary schools	-0.010 (0.003)**	-0.010 (0.009)
Secondary schools	-0.001 (5.9×10^{-4})**	-0.012 (0.001)***
Taxi & bus for transport	-0.002 (0.002)	-0.004 (0.004)
Dry weather road	-0.003 (3.7×10^{-4})**	-0.028 (0.003)***
Telephone booth	-0.001 (0.001)	-0.005 (0.003)

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: robust standard errors are reported.

In relation to this, market accessibility by farm households can also be vital for boosting farm income. The estimation results (table 4.5) show that distance to markets is inversely related to the income from farm productive activities. The conditional marginal effects of log of income with respect to distance to markets indicate that a 1 km increase in distance to markets leads to a reduction of income from farm productive activities by 1.5 percent, *ceteris paribus*. Closer markets help households earn higher farm income because they can get higher farm gate prices and also can acquire vital information related to prices.

Telephone services are the other major town function that can contribute to higher income from farm productive activities. The effect of fixed transaction costs can be minimized if households have access to a telephone at close proximity. This is expected to help households in obtaining vital prices and input-related information, which ultimately play a positive role in farm production, sales and income. In relation to this, educational institutions (primary and secondary schools) are expected to support farm (agricultural) productive activities by creating opportunities for training, creating skilled labor and promoting better farm management techniques and productivity-enhancing technologies that ultimately exert a positive influence on farm income. This notion suggests a closer distance to primary and secondary schools would help increase farm income. However, as the results in table 4.5 show this argument finds little support from our data. It may be that, with close proximity to primary and secondary schools, households have the opportunity to equip themselves with the skills required to work more in non-farm activities and less in farm activities, which eventually may reduce farm income.

Table 4.7: Marginal effects for income from each productive activity

Variables	Non-farm household enterprises income		Non-farm wage income		Farm income	
	Probability of participation	Conditional marginal effect	Probability of participation	Conditional marginal effect	Probability of participation	Conditional marginal effect
Age	0.003 (0.002)	0.025 (0.021)	0.008 (0.004)**	0.053 (9.6×10^{-4})***	0.002 (4.9×10^{-4})***	-0.001 (0.003)
Female	-0.005 (0.015)	0.135 (0.114)	-0.001 (0.030)	-0.191 (0.019)***	0.083 (0.003)***	-0.172 (0.142)
Adult members	0.002 (0.005)	0.010 (0.002)***	0.003 (0.001)	0.075 (0.007)***	0.024 (0.008)***	0.009 (0.005)*
Dependent members	0.011 (0.001)***	-0.075 (0.019)***	0.003 (0.002)	0.043 (0.021)**	0.012 (0.001)***	0.022 (0.002)***
Married	0.001 (0.001)	0.066 (0.168)	-0.020 (0.009)**	-0.036 (0.028)	0.063 (0.032)*	0.013 (0.157)
Primary education	0.013 (0.042)	0.774 (0.167)***	0.035 (0.041)	0.024 (0.355)	0.055 (0.066)	0.188 (0.021)***
Secondary education	0.056 (0.098)	1.210 (0.870)*	0.607 (0.065)***	1.215 (0.223)***	-0.105 (0.046)**	0.474 (0.044)***
College education	-0.032 (0.014)**	0.790 (0.202)***	0.894 (0.112)***	1.841 (0.225)***	-0.088 (0.023)***	0.040 (0.190)
Health status	-0.049 (0.004)***	-0.676 (0.069)***	-0.074 (0.036)**	-0.196 (1.0×10^{-4})***	-0.027 (0.003)***	-0.068 (0.127)
Cattle ownership					0.004 (0.002)**	0.030 (0.003)***
Access to land	0.019 (0.017)	0.090 (0.129)	-0.090 (0.016)***	0.207 (0.177)	0.195 (0.002)***	0.053 (0.019)***
Home ownership	0.037 (0.009)***	0.137 (0.118)	-0.051 (0.007)***	0.330 (0.100)***	0.175 (0.013)***	0.398 (0.105)***
Access to electricity	0.136 (0.011)***	0.850 (0.382)**	0.164 (0.077)**	0.610 (0.038)***	-0.557 (0.042)***	0.370 (0.081)***
Tapped (piped) water	0.004 (0.002)**	1.500 (0.208)***	0.130 (0.051)**	0.880 (0.101)***	-0.161 (0.089)*	0.475 (0.118)***
Town functions						
Markets	-0.002 (0.7×10^{-4})***	-0.049 (0.001)***	-0.120 (0.013)***	0.026 (0.284)	-0.292 (147)**	-0.015 (0.007)**
Primary schools	0.0003 (0.001)	0.085 (0.025)***	-0.015 (0.004)***	-0.018 (0.057)	-0.005 (0.007)	0.010 (0.012)
Secondary schools	0.002 (1.5×10^{-4})***	0.020 (0.002)***	0.002 (7.7×10^{-4})**	-0.002 (0.001)**	0.001 (1.3×10^{-4})***	0.004 (0.001)***
Taxi & bus for transport	-0.004 (0.002)**	-0.012 (0.037)	-0.052 (0.016)***	-0.007 (0.004)*	-0.206 (0.164)	-0.014 (0.002)***
Dry weather road	-0.001 (0.001)	-0.036 (0.012)***	-0.0003 (0.001)	-0.027 (0.008)***	-0.001 (0.001)	-0.013 (0.003)***
Telephone booth	-0.076 (0.034)**	-0.007 (0.002)***	-0.004 (4.6×10^{-4})***	-0.007 (0.001)***	-0.005 (0.001)***	-0.007 (0.002)***

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: values in parentheses are standard errors.

Influence of household and farm-specific characteristics

Farm earnings are found to be lower for female-headed households. However, the results suggest that it is the female-headed households that have a higher probability of employment in farm productive activities as compared to male-headed households. The conditional marginal effect of log of income from farm productive activities with respect to female heads among participants of farm productive activities is 0.172 (=18.8%), implying that female-headed households had 18.8 percent lower income from farm productive activities as compared to male-headed households, *ceteris paribus*. Often in developing countries, male-headed and female-headed households may have varying access to important farm inputs (such as land) or bullock ownership, which can have a significant effect on farm income.

The educational level of household heads is observed to have an inverse relationship with employment in farming, especially secondary education and above. Results on the other hand are observed to have no significant effect on income from farm productive activities. While our results indicate the negligible effect of education on farm income (see also Corral and Reardon, 2001; Matsumoto *et al*., 2006), other studies such as Isgut (2004) present empirical evidence that show the significant effect of education on farm income.

Moreover, results show that farm income increases with access to land. The conditional marginal effect of log of income from farm productive activities with respect to access to land is 0.053. This indicates that among participants of farm productive activities, households with access to land earn 5.4 percent more income from farm productive activities as compared to households without access to land, *ceteris paribus*. Participation in farming and production, and hence farm income, is usually positively associated with access to land and land holdings (see also Matsumoto *et al*., 2006). Similarly, cattle (especially oxen ownership) are among the vital inputs in crop farming in rural areas of Ethiopia and many other developing countries. In this case, income from farm productive activities is positively associated with oxen ownership.

4.6 Town functions and income: Discussion of key roles

Rural towns and towns possess many of the major functions that are often lacking in rural areas of developing countries. In rural towns and towns, different productive activities can flourish with the help of the functions and become instruments of household income growth and hence foster economic development (Mukherjee and Zhang, 2007). The geographical distribution of these towns, in terms of accessibility to, and remoteness from, households is important because of the relative high proportion of rural households. However, due to rural-urban linkages there is also a positive effect for urban households. Empirical findings suggest that income decline with distance to roads. Comparatively, the effect of longer distance to roads is stronger on income from non-farm household enterprises (3.6%), total income (2.8%) and non-farm wage income (2.7%) per 1 km reduction in distance. Greater distance to roads also was observed to harm non-farm income more than farm income. This relationship is also pointed out by Lanjouw (1999) who emphasizes the critical importance of the transport infrastructure for income from non-farm activities located in towns and urban areas. The longer the distance to these towns, the higher the negative effect on non-farm income. Conversely, it is also emphasized that shorter distances to roads leading to towns can translate into higher income (Abdulai and Delgado, 1999; Jonasson and Helfand, 2010) from non-farm jobs that are often concentrated in towns and higher-order urban areas (Fafchamps and Shilpi, 2003). The influence of shorter distances on farm income is positive, but rather small (see also Dercon and Hoddinott, 2005; Dercon *et al*., 2009).

Table 4.8: Elasticities and discrete effects of town functions on income

Town functions (distance in km)	Income categories			
	Total income	Non-farm income		Farm income
		Home-based	Wage	
Elasticities				
Markets	-0.7 (0.21)	-5.1 (0.13)	2.6 (2.84)	-1.5 (0.79)
Primary schools	-1.0 (0.89)	8.9 (2.50)	-1.8 (5.68)	1.0 (1.19)
Secondary schools	-1.2 (0.12)	2.0 (0.19)	-0.2 (0.15)	0.4 (0.10)
Dry-weather roads	-2.8 (0.30)	-3.6 (1.23)	-2.7 (0.78)	-1.3 (0.28)
Bus/taxi transport	-0.4 (0.43)	-1.2 (3.71)	-0.7 (0.37)	-1.4 (0.22)
Telephone booth	-0.5 (0.33)	-0.7 (0.15)	-0.7 (0.13)	-0.7 (0.22)
Discrete effects[a]				
Electricity	124.2 (22.3)	134 (38.2)	84 (3.76)	44.8 (8.07)
Tap water	126.1 (8.0)	348.2 (20.8)	141 (10.1)	60.8 (11.8)

Notes: values in parentheses are standard errors.
The semi-elasticities indicate the effect of a 1 km increase in distance to the town functions on the percentage change of income from productive activities.
[a] For electricity and tap water, figures represent the effect of going from 0 to 1.

However, the literature indicates that road distance alone may not cause a significant increase in income. For instance, Matsumoto *et al*. (2006) find that proximity to the nearest town brought more income from farm and non-farm activities in Kenya, while the same empirical evidence concludes that proximity did not translate into higher income in Ethiopia and Uganda. It may be that shorter road distances leading to towns do not always lead to higher income if the quality of these roads is poor (Lanjouw, 1999; Gibson and Olivia, 2010). It could also be that 'good state of roads' may not bring significant non-farm income growth if accessible transport systems are limited or lacking (Abdulai and Delgado, 1999). The indication is that road quality and transport services are useful to income. From our empirical results, the effect of distance to transport services is observed to have a stronger effect on farm income, which may come through improved farm sales (1.4%, see table 4.8). This is because farm income may depend to a large extent on taking farm products at lower cost to markets in towns. In this regard, shorter distances to roads that lead to towns and markets helps boost income through facilitated (lower cost or higher farm gate prices) transport of farm products. Similarly, transport services can be useful to transport products of home-based enterprises, which eventually affects income. The longer the distance, the lower is the income from home-based enterprises (a reduction of 1.2% for each 1 km increase in distance to transport services).

The implication so far as transport infrastructure is concerned is that shorter distances to roads coupled with accessible transport systems significantly contribute to connecting households with employment opportunities in towns, which leads to higher income. Therefore, investment in the transport infrastructure in less-endowed areas may enable a reduction in production costs and transaction costs. This would foster trade and make division and specialization of labor possible, which is regarded as a crucial element for higher income and sustainable economic growth (Calderón and Chong, 2004) and household welfare improvements through helping increase income and consumption (Decron and Hoddinott, 2005; Pender and Gebremedhin, 2008).

Similarly, market accessibility is observed to be instrumental in promoting income. The contribution of shorter distances to markets is particularly useful to income from non-farm home-based and farm productive activities (the effect being stronger on income from home-based enterprises, which is 5.1%). This is because the level of income from these activities (home-based and farm productive activities) is significantly dependent on the level of sales of the products of each activity. Closer markets (also lower transport and transaction costs as a result) can mean higher farm-gate prices for farm products and a bigger profit-margin for home-based products, which can lead to higher income. However, the effect on total income is found to be much smaller (only a 0.7% reduction in total income for a 1 km increase in distance to markets). This is mainly influenced by the opposite - although imprecise - effect on non-farm wage income. An indication in this case is that households that largely depend on home-based enterprises would benefit to a large extent if markets are brought closer to them. Rural towns and towns often accommodate the major markets that home-based and farm productive activities use to sell their products. In this regard, Pender and Gebremedhin (2008) find a strong positive impact of market access on household income, and suggest the development of rural towns and marketing systems in order to improve agricultural productivity, income and hence to reduce poverty.

Shorter distance to telephone services and connection to electricity and tap water facilities are highly associated with higher income from non-farm household enterprises and formally established non-farm productive activities. In this case, the effect of telephone access (in terms of a 1 km reduction in distance) is found to have a similar effect (0.7%) on income from the three types of productive activities. The aggregate effect (0.5%) is slightly lower. These effects may explain the insignificant effect of distance to telephone services on total income. Though mobile telephone services were hardly operational when data for this study was collected, expansion of mobile phones can effectively render distance to fixed telephone lines less influential. Furthermore, the discrete effects of access to electricity indicate that income for total income and income from home-based enterprises more than doubles when households are connected to electricity. It can also be seen that electricity access has the least, but still significant, effect on farm income (45% more farm income with connection to electricity). The evidence in this regard provides grounds for continuing and even expanding public financing on connecting small rural towns to their surrounding areas. This argument is further strengthened by the fact that these functions not only contribute to non-farm income but also would bring significant transformation to the farm sector in rural areas (Lanjouw, 1999; Isgut, 2004). This is because the production linkages that these functions create with activities in rural towns and towns can further increase employment opportunities and income.

As a final remark, the role of town functions may not be restricted to increasing income only. Calderón and Chong (2004) present sufficient empirical evidence to suggest that the expansion of such important town functions (both in terms of quantity and quality) help not only reduce poverty (through increased farm and non-farm incomes) but also income inequality. Dercon and Hoddinott (2005) in addition stress the importance of vital functions such as roads and markets in poverty reduction and welfare improvement. Given the important nature of major functions such as market information systems, roads and transport, electricity, tap water and telephone services, selective investment in one or more of the functions can connect households with opportunities in towns and other urban centers. It can also create platforms for the establishment and expansion of productive activities (through providing inputs such as electricity and opening up market opportunities such as roads and transport or markets) that can contribute to higher household income.

4.7 Concluding remarks

The primary approach of this chapter is to examine the effect of different town functions on income from productive activities in rural and urban households in a developing country. Total income from productive activities is constructed based on three observed income categories, distinguished as non-farm household income, non-farm wage income and farm income. Then, each of the income categories are aggregated to construct total income. We considered a relatively broad spectrum of major town functions to examine the effect on income from productive activities. This enables us to single out the most influential town functions (with their quantitative effect), thus improving our understanding of the varying degrees of effect that different town functions have on household income.

We find the transport infrastructure to be one of the major town functions that significantly influences income from productive activities. Total income is positively associated with shorter distances to dry-weather roads. The evidence suggests that proximity to dry-weather roads and transport facilities such as taxi and bus services are associated with positive income growth from farm and non-farm productive activities. The importance of closer roads is emphasized when substantial reduction in distance is achieved. For instance, a 10 km reduction in distance to roads leads to respectively 28, 36, 27 and 13 percent more total income, non-farm household income, non-farm wage income and farm income, *ceteris paribus* (all from productive activities). Shorter distances to markets similarly were observed to positively influence income from productive activities. Findings also show that access to electricity as a source of light and power, as well as, to tap water are significantly and positively associated with total income and income from each of the observed productive activities. These findings suggest that the expansion of infrastructural elements including roads, transport, power (electricity), tap water and telephones are instrumental in increasing household income from productive activities.

Current macroeconomic policies in Ethiopia are such that the overall economy is engineered by dynamic rural development (dynamic agricultural sector). Within this general policy lies the expansion of transport facilities, educational institutions and marketing services, particularly to the vast rural poor. And, this is expected to play an even bigger role in increasing income from various farm and non-farm productive activities. The importance of town functions to increasing farm income is particularly emphasized since a great proportion of the Ethiopian population lives in rural areas and derives its income from farm activities. Bringing functions as much closer to households can have a significant multiplier effect in improving rural farm income, which ultimately can contribute to non-farm income through the process of forward and backward linkages in production and consumption (Woldehanna, 2000).

The coefficients of distance to primary and secondary schools on the income categories suggest scattered effects. Close proximity to secondary schools was found to increase total income while distance to schools has the opposite effect on farm income and income from non-farm home-based enterprises. This may be because accessible schools help households equip themselves with skills and knowledge that are useful for total income (through wage income). Closer schools may be expected to provide households with skills and management knowledge that may influence non-farm household income and farm income. However, the empirical findings do not support this relationship, which is unexpected. One explanation is that households close to schools (and therefore expected to gain skills and knowledge from schools) may opt for non-farm wage employment. However, this still does not explain why they may not earn higher farm income and non-farm income from household enterprises. Further research is required to examine the unexpected relationship.

Similar to previous studies, we find that variables used as proxy for human capital such as education level and health status are among the significant determinants of total income and income from non-farm household and waged productive activities. A higher educational level and a good health status are associated with higher income from these productive activities.

Therefore, developing the human capacity of households and providing the necessary institutional (infrastructural) elements that reinforce skills and knowledge of households are instrumental in increasing income, especially income from non-farm waged productive activities.

Finally, we note that the analysis in this chapter was based on cross-sectional data. For a better understanding of income growth however (*vis-à-vis* town functions), panel data on employment and income would make it feasible to quantify the importance of different types of linkages (labor market, input market, etc.) and the influence of town functions that are bound to change over time. Studies that consider the interaction among town functions and different productive activities would also be useful for gaining a much better understanding of the role of town functions.

Appendix 4.1A: *Derivation of conditional marginal effects*

Given the selection and outcome models in (4.7)-(4.10) the derivation of the conditional marginal effect from the conditional expectation of y with respect to the kth regressor (x_k), can be presented as (see Hoffmann and Kassouf, 2005):

$$\begin{aligned}\frac{\partial E(y_i|y_i>0)}{\partial x_k} &= \theta_k + \beta_\lambda \frac{\partial}{\partial \alpha_u}\left[\frac{\phi(\alpha_u)}{1-\Phi(\alpha_u)}\right]\frac{\partial \alpha_u}{\partial x_k} \\ &= \theta_k + \beta_\lambda \frac{\phi'(\alpha_u)[1-\Phi(\alpha_u)]+[\phi(\alpha_u)]^2}{[1-\Phi(\alpha_u)]^2}\times\left(-\frac{\gamma_k}{\sigma_u}\right)\end{aligned} \qquad (4.1a)$$

where $\beta_\lambda = \rho\sigma_\varepsilon$. The term $\phi'(\alpha_u)$ equals $-\alpha_u\phi(\alpha_u)$, and it follows that

$$\begin{aligned}\frac{\partial \mathrm{E}(y_i|y_i>0)}{\partial x_k} &= \theta_k + \beta_\lambda \left\{[\lambda(\alpha_u)]^2 - \alpha_u\lambda(\alpha_u)\right\}\left(-\frac{\gamma_k}{\sigma_u}\right) \\ &= \theta_k - \frac{\gamma_k}{\sigma_u}\beta_\lambda\lambda(\alpha_u)[\lambda(\alpha_u)-\alpha_u]\end{aligned} \qquad (4.2a)$$

Denoting $\lambda(\alpha_u)[\lambda(\alpha_u)-\alpha_u]=\delta$, the marginal effect of x_k on the conditional expected value of y is given by

$$\frac{\partial \mathrm{E}(y_i|y_i>0)}{\partial x_k} = \theta_k - \frac{\gamma_k}{\sigma_u}\beta_\lambda\delta \qquad (4.3a)$$

The marginal effect of an explanatory variable x_k affects the actual conditional expectation of y in three ways: through its effect on the selection equation (captured by γ_k), through its direct effect in the conditional equation (captured by θ_k) and through its indirect effect through the inverse Mills ratio λ (captured by $\delta = \lambda(\alpha_u)[\lambda(\alpha_u)-\alpha_u]$) Correspondingly, the statistical significance of the marginal effects depends on the standard errors, variances, and covariance of all of these parameters (Dow and Norton, 2003).

If on the other hand x_k is a binary explanatory variable, the marginal effect is interpreted as the effect of going from 0 (non-participation) to 1 (participation). Suppose $\overline{\mathbf{w}}_{(0)}$ denotes the vector of explanatory variables in the selection (participation) equation with x_k equal to zero, and all the other variables at their mean values, and let $\overline{\mathbf{w}}_{(1)}$ be the same vector, but with x_k

equal to one. It follows from equation (4.10) that the conditional marginal effect of x_k going from 0 to 1 is

$$E[y_i | y_i > 0, \mathbf{x}] = \mathbf{x}_\mathbf{i}'\boldsymbol{\theta} + \beta_\lambda \Delta\lambda \qquad (4.4a)$$

Interest usually lies in computing the marginal effect at the mean values and in that case $\Delta\lambda$ can be computed as (see Hoffmann and Kassouf, 2005)

$$\Delta\lambda = \frac{\phi\left(\boldsymbol{\gamma}\overline{\mathbf{w}}'_{(1)}/\sigma_u\right)}{\Phi\left(\boldsymbol{\gamma}\overline{\mathbf{w}}'_{(1)}/\sigma_u\right)} - \frac{\phi\left(\boldsymbol{\gamma}\overline{\mathbf{w}}'_{(0)}/\sigma_u\right)}{\Phi\left(\boldsymbol{\gamma}\overline{\mathbf{w}}'_{(0)}/\sigma_u\right)}$$

When y_i is specified as the natural logarithm of income, the conditional marginal effect equations of $(4.3a)$ and $(4.4a)$ corresponds to a relative change in earnings. The estimated percentage change in earnings due to a unit increase in x_k can be computed from $[\exp(c)-1]\times 100$, where c is the estimated value of the conditional marginal effect. Derivation of unconditional marginal effects can be obtained from Hoffmann and Kassouf (2005). A different perspective of the derivation of conditional and unconditional marginal effects from a Heckman selection model can also be obtained from Yen and Rosinski (2008).

CHAPTER 5

THE ROLE OF TOWN FUNCTIONS AND NETWORK RELATIONS IN HOUSEHOLD CROP OUTPUT MARKETING

Abstract

In rural areas of developing countries, markets are highly imperfect. This may be due to, among other things, a lack of infrastructural facilities, which provide vital functions. In this chapter, the objective is to examine crop marketing behavior in response to network relations and access to functions provided from towns. For this purpose, data collected in Ethiopia from a sample of 1290 rural households is used. Town functions may affect not only *choice* and *sales share* but also *ability* to participate. Moreover, the effects can be different. To account for this, the double hurdle model is used. Results show that market participation ability and sales share decline with distance to markets, roads, telephone and educational centers. Furthermore, road type and quality is found to play significant role in enabling increased market participation and intensity of marketing. Moreover, the strength of network relations influences sales share in a positive way. These results suggest that interventions aimed at strengthening household networks and expanding major functions provide considerable opportunity to strengthen rural households' linkage with towns in order to promote crop marketing and commercialization.

Key words: town functions, network relations, crop marketing, transaction costs, Box-Cox double hurdle, Ethiopia

5.1 Introduction

Understanding the role that different town functions play in rural household output marketing can help us identify key functions for prioritized intervention. Functions such as roads, markets and agricultural technologies are among the vital elements that facilitate rural household market access (Alene *et al.*, 2008; De and Chattopadhyay, 2010). Markets and improved market access in turn are of critical importance in enhancing rural household income (Gebremedhin *et al*., 2009). In many rural areas of developing countries however, participation of farm households in output markets remains restricted due to a range of constraints (Jagwe *et al*., 2009). One major reason is that poor infrastructure limits market access for many farm households. Lack of transport infrastructure can lead to high travel costs and farm (agricultural) output transportation. Combined with a lack of telecommunication facilities and weak network relations, this can also raise the costs of searching, screening and getting information, including information that is crucial for linking producers and various categories of rural and urban traders.

Rural or small towns that possess some of the major functions present a considerable opportunity to compensate for the lack of vital infrastructures and institutions in rural areas. Often, these facilities are physically connected to and provided from towns. They are *town functions* in the sense that they provide various functions to rural households and create opportunities for town and rural households to establish and maintain networks. In this case, farm households' access to town functions, networking and agricultural technologies in nearby towns can be instrumental for greater market access and commercialization (Renkow *et al*., 2004; Barrett, 2008). In addition, farm households' profitability can be improved through better access to such town functions as transport and communication facilities and financial services, such as credit (Grootaert *et al*., 2004).

However, the role that town functions play is often overlooked in economic analyses of farm households' crop output marketing behavior (Barrett, 2008). Previous studies that examined output marketing behavior among rural households in developing countries (such as Key *et al*., 2000; Renkow *et al*., 2004; Fafchamps and Hill, 2005) focused on rural infrastructure (with the emphasis on the theoretical analysis). In addition, these and other empirical studies (such as Alene *et al*., 2008; Shilpi and Umali-Deininger, 2008) adopted different approaches to the one used in this chapter. Some of them considered one or two functions (often markets and/or roads) and the others used aggregate indices. Restricting focus to roads and markets however disregards the contribution that other town functions can make to market access and commercialization. Fan and Zhang (2004) for instance argue that investment in, amongst other things, roads, electrification, education, and other public investment in rural areas may be some of the major factors that contribute to the rapid growth in agricultural production in

China (which can induce marketing). And, they continue to assert that omitting these variables (town functions that may influence market access) will likely bias estimates.

In this chapter, we study the effect of a relatively broad spectrum of town functions on farm households' crop output marketing behavior. The specific objective of this chapter is to examine the influence of major town functions on crop market participation ability, the decision to participate and the intensity of participation. For this purpose, we consider data collected from farm households in 15 rural areas of Ethiopia. To achieve this, we employ the Box-Cox double hurdle model (Jones and Yen, 2000) to estimate the relationships between crop marketing behavior and access to town functions.

The rest of the chapter is structured as follows. In section 5.2, we present a concise model of household utility-maximizing behavior under transaction costs in order to highlight the implication for farm households' market participation and crop quantity marketed. We then present the estimation strategy in section 5.3. In this section, we start by briefly discussing the methods that we used to construct different indices (for network relations and social capital) and then proceed to the specification of the Box-Cox double hurdle model used for estimation purposes. In section 5.4, a general description of the dataset used for analysis is presented. In section 5.5, we present the estimation results and discuss the role of town functions and network relations in farm households' crop output marketing behavior. Finally in section 5.6, we draw conclusions and discuss the implications of the empirical findings.

5.2 Conceptual framework

Analyzing the influence of town functions and network relations on household crop output marketing can be done in a framework which views these elements as exogenous utility-influencing factors. In this framework, we start from the proposition that the farm household's objective is to maximize utility (U) by making non-separable household consumption and production decisions.

$$Max\ U = U(c, l; \mathbf{z_s}) \tag{5.1}$$

where c is the consumption of own produced and/or purchased goods, l is leisure and $\mathbf{z_s}$ is the vector of utility-shifting household characteristics.

Rural household crop market decision-making is assumed to be affected by transaction costs. These transaction costs can be of two types. On the one hand, there are fixed transaction costs incurred when a farm household searches for market information, negotiates, screens and bargains marketing activities. On the other hand, there are variable transaction costs associated with transportation (transport cost) and imperfect information. We argue that town functions, network relations and social capital influence these (variable and fixed) transaction costs. Non-existent or limited town functions can lead to prohibitive transaction costs that prevent transactions from taking place. Excessive transaction costs due to a lack of functions or a weak network can also make a transaction much more expensive. In this case, Key *et al*. (2000) state that factors that can be observed (such as assets and networks) can help explain transaction costs, which can vary with crop sales amount (variable transaction costs) or can be fixed regardless of the exchange amount (fixed transaction costs).

Some of the major town functions such as markets, roads and transport facilities (denoted by the vector $\mathbf{TF_v}$) mainly influence variable transaction costs. On the other hand, town functions such as telephone services and extension or agricultural cooperative centers can help reduce fixed transaction costs through facilitating the flow of market information (these are denoted by the vector $\mathbf{TF_f}$). Similarly, network relations that households individually establish can help 'bridge the gap' in facilitating the exchange of market information when communication town functions are lacking or limited. Likewise, social capital, which can be assumed to play the role of 'institutional environment' represents the 'social fabric' that gets things going and supplements network relations. Both of these forms of institutions are denoted by the vector **NS**.

Following Key *et al*. (2000), suppose τ_q^v denotes variable transaction costs per unit of sales (q) and τ_s^f denotes fixed transaction costs. If a farm household participates in crop output marketing, the adjusted crop output price become $p_s^t = (p_s - \tau_q^v)$, where p_s is the price of crop outputs sold at the market. In this chapter, we focus on two hurdles that have to be taken to participate in crop marketing. The first hurdle is related to the ability of participate (D) in a crop market. This relationship is specified as[1]

[1] The way town functions are integrated into the household model is presented in Appendix 5.1A. Here reduced forms are derived.

$$D = D\{\tau_s^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\} \tag{5.2}$$

When the lack of town functions is not prohibitive, the first hurdle of market participation is taken. Then, the second hurdle can be considered. The second hurdle is to decide about market participation and sales share. In this decision, the price (p_s) and variable transaction costs play a vital role next to the role of the fixed transaction costs. The participation and sales share (share of total crop output sold) function (S) is specified as

$$S = S\{p_s, \tau_q^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\} \tag{5.3}$$

A possible outcome is to decide not to participate in the market. In this case, the second hurdle is not taken and we observe zero sales share. If the second hurdle is taken, a positive sales share is observed. Town functions, network relations, social capital and household characteristics can all have an influence on both the ability to participate and the participation and sales share decision.

Town functions that affect both fixed and variable transaction costs are represented by distance (*d*). On the other hand, strength of network relations and social capital that influence fixed transaction costs are represented by indices. Based on this, the influence on crop output marketing can be presented as

$$D = D\{\mathbf{NS}, a(d, \mathbf{TF_f}), g(d, \mathbf{TF_v}); \mathbf{z_s}\} \tag{5.4}$$

$$S = S\{p_s, \mathbf{NS}, a(d, \mathbf{TF_f}), g(d, \mathbf{TF_v}); \mathbf{z_s}\} \tag{5.5}$$

where $a(d, \mathbf{TF_f})$ and $g(d, \mathbf{TF_v})$ respectively show the vector of distance to town functions that influence fixed and variable transaction costs.

5.3 Estimation strategy

5.3.1 Construction of network and social capital indices

In the literature, no clear-cut measurement procedure for network relations and social capital has been defined. Definitions for social capital and network relations vary where different indicators can be considered depending upon household- and community-specific characteristics. A common approach in measuring multidimensional social capital and network relations involves aggregation of information provided by many indicator variables into a composite index. The first step in building a summary measure of social capital and network relations concerns the selection of appropriate indicators. Once a preliminary set of variables has been selected, the second step is aggregation into a composite index in order to construct an appropriate weighting structure. By considering an appropriate model *vis-à-vis* our data, we construct indices of network relations and social capital in an attempt to see their effect on crop output marketing.

In the literature, principal components analysis (PCA) has been commonly used to construct indices. This is a multivariate statistical technique used to reduce data dimensionality. The applicability of this statistical technique is generally related to the type of data at hand. PCA is normally used when all the variables are strictly continuous and the relationship among the variables is linear (Asselin, 2002). A practical violation of the assumptions underlying the PCA arises when one wants to construct indices from categorical or discrete data (binary, ordinal or nominal). Njong and Ningaye (2008) argue that the problem arises from the fact that categorical variables do not have an origin or units of measurements, which renders the calculation of mean, variance and covariance meaningless (since PCA relies on covariance matrix estimation).

In our data, the indicators for the strength of network relations are denoted by continuous values. For social capital, we considered the Likert-scale values as if they were cardinal numbers. Based on this, PCA is used to construct indices for network relations and social capital. We run PCA for a number of inter-correlated quantitative indicator variables for network relations (and social capital) to extract the indices for our econometric models.

5.3.2 Method of estimation

In the survey data, not all households participated in crop output marketing, thereby resulting in zero observations. There can be different reasons as to why farm households registered zero responses (did not participate in crop output marketing). The reasons can include both economic and noneconomic factors (i.e. the zero values can be generated by more than one process). In a perfect market where farm households decide about selling solely based on factors such as prices and income, given their characteristics, the Tobit model is appropriate. However, in areas where markets are highly imperfect, a decision can be influenced by other factors such as lack of credit, lack of knowledge, remoteness, a lack of access or limited access to town functions. These factors can lead to high transaction costs preventing or limiting market participation and sales share. In these cases, market participation is governed by both economic and noneconomic factors, which requires the use of an appropriate model that takes this phenomenon (for instance the different data generating process) into account. This phenomenon suggests that decision-making related to crop marketing can involve more than one way of data generating processes.

The double hurdle model is useful in this situation since it considers two ways of data generating processes in decision-making related to crop marketing (Himaz, 2010). This model contains two equations: one equation explaining the ability of households to participate in the market (first hurdle) and the other explaining the choice to participate and intensity of participation once households are able to participate in the market (second hurdle). The second hurdle is similar to a Tobit model explaining participation and intensity of participation when the first hurdle of a reasonable ability to participate is taken. Each hurdle is conditioned by the household's specific characteristics and other exogenous factors. While factors creating market imperfection alone can condition the attainment of the first hurdle, economic factors are important in determining a positive outcome in the second hurdle (Aristei and Pieroni, 2008). The two sequential hurdles that the household has to take to get to a positive marketed amount are the participation ability hurdle and the participation choice hurdle. The first hurdle (*participation ability*) is presented as

$$\begin{cases} w_i^* = \mathbf{z}_i'\boldsymbol{\alpha} + u_i, \qquad u_i \sim iid(0,1) \\ w_i = \begin{cases} 1 & if \quad w_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \end{cases} \tag{5.6}$$

where w_i is a participation variable that takes the value 1 if the household is able to participate in crop output markets and 0 otherwise, w_i^* is a latent variable that relates the ability to participate to a vector, $\mathbf{z}$, containing household and other characteristics that explain market participation, $\boldsymbol{\alpha}$ represents the vector of parameters to be estimated and u_i is the error term assumed to be independently and identically distributed as $u_i \sim (0,1)$.

The second hurdle (*participation choice and level of participation*) is specified as

$$\begin{cases} y_i^* = \mathbf{x}_i'\boldsymbol{\theta} + \varepsilon_i, \qquad \varepsilon_i \sim iid(0,\sigma^2) \\ y_i = \begin{cases} y_i^* & if \quad y_i^* > 0 \ \& \ w_i^* > 0 \\ 0 & if \quad y_i^* \le 0 \ or \ w_i^* \le 0 \end{cases} \end{cases} \tag{5.7}$$

where y_i is the amount of crop output sold, which is obtained from the latent variable y_i^*, the vector $\mathbf{x}$ contains the variables that determine the amount of crop output sold, $\boldsymbol{\theta}$ contains the vector of parameters to be estimated and ε_i is the error term assumed to be independently and identically distributed as $\varepsilon_i \sim (0, \sigma^2)$. While (5.6) is a probit model, (5.7) resembles a Tobit model[2]. The idea behind the double hurdle model is that we can think of (5.6) as saying that when $w_i = 0$, farm household i would not participate in crop output market regardless of factors such as price or variable transaction costs. However, equation (5.7) shows that, even if market participation is possible $(w_i = 1)$, we may still observe zero responses for crop output sold because of low prices or high variable transaction costs.

The standard double-hurdle specification[3] relies on the assumption of bivariate normality of the error terms u_i and ε_i (from equations 5.6 and 5.7). If the normality assumption is violated, the maximum likelihood estimates will be inconsistent. This is particularly relevant when the model is applied to a dependent variable with a highly skewed distribution, as is often the case with survey data on crop output sales. One way to accommodate the assumption of normality is using Box-Cox transformation of the response (outcome) variable as follows:

$$y_i^T = \frac{y_i^\lambda - 1}{\lambda}, \quad 0 < \lambda \le 1 \qquad (5.8)$$

where y_i^T represents the transformed dependent variable and λ is the transformation parameter. In this case, the log-likelihood function becomes (see Moffatt, 2005)

$$\ell(\boldsymbol{\alpha}, \boldsymbol{\theta}, \sigma, \lambda) = \sum_0 ln\left[1 - \Phi(\mathbf{z}_i'\boldsymbol{\alpha})\Phi\left(\frac{\mathbf{x}_i'\boldsymbol{\theta} + 1/\lambda}{\sigma}\right)\right] + \sum_+ ln\left[\Phi(\mathbf{z}_i'\boldsymbol{\alpha}) y_i^{\lambda-1} \frac{1}{\sigma}\phi\left(\frac{y_i^T - \mathbf{x}_i'\boldsymbol{\theta}}{\sigma}\right)\right] \qquad (5.9)$$

---

[2] Equation (5.7) resembles a typical Tobit model because the variable y_i in the same equation is censored at zero.

[3] Log-likelihood of a standard double hurdle modes is specified as

$$\ell(\boldsymbol{\alpha}, \boldsymbol{\theta}, \sigma) = \sum_0 ln\left[1 - \Phi(\mathbf{z}_i'\boldsymbol{\alpha})\Phi\left(\frac{\mathbf{x}_i'\boldsymbol{\theta}}{\sigma}\right)\right] + \sum_+ ln\left[\Phi(\mathbf{z}_i'\boldsymbol{\alpha})\frac{1}{\sigma}\phi\left(\frac{y_i - \mathbf{x}_i'\boldsymbol{\theta}}{\sigma}\right)\right]$$

The likelihood function of the double hurdle model is not separable; even with the assumption of independent hurdle models (see Martínez-Espiñeira, 2006).

This Box-Cox double hurdle model is estimated using Maximum Likelihood where Φ and ϕ are respectively cumulative distribution function (*cdf*) and probability density function (*pdf*) of the standard normal distribution. The first term in (5.9) corresponds to the contribution of all the observation units (to the likelihood) with observed zero sales. The second term is related to the contribution of all observation units with non-zero intensity of crop output sale.

The economic interpretation of estimation results from hurdle models often lies on the marginal effects on the expected value of y_i, which can be decomposed into an effect on participation and an effect on crop amount sold. This is given by

$$E(y_i) = \text{Prob}(y_i > 0) E(y_i | y_i > 0) \tag{5.10}$$

The interpretation of the coefficient estimates can be tricky, particularly when a variable appears in both the first and the second hurdle. In this case, the marginal effect is not given by the coefficient estimate, itself, but rather must be calculated using a non-linear function of the underlying model parameters. In such models therefore, the conditional (and unconditional) responses of marketing behavior (by farm households) to changes in a given independent variable can be reported. Following Jones and Yen (2000), the probability of passing the two hurdles is given by

$$\text{Prob}(y_i > 0) = \Psi\left(\mathbf{z}_i'\boldsymbol{\alpha}, \frac{\mathbf{x}_i'\boldsymbol{\theta} + 1/\lambda}{\sigma}\right) = \Phi(\mathbf{z}_i'\boldsymbol{\alpha})\Phi\left(\frac{\mathbf{x}_i'\boldsymbol{\theta} + 1/\lambda}{\sigma}\right) \tag{5.11}$$

where the errors are assumed to follow bivariate normal distribution (Ψ). On the other hand, the conditional mean[4] of y_i (share of crop amount sold given a particular household is able to participate) is specified as

$$\begin{aligned} E(y_i | y_i > 0) &= E\left(y_i \middle| u_i > -\mathbf{z}_i'\boldsymbol{\alpha}, \varepsilon_i > -\mathbf{x}_i'\boldsymbol{\theta} - \frac{1}{\lambda} \right) \\ &= \int_0^\infty y_i f\left(y_i \middle| u_i > -\mathbf{z}_i'\boldsymbol{\alpha}, \varepsilon_i > -\mathbf{x}_i'\boldsymbol{\theta} - \frac{1}{\lambda} \right) \mathrm{d}y_i \end{aligned} \tag{5.12}$$

[4] The conditional density of $f(y_i|.,.)$ is defined as

$$f\left(y_i \middle| u_i > -\mathbf{z}_i'\boldsymbol{\alpha}, \varepsilon_i > -\mathbf{x}_i'\boldsymbol{\theta} - \frac{1}{\lambda} \right) = \left[\Psi\left(\mathbf{z}_i'\boldsymbol{\alpha}, \frac{\mathbf{x}_i'\boldsymbol{\theta} + 1/\lambda}{\sigma} \right) \right]^{-1} y_i^{\lambda - 1} \frac{1}{\sigma} \phi\left(\frac{y_i^T - \mathbf{x}_i'\boldsymbol{\theta}}{\sigma} \right) \Phi(\mathbf{z}_i'\boldsymbol{\alpha})$$

where Ψ denotes a bivariate normal distribution.

Differentiating equations (5.11) and (5.12) with respect to a given independent variable gives the marginal effects. Using (5.13), elasticities can also be computed (see Jones and Yen, 2000 for the derivation of the elasticities).

$$e = \frac{\partial E(y_i)}{\partial x_{ij}} \times \frac{x_{ij}}{E(y_i)} = \left[\frac{\partial \text{Prob}(y_i > 0)}{\partial x_{ij}} \times \frac{x_{ij}}{\text{Prob}(y_i > 0)}\right] + \left[\frac{\partial E(y_i | y_i > 0)}{\partial x_{ij}} \times \frac{x_{ij}}{E(y_i | y_i > 0)}\right] \quad (5.13)$$

This gives specifically the unconditional elasticity.[5] While the first term represents the elasticity of probability of market participation, the second term denotes elasticity on the amount of crop sold provided that a farm household participates in crop output marketing.

5.4 Data description

The data used in this chapter come from the Ethiopian Rural Household Survey (ERHS) collected in 2004. The household data were collected from 15 rural areas in 4 major regional states of Ethiopia[6] using a structured questionnaire. For the purpose of this chapter, we use a sample of 1290 households that yielded complete information. A wide range of issues affecting rural households' livelihood and living standard were covered in the questionnaire, including marketing of crop outputs, adoption and use of production inputs, land use practices, labor sharing arrangements, off-farm participation, business activities, agricultural credit, networking and social capital, asset ownership and access to town functions (chapter 3 presents a broader description of the data and study areas; see also Kebede, 2002; Dercon and Hoddinott, 2005; Dercon *et al.*, 2009).

The rural areas considered are characterized by different endowments of town functions. Almost all of them had a primary school. Some had only a health clinic and a market. Others had only a school and a clinic but no market. Some had only a primary school. A few did not possess any of the aforementioned facilities. Some of the major town functions (such as telephone facilities, banks, post offices, markets, electric power, higher schools and health

[5] Conditional elasticity refers to the effect of a given regressor on crop output sales share, given that a household passes the first hurdle. This effect is therefore relevant only to a sub-sample (market participants only). On the other hand, unconditional elasticity refers to the effect of regressors on crop output sales share for all households (both market participants and non-participants).

[6] These study areas constitute the highlands of Ethiopia where mixed farming is the main livelihood strategy. Thus, readers need to be cautious as the dataset does not incorporate pastoral households.

centers) were not available in the rural areas. Households needed to travel to the nearest towns or secondary and tertiary towns/urban areas to reach the town functions.

As variables of main concern, town functions are among the explanatory variables that are hypothesized to influence crop marketing. Distance indices to major town functions including roads, markets and telephone services are considered. We hypothesize that the higher the index (i.e. the nearer the town function) the lower the transaction costs and the higher the participation and sales share. In addition, access to knowledge-generating, processing and disseminating functions (such as schools, extension and agricultural cooperative centers) are hypothesized to lower transaction costs and increase market participation and sales share. Indices from network relations and social capital are used to explore the effect of the number and frequencies of interactions that households have with different economic agents. Higher indices of network relations refer to greater number and frequencies of interactions, which can help households obtain market-related information. In this case, it is hypothesized that strong networks contribute to higher crop output market participation and sales share.

Crop output prices are also considered. For this, sufficient price variation is observed for crop outputs and used as average prices in estimation. Higher crop prices are hypothesized to encourage farm households to visit the market and transport more crop output to the market as it would lead to higher profits. Other factors considered include livestock size and off-farm employment. These are expected to ease liquidity constraints that households have to cover from the sales of crops. More livestock or off-farm participation can lead to more income that would otherwise have been obtained from crop sales. This can lead to lower crop market participation and sales share. Fertilizer application is hypothesized to promote crop marketing through enhancing production and productivity, in which the resulting surplus may be channeled to the market for sale.

Similarly, agricultural infrastructure such as irrigation service can help boost production. This may lead to surplus production, a part of which may be sold at the market. Attributes related to land and land characteristics are also considered. With land size, it is hypothesized that crop marketing would increase since the scale of economies created by land size would lead to higher production and surplus for sale. For these and other variables, *a priori* hypothesized relationships among market participation and distance to town functions are indicated in table

5.1. Furthermore, the dependent and some of the explanatory variables used for regression analysis and their descriptive statistics are reported in table 5.1.

Non-parametric Lowess[7] smoothers can be used to present exploratory relationship between crop sales and town functions (or network relations). A Lowess curve can be usefully thought of as a graph that indicates whether predicted values of crop sales (from regression rather than means) is followed by data from town functions (i.e., if the independent follows the data of the dependent variable). It can also give an indication as to whether the pattern of relationship is linear or not, which would help determine model specification.

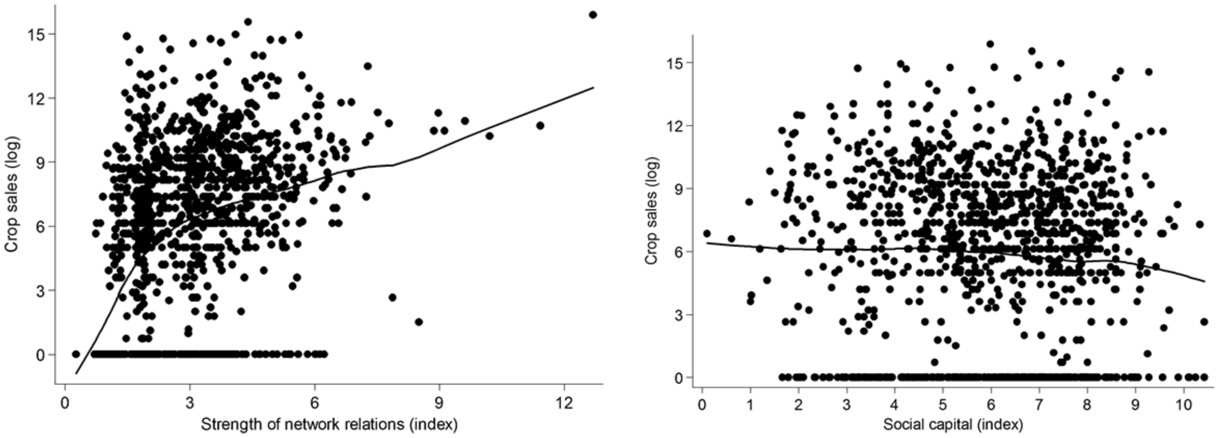

Figure 5.1: Lowess smoother among crop sales and networks and social capital

The Lowess in figure 5.1 shows the relationship between crop output sales and some of our main variables. The analysis shows that the amount of crop sales is positively associated with network relations[8]. On the other hand, the relationship between the amount of crop sales and social capital is shown by the horizontal Lowess smoother. It may not give us conclusive

[7] Lowess stands for locally weighted regression scatter plot smoothing. More information on Lowess smoothers can be obtained from Royston (1991). When running a Lowess smoother, the least square prediction of one variable with another gives the ‘smoothing’ line that more or less indicates what the relationship is like between the variables (linear or not; decreasing or increasing). By default, this ‘smoothing’ line is requested to be shown in the graph as it shows ‘trend’; but there is also an option to leave it out.

[8] Non-parametric analysis about the relationship between network relations and participation in crop output marketing also shows a positive relationship. Similar analysis between social capital and market participation in crop output resulted in a horizontal Lowess smoother. The non-parametric analysis also shows that roads play a positive role in facilitating market participation. On the other, distance to markets, electricity and telephone services are inversely related to crop output market participation.

evidence but such a relationship suggests the absence of a strong effect of social capital on crop sales. Similar analysis with respect to the relationship between town functions (such as roads, telephone, markets and electricity) and the amount of crop sales are shown in figure 5.2. A positive association is observed between the amount of crop sales and accessibility to shorter and good quality roads. Similarly, the amount of crop sales is observed to decline with distance to some of the major town functions such as markets, telephone and electricity services (see Lowess[9] in figure 5.2).

[9] The Lowess depicts village-level association with distance to the town functions. That is why discontinuity in the distribution of the sample households in distance to the town functions is observed.

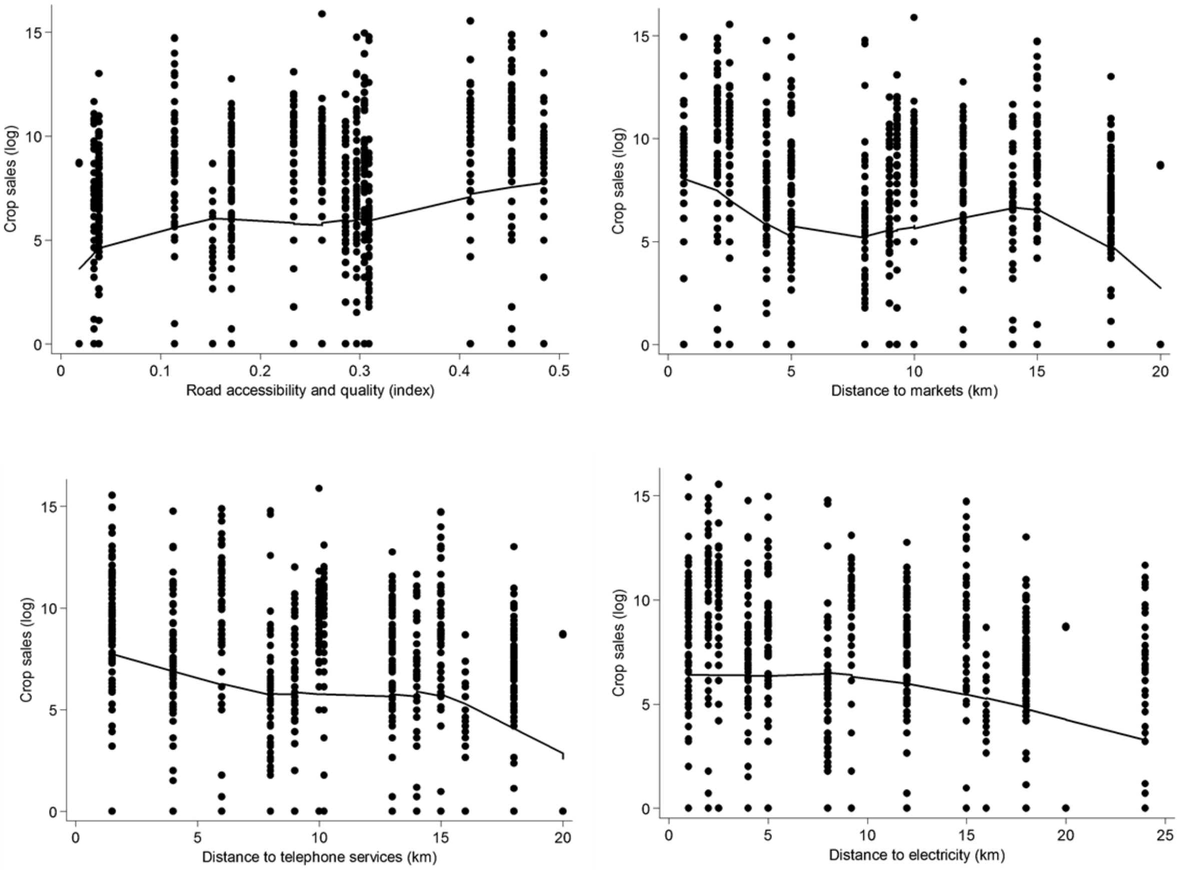

Figure 5.2: Lowess smoother among town functions and crop sales

Computing indices using the PCA method

Principal Components Analysis (PCA) was used to construct indices of network relations and social capital. The indicators used to construct indices of network relation and social capital are presented in Appendix 5.2A. The network relation index was constructed by running PCA on 11 continuous indicators (with a scale reliability coefficient of Cronbach $\alpha = 0.63$). Eleven components were extracted in the first stage of the PCA but only the first four were significant based on the Kaiser Criterion of an Eigen value greater than one. The first component explained close to 20 percent of the total variance in the eleven indicators, which provide positive weight for all of them. The resulting weights were used to construct a composite network relations index[10] for the double hurdle model. In addition, a social capital index was constructed using PCA on 10 indicators each specified by a 7-point Likert scale (from 1 denoting 'strongly disagree' to 7 indicating 'strongly agree', Cronbach $\alpha = 0.78$). Similarly, an index score was extracted from the PCA for regression purposes at a later stage.

We constructed separate indices for roads, markets and other major town functions following Oostendorp *et al*. (2009) in order to examine the individual effect of these town functions on participation in crop output markets and sales share. The detailed formulae used to construct indices for the town functions are presented in Appendix 5.3A. In the double hurdle regression model, the town functions are represented by their indices, the summary statistics of which is given in Appendix 5.4A.

About 73 percent of the farm households sold a positive amount of crop output. The average crop output sold at the market was 403.6 kilogram (kg). Among the study areas, the Debre Berhan area (specifically, Kormaragefia), Sirba na Goditi, Koro Degaga and Trirufe Ketchema registered the highest sales of crop output (see figure 3.1 in chapter 3 for the location). These areas are situated in the highlands of Ethiopia characterized by fertile soil and better rainfall. Higher production in these areas as a result of the favorable agro-ecology may explain the higher sales. These areas also roughly lie in the geographical area of Ethiopia where there is the highest population density, which is an expanded market base that may lead to higher sales. In contrast, Geblen and Haresaw registered among the lowest sales of crop output by farm households. These rural areas are known to be among the drought-prone areas of Tigray and the rather less favorable agro-climatic condition can cause a poor agricultural harvest and hence low crop marketing.

Farm households on average travel 11 km to get to a daily market for crop outputs. Around 47.5 percent of the farm households travelled to a local market town to sell their crop output while 52.5 percent of the households sold their products in the same village or one nearby. The

---

[10] For network relations indicators, a sensitivity analysis was performed through varimax rotation to see if a meaningful classification of the indicators could be made. The results from this rotation did not provide informative classification (*a priori* expected categorization). In addition, extracting the scores from the components (four in our case) that had an Eigen value greater than one and plugging them in the double hurdle regression provided a significant coefficient only for the first score. Hence the aggregate composite index was preferred to make use of as much complete information as possible (since the results are similar).

study villages are on average situated 9.3 km from a town that has most of the major town functions (services) such as daily and periodic markets, telephone, postal, banking, and electricity services and educational centers. When farm households are unable to get these services in the nearby town, they usually travel to larger towns or other urban centers.

Table 5.1: Summary statistics of variables

Variable definition	Mean	SD	Min	Max	Hypothesized relationship
Crop output market participation (1= if the household participated; 0= otherwise)	0.73	0.44	0	1	
Crop output quantity marketed (kilogram)	404	976	0	7500	
Crop output sales share (percent)	0.21	0.25	0	1	
Gender of the household head (1= male; 0= female)	0.78	0.41	0	1	*
Age of the household head (years)	50.4	13.7	18	90	+
Household size (number)	5.63	2.55	1	15	-
Education dummies of the household head					
(1= primary education; 0= otherwise)	0.30	0.46	0	1	+/a
(1= secondary or above education; 0= otherwise)	0.08	0.27	0	1	+/a
(1= illiterate; 0= otherwise)	0.62	0.49	0	1	a
Access to credit (1= if the household has access to credit; 0= otherwise)	0.56	0.50	0	1	*
Plot (land) size (hectares)	1.47	1.69	0	36.2	+
Composite price for crop outputs (Birr per kilogram)	2.84	2.60	0	5.7	+
Use of irrigation practices (1= yes; 0= otherwise)	0.21	0.40	0	1	+
Use of fertilizer (1= yes; 0= no)	0.44	0.50	0	1	+
Livestock size (Tropical Livestock Unit)	3.88	5.52	0	64	-
Off-farm participation (1= if household member participates; 0= otherwise)	0.50	0.50	0	1	-
Distance to junior schools (km)	4.15	4.37	1.5	15	-
Distance to secondary schools (km)	15.2	15.2	1.5	66	-
Distance to telephone services (km)	10.2	5.62	1.5	20	-
Distance to electricity (km)	9.20	7.52	1	24	*
Distance to bank services (km)	34.2	52.2	1.5	180	*
Distance to extension and cooperative centers (km)	4.50	4.60	1.5	18	-
Distance to daily output market (km)	11.0	15.5	1	20	-
Road index (average of both rainy and dry seasons)	0.23	0.14	0.02	0.49	+
Daily market index	0.83	0.24	0	0.98	+
Network relations index	3.02	1.50	0.26	12.69	+
Social capital index	6.01	1.86	0.11	10.42	+

Notes: '*'represents not determined *a priori*; '+' denotes hypothesized positive relationship; and '-' denotes hypothesized negative relationship. Also, 'a' denotes the reference educational level, in reference to which the effect of possessing primary and secondary school level is compared.

5.5 Results and discussion

This section is divided into three sub-sections. In section 5.5.1, results of the effect of town functions on crop output marketing behavior are presented. Section 5.5.2 presents results related to the role of network relations and social capital on crop marketing. And section 5.5.3 presents results of the effect of household and farm-specific characteristics on crop marketing behavior. The Box-Cox parameter ($\lambda = 0.730$) is found to be significantly different from zero and one, which indicates the usefulness of the Box-Cox transformation of the dependent variable to satisfy the normality assumption (Jones and Yen, 2000). The Box-Cox double hurdle model results[11] are presented in table 5.2. While coefficients shown in the first column are related to passing the first hurdle (market participation ability), those in the second column correspond to passing the second hurdle (deciding to participate and intensity of participation). The elasticities of continuous variables, which indicate the effect for the average household are shown in table 5.3. Discrete effects[12] of binary variables are given in table 5.4. For interpretation purpose of the elasticities of town functions, the percentage change of the effect of a 1 km change in distance to town functions are computed[13] and presented in table 5.5.

5.5.1 Effect of town functions on crop marketing

Some of the major town functions are found to play a key role in promoting crop output marketing. Among these important town functions are roads, markets, telephone services, educational centers, electricity, extension and cooperative centers.

Closer roads of good quality[14] have a highly significant positive effect on enabling market participation and increasing sales share. The elasticities with respect to road index are all

---

[11] A conditional moment test for normality after Tobit model suggested the rejection of the normality assumption. To circumvent this problem, a Box-Cox transformation was applied to the dependent variable.

[12] The discrete effects show the effect of moving from 0 to 1. For instance, the effect of having no access to credit (0) to having access to credit (1).

[13] The effect of a 1 km change in distance to town functions on the percentage change of crop market participation and sales share are computed based on the formulae given in Appendix 5.3A.

[14] See appendix 5.3A for the way distance indices are constructed for roads and markets, junior and secondary schools, telephone services, bank services, electricity, markets, extension and agricultural cooperative centers.

positive and significant. The overall effect (unconditional elasticity),[15] conditional elasticity and participation probability elasticity are equal to 0.96, 0.73 and 0.23, respectively. The elasticities with respect to the indices related to town functions do not have a clear intuitive interpretation. For this reason, elasticities that show the effect of a 1 km reduction in distance to some of the major town functions are presented in table 5.5. This measure does not take other factors than distance into account. In the indices, we do include other factor such as road quality.

Table 5.2: Box-Cox double hurdle estimates of crop output marketing

Variables	First hurdle	Second hurdle
Age	0.010 (0.012)	0.001 (0.001)
Gender of head	0.102 (0.438)	-0.044 (0.026)*
Household size	-0.239 (0.108)**	-0.016 (0.004)***
Primary education	0.391 (0.394)	0.036 (0.024)
Secondary education	-1.470 (0.900)	0.072 (0.040)*
Access to credit	1.340 (0.482)***	0.010 (0.022)
Off-farm participation	-0.257 (0.337)	-0.032 (0.023)
Livestock size	0.010 (0.087)	-0.004 (0.002)**
Plot (land) size	1.671 (0.564)***	0.017 (0.006)**
Use of irrigation	0.506 (0.558)	0.065 (0.029)**
Use of fertilizer	-0.230 (0.556)	0.075 (0.023)***
Bank services	-1.350 (2.065)	
Junior schools	28.52 (10.62)**	
Secondary schools	38.89 (15.89)**	0.457 (0.201)**
Telephone services	57.94 (10.06)***	0.306 (0.120)**
Electricity	7.012 (4.061)*	0.015 (0.102)
Extension and cooperative centers	9.485 (4.342)**	-0.028 (0.038)
Daily market	24.31 (9.050)**	0.241 (0.140)*
Road access and quality	26.51 (10.34)***	1.510 (0.461)***
Network relations	0.272 (0.187)	0.037 (0.008)***
Social capital	0.436 (0.200)**	-0.011 (0.006)*
Average price		0.058 (0.006)***
constant	-189.8 (71.78)***	-2.200 (0.434)***
λ (Box-Cox parameter)		0.730 (0.019)***

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: Values in parentheses are standard errors.

[15] For continuous variables, the overall (unconditional) elasticity is equal to the sum of the elasticity related to probability of participation and conditional elasticity.

For the average household, the unconditional distance elasticity suggests that a reduction in road distance (the road being *well accessible to any vehicle*) by 1 km leads to 6.6 percent higher sales share, *ceteris paribus*. On the other hand, for the average household that is already participating in the market a reduction in road distance by 1 km leads to 1.6 percent higher sales share, *ceteris paribus*. Readily accessible roads help reduce variable transaction costs and higher amount of crop output can be transported to the market as a result. Similarly, the probability of market participation increases by 5 percent when distance to roads that are *well accessible to any vehicle* reduces by 1 km, *ceteris paribus*. Nearby roads increase the ability of rural households to visit the market through significantly lowering costs related to fertilizer transport.

With an improvement in road quality, ability and intensity of crop output market participation is also observed to increase, *ceteris paribus*. Similarly, a significant increase in the intensity of crop marketing is observed when *well accessible to any vehicle* roads are brought closer. The evidence also provides a clear indication about the greater effect that roads of better quality (higher-grade roads) have on promoting crop marketing. For instance, reducing the distance to *roads accessible to trucks* by 1 km increases the probability of participation ability and sales share by 3.1 and 4.1 percent respectively, *ceteris paribus* (see table 5.6). This is an indication of the varying effect that roads of different qualities (grades) have on crop marketing. The implication is that roads of very good quality are useful to facilitate market participation ability and the quantity of crop output that can be transported to the market for sale. Where there is an acute shortage of road access (such as very long distance to roads), the resulting high variable transaction costs can be stumbling blocks to the quantity of crop output sold at the market.

Farm households' access to other major town functions such as markets is associated with higher participation ability and crop sales share. The results show shorter distances to markets enable and encourage farm households to participate in crop output markets, thereby increasing sales share. In this regard, bringing markets closer by 1 km would lead to 0.6 percent higher probability of market participation (this however is only weakly significant at the 10% level). This effect may seem small but the contribution of markets is seen when there is a significant reduction in distance. A 10 km reduction in distance to markets would lead to 6% higher probability of market participation. The contribution of nearby markets can be twofold. One, markets available in closer proximity may reduce costs of searching for market information and transport costs. Second, shorter distances to the market can mean higher farm gate prices for crops. The overall reduction in transaction costs and higher farm gate prices would then increase market profitability and encourage farm households to participate more and increase sales share.

Dissemination of market information is key to increased market access. In this regard, telephone services facilitate the exchange of market information and increase market access by reducing the effect of fixed transaction costs. Coefficients estimates in table 5.2 suggest that shorter distance to telephone services has a significant and positive effect on enabling and encouraging households to visit the market (increase participation) and increase sales share. The indications are that crop market participation increases with decline in distance to telephone services. This shows that some non-participants would participate in crop marketing if telephone services were brought closer. However, the magnitude of effect depicted by the elasticities in table 5 indicates a relatively small effect (an increase in probability of participation by 0.8% with each 1 km reduction in distance).

Table 5.3: Elasticities of continuous variables

Variables	*prob.*	*cond.*	*uncond.*
Age	0.015 (0.56)	0.048 (0.56)	0.063 (0.56)
Household size	-0.051 (2.98)***	-0.164 (3.03)***	-0.215 (3.05)***
Livestock size	-0.011 (2.11)**	-0.037 (2.11)**	-0.048 (2.12)**
Plot (land) size	0.017 (2.69)**	0.055 (2.65)**	0.072 (2.68)**
Secondary schools	0.222 (2.11)**	0.720 (2.11)**	0.942 (2.12)**
Junior schools	0.001 (0.25)		0.001 (0.25)
Bank services	-5.5×10^{-6} (0.27)		-5.5×10^{-6} (0.27)
Telephone services	0.081 (2.00)**	0.272 (2.14)**	0.355 (2.11)**
Electricity	0.035 (0.83)	0.113 (0.83)	0.148 (0.83)
Extension & cooperative centers	-0.035 (0.99)	-0.115 (1.00)	-0.150 (1.00)
Daily market	0.098 (1.71)*	0.320 (1.19)	0.418 (1.76)*
Road access and quality	0.227 (3.00)***	0.735 (3.17)***	0.962 (3.15)***
Network relations	0.068 (1.64)	0.222 (4.14)***	0.290 (4.14)***
Social capital	0.043 (1.79)*	-0.140 (1.80)*	-0.097 (1.81)*
Average price	0.102 (7.59)***	0.330 (10.8)***	0.432 (10.8)***

Significance level: *** = 1%; ** = 5% and * = 10%.

Notes: values represent probability, conditional and unconditional elasticities. The absolute values of t-statistic are reported in parentheses.

Telephone services can also lead to a higher sales share. If farm households obtain timely information about the higher prices of crops at the market, they can be tempted to sell more. Farmers who already participate in the market sell 2.8 percent more when telephone services are 1 km nearer. The overall elasticity with respect to distance to telephone services indicates that sales share increases by 3.6 percent when distance to telephone services decreases by 1 km.

However, the contribution of telephone services may be limited if market distance is shorter than telephone distance. In this case, households can travel to the market (that is located at a relatively closer distance than telephone services) and collect crop market information. In chapter 3 (table 3.3), it is indicated that about 46.5 percent of the sample households travel beyond 10 km to reach telephone services (while only 35% travel a similar distance to reach major markets). This indicates that telephone services would be useful only when they are available at (much) closer distance than markets. In fact, distance to telephone services can be effectively reduced through the expansion of mobile telephone services. Though not considered in this study, mobile phones are among the major communication facilities that households can use for facilitating crop marketing.

Extension and agricultural cooperative centers can also be instrumental in facilitating market participation through information diffusion. We find that extension centers have a positive effect on the ability to participate, but not on the actual participation. The combined effect represented by the elasticities in table 4 and 5 are not significantly different from zero. This is an unexpected result. Agricultural cooperative centers act like 'unions' and particularly help member farmers enjoy more bargaining power and get higher prices for their crop sales. Next to that, they promote social networks. It seems that the effect of extension and cooperative centers is picked up by these kind of factors that are represented in the model as well.

Schools can serve as knowledge-generating, processing and disseminating facilities that households can exploit to advance their crop marketing activities. Shorter distances to schools can help households obtain and process market and/or other information, thereby reducing the effect of fixed transaction costs and increasing the probability of crop market participation. In this case, while the effect of a 1 km reduction in distance to secondary schools on the probability of market participation is small (0.5%), the overall effect on sales share is relatively high (2%).

Table 5.4: Discrete effects of binary variables

Variables	*prob.*	*cond.*	*uncond.*
Gender of head	-0.029 (1.91)*	-0.026 (1.67)*	-0.034 (1.96)**
Primary education	0.015 (1.10)	0.013 (0.96)	0.017 (1.17)
Secondary education	0.044 (2.43)**	0.046 (1.86)*	0.058 (2.19)**
Access to credit	0.003 (0.19)	-0.002 (0.17)	-0.003 (0.21)
Off-farm participation	-0.017 (1.22)	-0.014 (1.10)	-0.018 (1.34)
Use of fertilizer	0.040 (2.78)***	0.035 (2.54)**	0.044 (3.09)***
Use of irrigation	0.026 (1.65)	0.024 (1.41)	0.031 (1.70)*

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: values represent probability, conditional and unconditional effects. The absolute values of t-statistic are reported in parentheses.

5.5.2 Role of network relations and social capital on crop marketing

Limited or a lack of access to functions worsens the highly imperfect markets in rural areas of developing countries. This is where network relations play a big role in partly filling the gap left by a lack of functions (such as telephone facilities). They are be considered as vital informal human capital elements. Different farm households accumulate a stock of network relations differently, which they can use to their advantage in searching, obtaining or processing crop output market information.

Estimation results indicate that network relations have a significant and positive influence on sales share. The overall effect of network relations is shown by the unconditional elasticity equal to 0.29. For the average household, this suggests that an increase in network relations index by 1 percent leads to an increase in sales share by 0.29 percent, *ceteris paribus*. For the average crop market-participating household, an increase in network relations index by 1 percent leads to an increase in sales share of 0.22 percent (conditional elasticity), *ceteris paribus*. Although these elasticities may not be directly (and clearly) interpreted, they indicate the key role that strong network relations play in promoting market participation. The higher the number of interactions or frequency of interactions, the higher the network index. The higher the network index, the higher the indication of the strength of household network ties. These strong network relations create sources and facilitate the exchange of market information, inputs and technology and credit that lead to increased crop marketing.[16]

[16] An interaction variable between telephone services and network relations was created. This was done to examine if the social network element is substituting for lacking town function (in this case,

The results present an important implication of network relations in promoting market participation and expanding commercialization. Opportunities presented by traditional social and saving networks in Ethiopia Equb and Iddir or rural work parties can be used to communicate and disseminate market information related to crop outputs, inputs and agricultural technologies. Some of the network niches that rural households establish are situated in rural towns or towns. These network relations connect farm households with economic agents (consumers, producers or lenders) in towns. This may present an opportunity for farm households to increase market access (through increased information access), expanded credit and input sources, which can influence farm production and crop surplus for market.

Table 5.5: Elasticities representing the effect of a 1 km reduction in distance

Town functions	Elasticities		
	prob.	*cond.*	*uncond.*
Markets	0.60 (1.71)	1.90 (1.19)	2.50 (1.76)
Secondary schools	0.50 (2.11)	1.50 (2.11)	2.00 (2.12)
Roads	5.00 (3.00)	1.60 (3.17)	6.60 (3.15)
Electricity	0.20 (0.83)	0.70 (0.83)	0.90 (0.83)
Telephone facilities	0.80 (2.00)	2.80 (2.14)	3.60 (2.11)
Extension center	-0.30 (0.99)	-0.90 (1.00)	-1.20 (1.00)

Notes: values represent probability, conditional and unconditional elasticities. The absolute values of t-statistic are reported in parentheses.

Social values and norms embedded in a society for a long time may also influence marketing behavior. Results show that social capital has a significant positive effect on market participation. Conversely, results show that sales share decline with social capital index. Institutional elements such as trust, honesty, competitive ability of government officials and reliability and trustworthiness of neighbors, farming and other business partners create a conducive environment for increased market participation. When these institutions are working more efficiently, market information becomes readily available at lower cost, which increases ability of market participation. The stock of social capital, which is the 'social fabric' acts like an 'institutional environment'. As a result, households are more likely and

telephone services). However, the estimation results show that the effect is not statistically significant (but the resulting negative coefficient indicated that social networks may substitute for communication gaps left by distant telephone services).

able to participate in crop marketing, which in part may be due to reduced transaction costs. The lower costs in turn may induce lower sales share of crop output.

5.5.3 Effect of household and farm characteristics on crop marketing

The results indicate that sales share declines with family size. Human capital indicators such as possession of a secondary-level of education are observed to positively influence sales share. The discrete effects on sales share with respect to a secondary educational-level are all positive and significant, with an overall effect (unconditional level) equal to 0.058. For the average household, this implies that possession of secondary education leads to a 5.8 percent higher sales share than illiterate heads, *ceteris paribus*. This result highlights how household heads with different educational levels exhibit different sales patterns in relation to crop outputs. For households that are already participating in the crop market, upgrading their education to secondary-level (from the illiterate-level) increases the share of crop output sold for the average household by 4.6 percent (albeit at 10%), *ceteris paribus* (see the discrete effects in table 5.4). It may be that better education helps farm households in their quest to obtain and process market information, thereby reducing the effect of transaction costs. On the other hand, results also suggest that illiterate heads and heads with primary education do not have a statistically significant difference in crop marketing behavior, while secondary education does increase crop marketing.

Table 5.6: Effect of bringing roads with different quality closer by 1 km

Road type (quality)	Elasticities		
	prob.	*cond.*	*uncond.*
Well accessible to any vehicle	5.0	1.6	6.6
Reasonably accessible to any vehicle	4.1	1.3	5.4
Reasonably accessible to trucks and buses	3.1	1.0	4.1

Notes: values represent probability, conditional and unconditional elasticities.

Households' access to credit is one of the factors considered to ease liquidity constraints. This situation may influence their decision to participate in crop output markets. Estimation results in table 2 suggest the existence of significantly higher crop output market participation ability for households that have access to credit compared to those that do not have access to credit. It may be invested in transport services (such as pack animals) used to transport crop output to the market, which may increase the ability of market participation. Nevertheless, access to credit is found to have no statistically significant effect on sales share. This is in line with the literature (Key *et al*., 2000; Renkow *et al*., 2004) that asserts that the amount of crop output marketed is largely influenced by factors that affect variable transaction costs (such as roads and transport) and the effect of credit may not be that significant.

Similarly, liquidity constraint can be further eased if farm households increased their livestock. Estimation results suggest that the number of livestock units owned affects sales share negatively. Farm households can ease liquidity constraints by selling their livestock, which would discourage (reduce) the sale of crop output. For farm households that own a relatively large number of livestock, this is a reasonable argument. Cash needs for consumption, loan repayment and other expenses may be met through the sale of livestock assets. Instead of selling their crop output therefore farm households may decide to cover their cash requirement by selling livestock, which may turn out to discourage households from selling more crop output.

Land is one of the most important factors of production that enable farm households to produce surplus crop output for the market. Hence, plot size is expected to have an influence on the quantity of crop produced (based on plot size and quality). A larger plot size means higher production and that may lead to surplus production. This can also lead to the possibility of marketing out the excess production. Estimation results show that plot size does have a statistically significant and positive influence on market participation ability and increasing sales share. These results highlight the significant contribution that plot size has to the probability of higher market participation and sales share. With other things being constant, larger plots could mean surplus production and output that is deemed surplus to consumption requirements may be channeled to the market.

The literature highlights the significant contribution that productive agricultural technologies have on crop marketing (Alene *et al*., 2008; Gebremedhin *et al*., 2009). In line with this, estimation results show that use of both fertilizer input and irrigation practices positively influence crop output sales share. The use of fertilizer has a highly significant positive effect on sales share. Estimation results in table 5.2 show that the probability of crop output market participation ability increases with fertilizer use. Specifically, discrete effects in table 5.4

indicate that households that use fertilizer have a 4.4 percent higher crop output sales share than households that do not use fertilizer, *ceteris paribus*.

The use of irrigation is also found to have a highly significant effect on sales share (an increment in participation probability by 3.1% with access to irrigation). With irrigation, crop production can be done twice or thrice a year, which opens up the possibility of much higher (surplus) production. With surplus production, share of crop output sold at the market may also increase, *ceteris paribus*. This relationship is expected *a priori*, since irrigation helps households to continuously grow crops (including high-value crops) and ensure sustained production, part of which may be sold at the market. The results demonstrate the critical role of productive technology and support services in promoting crop output marketing that may also have a significant effect on income.

When farm households decide about crop marketing, prices can have a significant influence. Farm households in many developing countries usually are observed to sell their crop output right after harvest (Alene *et al*., 2008). This could be induced by the need to satisfy their cash needs to fund loan repayments or to buy agricultural inputs and consumption goods. Consistent with expectations, prices are found to have a significant effect on sales share (crop output supplied), showing that sales share increases with price. Price[17] elasticities are all positive and significant. The overall effect reflected by the unconditional elasticity is equal to 0.43. For the average household, it means that an increase in crop prices by 1 percent leads to a 0.43 percent increase in sales share, *ceteris paribus* (for market-participating households, the effect of price incentives are slightly small, 0.33%).

5.6 Concluding remarks

There is a growing recognition that strong linkage of rural households with (economic agents in) towns, urban centers and other rural areas facilitate input-output marketing. However, there is a gap to contribute to the literature by identifying the role that town functions play in rural household crop marketing. Using data from a farm household survey of 15 rural areas of

---

[17] Economic factors (such as price or income) are often not expected to influence outcomes of the first hurdle (see for example, Aristei and Pieroni, 2008). In our case, the first hurdle indicates the probability of crop market participation ability, where crop price is assumed to have less effect on ability of participation. However, marginal effects (hence, elasticities) for the probability of market participation ability depend on variables from both hurdles (see equation 5.11).

Ethiopia, this chapter attempts to assess the role that town functions, network relations and social capital play in crop output marketing. A robust Box-Cox double hurdle model was used to estimate the responses of crop output sale to changes in access to town functions, strength of network relations and social capital, among others. The double hurdle model distinguishes between the effects of these factors on, on the one hand, the ability to participate in crop marketing and, on the other hand, the participation decision and sales share.

The empirical results emphasize the importance of town functions that take farm households closer to the market in towns. Some of these major functions are roads, markets and telephone services. Shorter distances to roads that lead to towns contribute to higher crop market participation. The effect of a 1 km reduction in distance to *well accessible roads to any vehicle* was observed to have the highest effect on increasing crop market participation (5%) and sales share (6.6%). Physical proximity to roads however may not translate into more market participation if the quality of the roads leading to towns is poor (Lanjouw, 1999). Empirical evidence in this chapter suggest that quality of roads also plays an instrumental role in promoting crop marketing. Specifically, it is shown that 'lesser grade' roads such as those *reasonably accessible to trucks* have a lower effect on the probability of market participation (3.1%) and sales share (4.1%) for a similar reduction in distance. Similarly, sales share increase by 2 and 3.6 percent with each 1 km reduction in distance to secondary schools and telephone services, respectively. These functions enable households share and process market-related information, which contributes to increased crop marketing.

The empirical evidence further suggests that institutional elements such as network relations and social capital influence crop marketing. While network relations encourage more crop sales, social capital was observed to discourage sales share. The indication is that farm households with strong network relations have a higher probability of entering crop output markets. On the other hand, efficiency gains through strong social capital may lead to lower costs and smaller sales share (of the subsistence crop output). Where markets are highly imperfect, social capital elements such as trust, honesty, ability of government officials and reliability and trustworthiness of neighbors, farming and other business partners can be the 'social fabric' that gets things going enabling crop marketing and related activities to thrive. Traditional saving and social networks in Ethiopia such as Equb and Iddir and work parties can be exploited to further strengthen rural household networks, which can be useful for disseminating market information.

The results also show that crop output prices significantly influence crop supply. In this case, we go along with the argument of Key *et al*. (2000) that price policies could be designed to play a significant role in facilitating farm households' crop marketing and expand commercialization. There is also sufficient empirical evidence to conclude that access to credit by farm households plays a significant positive role in facilitating crop output market participation. Credit may be often lacking among farm households but results obtained suggest the significant effect that access to credit has on crop output marketing. Results also show that ownership of more livestock discourages crop output sales share. Farm households can ease their liquidity constraint by selling part of their livestock holdings, which can have discouraging effects on sales share.

Overall, the results indicate that proximity to towns strengthens rural households' linkage with the higher hierarchy of development (rural towns, towns and urban centers) so as to promote crop output marketing and commercialization. In this regard upgrading selected villages to rural towns by adding town functions or decreasing virtual distance to towns by creating better roads is instrumental in crop marketing and rural development.

Appendix 5.1A: *Derivation of the reduced forms of market participation and sales share*

The utility model (U), which maximizes utility over consumption and leisure, given the attributes of a farm household, is used for the derivation of the functional forms for market participation of those households. For a market-participating farm household, we assume that it decides to consume goods (c), both own and purchased; produce goods (q); using inputs (b), with price p_b and sell outputs (s), with price p_s. The number of goods a household is assumed to produce and consume (or buy) is represented by $n = 1,..., N$. The utility of the household, given in $(5.1a)$ is maximized subjected to production technology $(5.2a)$, full income $(5.3a)$, total time endowment $(5.4a)$, commodity resource balance $(5.5ab)$ and the non-negativity constraints $(5.6a)$.

$$Max\ U = U(c, l; \mathbf{z_s}) \qquad (5.1a)$$

where l is leisure and $\mathbf{z_s}$ is the vector of utility-shifting household characteristics. Goods for consumption by the household can be obtained either from own production or purchased, or both. The production technology of the household can be presented as

$$Q(q, b; \mathbf{z_d}) \qquad (5.2a)$$

where $Q(\ )$ is the production technology and $\mathbf{z_d}$ represents the vector of production-shifting exogenous factors such as fixed and quasi-fixed inputs.

A key feature of crop output marketing in rural areas of developing countries is the existence of high transaction costs. These transaction costs, which may be due to limited or lacking functions (infrastructures and institutions) can be important determinants of market participation. Transaction costs affect prices and they effectively reduce prices received by sellers. Following Key *et al*. (2000), let τ_q^v and τ_b^v denote variable transaction costs per unit of output (q) and input (b) respectively. If fixed transaction costs for sales (τ_s^f) are high, a farm household would not be able to participate in crop sales. On the other hand, if a farm household participates in crop output marketing, the adjusted output and input prices become $p_s^t = (p_s - \tau_q^v)$ and $p_b^t = (p_b + \tau_b^v)$.

Suppose town functions such as roads, markets and transport facilities that influence variable transaction costs are denoted by the vector $\mathbf{TF_v}$. Let also other town functions (such as telephone services, extension or agricultural cooperative centers) that reduce the effect of fixed transaction costs be denoted by the vector $\mathbf{TF_f}$. In addition, denote network relations and social capital by $\mathbf{NS}$, which can be vital in reducing fixed transaction costs through facilitating the exchange of market information. If we in addition denote the fixed transaction costs that buyers[18] face by τ_b^f, then the income constraint,[19] implying that expenditure on all purchases must not exceed revenues from all sales, other income (such as non-farm income) and transfers (E), is given in a rearranged manner by

$$\sum_{n=1}^{N}\left[\left(p_s - \tau_q^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\right)s\right] + \sum_{n=1}^{N} E - \sum_{n=1}^{N} p_s c - \sum_{n=1}^{N}\left[\left(p_b + \tau_b^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b})\right)b\right] \\ - \tau_s^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\delta_s^f - \tau_b^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b})\delta_b^f \geq 0 \qquad (5.3a)$$

The income constraint in $(5.3a)$ is influenced by the decision of farm households' participation in crop output and input marketing.[20] The decision for participating in crop output and input markets can be represented by binary terms, δ_s^f and δ_b^f representing participation in crop output sales and input purchase respectively.

$$\delta_s^f = \begin{cases} 1 & if \;\; s > 0 \\ 0 & otherwise \end{cases} \text{ and } \delta_b^f = \begin{cases} 1 & if \;\; b > 0 \\ 0 & otherwise \end{cases}$$

These conditions imply that when the household is not participating in the crop output market, variable transaction costs (τ_q^v) will not exist, and the fixed transaction costs (τ_s^f) will determine whether the household participates or not.

Total time endowment of the farm household is allocated to farm work (l_f), off-farm and non-farm work (l_{nf}), other activities (l_o) and leisure time (l).

---

[18] The same household can sell crop outputs and buy production inputs. For this household therefore $z_s = z_b$, and hence can be used interchangeably.

[19] In its simplified form, the income constraint with transaction costs is given by

$$\sum_{n=1}^{N}\left[p_s c + \left(p_b + \tau_b^v\right)b\right] \leq \sum_{n=1}^{N}\left[\left(p_s - \tau_q^v\right)s + E\right]$$

Rearranging and considering the effect of town functions, network relations and social capital gives the income constraint in equation $(5.3a)$.

[20] In the model, the value of per unit consumption and production is assumed to be equal to the sales price.

$$l_f + l_{nf} + l_o + l \le T \qquad (5.4a)$$

The farm household is also constrained by the commodity resource balance. This restriction states that the value of goods consumed, used as inputs and sold is equal to the value of goods produced and bought from the market plus the endowment of the goods (e).

$$p_s c + p_s s + p_b b \le p_s q + p_b b + e \qquad (5.5aa)$$

Adding transaction costs into the commodity resource balance,[21] we get

$$\begin{aligned} & p_s q + \left(p_b + \tau_b^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b})\right)b + e - p_s c - \left(p_s - \tau_q^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\right)s \\ & - p_b b - \tau_s^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\delta_s^f - \tau_b^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b})\delta_b^f \ge 0 \end{aligned} \qquad (5.5ab)$$

The following non-negativity constraints also have to be met.

$$q, c, s, b, l_f, l_{nf}, l_o, l \ge 0 \qquad (5.6a)$$

The Lagrange associated with the household utility optimization problem that leads us to derive the output supply equation for a household participating in the market with transaction costs is then defined as:

$$\begin{aligned} L &= u(c, l; z_s) \\ &+ \mu\left\{\sum_{n=1}^{N}\left[\left(p_s - \tau_q^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\right)s\right] + \sum_{n=1}^{N} E - \sum_{n=1}^{N} p_s c - \sum_{n=1}^{N}\left[\left(p_b + \tau_b^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b})\right)b\right] - \tau_s^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\delta_s^f \right. \\ &\left. - \tau_b^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b})\delta_b^f\right\} + \kappa\left\{p_s q + \left(p_b + \tau_b^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b})\right)b + e - p_s c - \left(p_s - \tau_q^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\right)s - p_b b \right. \\ &\left. - \tau_s^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\delta_s^f - \tau_b^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b})\delta_b^f\right\} + \lambda(q, b; \mathbf{z_d}) + \varphi\left(T - l_f - l_{nf} - l_o - l\right) \end{aligned}$$

$(5.7a)$

The first-order condition from $(5.7a)$ of quantity of each output supplied to market is then given by

$$\frac{\partial L}{\partial s} = \mu\left(p_s - \tau_q^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\right) - \kappa\left(p_s - \tau_q^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\right) \qquad (5.8a)$$

Participation in crop output market can be obtained from the following first-order condition (see also Barrett, 2008):

[21] Notice that inputs used from own production do not involve transaction costs. But when farm households buy inputs from the market, a certain level of transaction cost is incurred. In this case, the value of inputs used from own sources $(p_b b)$ in the left hand side in $(5.5aa)$ does not cancel out inputs used from the market $(p_b b)$-right hand side, which involves transaction costs.

$$\frac{\partial L}{\partial \delta_s^f} = \mu\{\tau_s^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\} - \kappa\{\tau_s^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\}$$

It follows that the reduced-form equations for market participation and output supply conditional on market participation are shown by

$$D = D\{\tau_s^f(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\} \quad (5.9a)$$

$$S = S\{p_s, \tau_q^v(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_s})\} \quad (5.10a)$$

As can be seen from (5.9a) and (5.10a), town functions, network relations and social capital explain fixed and variable transaction costs. This in turn explains decisions about market participation and rate of participation.

Distance (d) captures the effects of access to town functions that influence fixed $(\mathbf{TF_f})$ and variable $(\mathbf{TF_v})$ transaction costs. The strength of network relations and social capital that influence fixed transaction costs are represented by indices. Based on this, the influence on crop output marketing can further be presented as

$$D = D\{\mathbf{NS}, a(d, \mathbf{TF_f}), g(d, \mathbf{TF_v}), \mathbf{z_s}\} \quad (5.11a)$$

$$S = S\{p_s, \mathbf{NS}, a(d, \mathbf{TF_f}), g(d, \mathbf{TF_v}), \mathbf{z_s}\} \quad (5.12a)$$

where $a(d, \mathbf{TF_f})$ and $g(d, \mathbf{TF_v})$ respectively show the vector of distance to town functions.

Appendix 5.2A: *Items used to construct indices for network relations[a] and social capital*

Items used to construct network relations index	Mean	SD	Min	Max
Number of Equub[b] members in which the head is a member	4.81	16.8	0	300
Number of Iddir members in which the head is a member	83.5	114.9	0	1200
Number of people the household head met in the last month	2.8	5.4	0	90
Number of times the head visited church/mosque in the last month	6.67	8.67	0	120
Number of female participants in a work party[c]	0.36	1.35	0	17
Number of male participants in a work party	3.1	5.8	0	80
Number of work party the household organized	5.0	6.7	0	35
Number of years since joining Iddir	17.6	13.8	0	76
Number of Iddirs the household head is a member	0.34	0.47	0	1
Number of extension visits by/to agents	0.98	3.9	0	100
Number of minutes to travel to input suppliers	59	39.8	10	360
Items used to construct social capital index[d]				
Most people are basically honest	4.42	1.75	1	7
Most people can be trusted	4.38	1.71	1	7
I believe that the government does what is right for the people	4.64	1.62	1	7
I am confident of the ability of government officials to do their job	4.41	1.67	1	7
I am confident of the ability of Kebele[e] officials to do their job	4.18	1.70	1	7
I could rely on my neighbor to mail an important letter for me	4.96	1.48	1	7
I feel I can trust my neighbors to look after my house if I am away	5.11	1.49	1	7
My life is determined by my own actions	4.89	1.53	1	7
I have the power to make important decisions to change the course of my life	4.66	1.62	1	7
I am usually able to protect my personal interests	4.46	1.57	1	7

[a] Network relations can be considered as a *flow variable* where households individually establish and develop networks. It can be continuously established, accumulated, maintained or strengthened. Social capital on the other hand is considered as a *stock variable* which is embedded in the society for a long time. It is largely a common stock subjected to little change.

[b] Equb and Iddir are local associations with the objective of saving and finance and information exchange (Equb) and financial assistance, asset sharing and funeral services provision (Iddir).

[c] Work parties are labor-pooling mechanisms that rural households use while harvesting, weeding and preparing crop farms.

[d] Likert-scale: 1 = strongly disagree; 2 = disagree; 3 = slightly disagree; 4 = neither agree nor disagree; 5 = slightly agree; 6 = agree; 7 = strongly agree

[e] Kebele is the smallest administrative unit in Ethiopia.

Appendix 5.3A: *Indices for individual town functions*

The distance indices for junior and secondary schools, telephone centers, banks, electricity, extension and agricultural cooperative centers are computed using the same formula used to calculate market indices (below).[22]

1. $\text{Daily market index} = \left(1 - \frac{\text{distance to nearest daily market}}{\text{Maximum distance}}\right)$

2. $\text{Periodic market index} = \left(1 - \frac{\text{distance to nearest periodic market}}{\text{Maximum distance}}\right)$

3. Road index is calculated as an average value from indices in the rainy and dry seasons

$$\text{Road index in the dry season} = \left(1 - \frac{\text{distance to nearest road}}{\text{Maximum distance}}\right) \cdot \left(\text{Quality of road}\right) \cdot \tfrac{8}{12}$$

$$\text{Road index in the rainy season} = \left(1 - \frac{\text{distance to nearest road}}{\text{Maximum distance}}\right) \cdot \left(\text{Quality of road}\right) \cdot \tfrac{4}{12}$$

Average road index = road index (dry season) + road index (rainy season)

where,[23]

$$\text{Quality of road} = \begin{cases} = 1 & \text{if road is well accessible to any vehicle} \\ = 0.8 & \text{if road is reasonably accessible to any vehicle} \\ = 0.7 & \text{if road has good access to trucks and buses} \\ = 0.6 & \text{if road has reasonable access to trucks and buses} \\ = 0.4 & \text{if road is accesible to cart animals only} \\ = 0.2 & \text{if road is for walking only} \end{cases}$$

---

[22] The maximum distance is the longest distance to each town function observed within the sample.

[23] Accessibility of roads differs. In this chapter, the difference is accounted for by defining 'accessibility index' from 0 to 1, with index '1' for 'well accessible roads to any vehicle' and '0.2' for roads that 'allow only walking'. A similar approach about the quality or accessibility of roads can also be found in Oostendorp *et al*. (2009).

Appendix 5.4A: *Summary statistics of indices of town functions*

Town functions	Mean	Standard deviation	Min	Max
Junior school	0.77	0.29	0	0.90
Secondary school	0.72	0.23	0	0.98
Telephone center	0.49	0.28	0	0.93
Electricity	0.62	0.31	0	0.96
Bank services	0.81	0.29	0	0.99
Extension and agricultural cooperatives	0.72	0.29	0	0.92

CHAPTER 6

FERTILIZER ADOPTION AND USE IN SELECTED RURAL AREAS OF ETHIOPIA: THE ROLE OF TOWN FUNCTIONS

Abstract
Research attributes the adoption and use of fertilizer to different factors. Functions provided from towns, amongst others, can influence the *ability* and *decision-making behavior*. In this chapter, we aim to contribute to the literature by examining the effect of town functions not only on the ability to adopt fertilizer but also the decision to adopt and the intensity of adoption. Based on rural household survey data from 15 rural areas in Ethiopia, we use the Box-Cox double hurdle model to investigate the effect of town functions on fertilizer application. Results suggest that shorter distance to markets, roads and telephone services make significant contribution in enabling and encouraging households to adopt fertilizer and increase intensification. While ability of participation would increase by 1.5 and 3.2 percent, fertilizer intensification among adopters is estimated to increase by 1.3 and 2.6 percent for each 1 km reduction in distance to well accessible roads and markets, respectively. Moreover, strong network relations are positively associated with fertilizer adoption and intensity of use.
Keywords: town functions, fertilizer adoption and use, rural households, Box-Cox double hurdle model, Ethiopia

6.1 Introduction

The adoption of agricultural technologies in developing countries has attracted considerable attention over the years. This is because the use of improved or new technologies and management systems is an important way of ensuring better production and productivity in agriculture (Doss, 2006). The stock of literature sufficiently highlights the positive effects of chemical fertilizers on agricultural production. Kelly (2006) for instance states that as much as 50 percent of the Green Revolution yield growth is attributed to fertilizer use. Self and

Grabowski (2007) similarly argue that new agricultural technologies (primarily fertilizer intensity) help facilitate economic growth through their effect on improving agricultural productivity.

The role of new (improved) technologies is so important that agricultural yield is undermined without these (such as fertilizer, HYVs, disease or drought-resistant seeds, new management or production systems) technologies. In this regard, Diao and Pratt (2005) stress that the low agricultural production in Ethiopia is in general attributed to the low and inefficient use of modern inputs and technologies. Similarly, Croppenstedt *et al*. (2003) emphasize that low agricultural productivity in Ethiopia has its roots in the poor use of new technologies. The story is similar in other Sub-Saharan African (SSA) countries. For this, Kelly (2006) and de Janvry (2010) state that low agricultural production in SSA is partly attributed to a much smaller fertilizer application rate, on average, as compared to Asia and Latin America.

It begs the question: How can fertilizer application then be improved and what is the role of functions provided from towns? Increasing access to markets and infrastructure, among others, is one solution component expected to improve fertilizer application in Sub-Sahara Africa (Kelly, 2006). Yet these facilities are often missing in rural areas of many developing countries. But, many of the infrastructures and institutions (town functions) are locationally provided from towns with the aim of serving rural areas alike, which can play a crucial role in promoting agricultural technologies use and rural development (Rietveld, 1990; Tacoli, 1998b). This is because new agricultural technologies and management systems often flow from towns and urban centers to rural areas and the functions can strengthen the backward linkage.

An area of research that has garnered little attention in the literature is the influence that access to town functions has on rural household input use (for instance, fertilizer adoption and use). The bulk of the literature shows that a lot of research has been done in areas of fertilizer adoption (such as, Croppenstedt *et al*., 2003; Asfaw and Admassie, 2004; Xu *et al*., 2009), the focus being the analysis of the effect of household-specific, plot-level and technology-specific characteristics on technology adoption and use. Despite the rich adoption literature, research about the contribution of town functions to adoption of technologies has so far been limited and questions remain unaddressed concerning how town functions influence adoption behavior. A literature survey on technologies adoption by Doss (2006) underlines that the stock of literature is particularly limited in the study of the relationship between town functions (infrastructure and institutions) and fertilizer adoption. Doss (2006: 209) specifically emphasizes "…in particular, they [adoption studies] do not lend themselves to answering the bigger questions of how policy, institutions, markets, and infrastructure affect the adoption of new technologies…".

A scan of the literature after 2006 does not yield studies that examine the role of town functions in fertilizer adoption and use. Given the limited availability of knowledge about the relationship among different town functions and fertilizer adoption, this chapter aims to achieve one goal. The objective is to investigate the effect of town functions on fertilizer adoption and use. For this purpose, a cross-sectional data collected from 15 rural areas in Ethiopia (dataset from the Ethiopian Rural Household Survey) is considered. A Box-Cox double hurdle model is used to estimate and explain relationships among various kinds of town functions and fertilizer adoption and use.

The rest of the chapter is structured as follows. In section 6.2, we outline a simple theoretical model of household utility-maximizing behavior upon which the empirical model is based. In section 6.3, the method of estimation is discussed briefly. Section 6.4 presents a general description of the dataset used for analysis. In section 6.5, estimation results are presented and discussed, examining the role of town functions on fertilizer adoption and use. Section 6.6 provides a summary of the results and offers concluding implications.

6.2 Conceptual framework

The literature presents three conceptual paradigms to explain the technology adoption decision-making by small farm households. One is the innovation-diffusion model (attributed to the pioneer work by Rogers, 1962), which assumes that a technology is appropriate for use unless otherwise hindered by lack of information. This concept emphasizes that availability and access to information of a particular technology is the major factor in deciding whether to adopt and extension services, the media and community play a key role in promoting adoption. The second paradigm, the economic constraints model, holds that asymmetric endowments of resources among potential adopters are the major determinant factors in adoption behavior. In particular, access to such vital resources as land and capital could significantly influence the patterns of adoption of technological innovations. The third paradigm focuses on the adopter perception and technology characteristics. According to this model, technology-specific characteristics and the perception of potential adopters regarding the attributes of the technology influence adoption behavior.

The approach we follow in this paper is to integrate town functions that partly contribute to the reasoning of each paradigm. Different town functions can be considered in explaining fertilizer adoption behavior. The influence of the town functions can range from *enabling* farmers (increase the ability) to *encouraging* them to adopt fertilizer and influence the *rate of fertilizer application*. Some town functions may affect the perception of households (such as extension services, educational centers and networks) and help generate, process and disseminate technology-related information. These functions together with communication services (such as telephone services) may reduce the effect of fixed transaction costs $\left(\tau_b^f\right)$ related to information access by potential adopters (let's denote these functions by the vector $\mathbf{TF_f}$). Other town functions such as roads, transport services and markets denoted by the vector $\mathbf{TF_v}$ may influence variable transaction costs[1] $\left(\tau_b^v\right)$ related to the transport of fertilizer. Furthermore, functions such as, educational centers and credit facilities may affect resource endowments of potential adopters (Key *et al*., 2000), which may influence adoption behavior. Where there is high degree of market imperfection, informal institutions such as network relations and social capital denoted by $\mathbf{NS}$ can contribute to the exchange of fertilizer-related information, promote learning and reduce risk behavior and uncertainties.

To incorporate town functions, we start from the assumption that farm households make decisions to adopt fertilizer with the objective of maximizing utility. Considering a non-separable household consumption and production decisions, the utility maximizing function can be specified as:

$$Max\ U = U(c, l; \mathbf{z_b}) \qquad (6.1)$$

where c denotes consumption of goods, l is consumption of leisure and $\mathbf{z_b}$ is the vector of utility-shifting household characteristics. When farm households decide about fertilizer adoption and use, transaction costs associated with fertilizer use can influence decision-making behavior. While these transaction costs may not be observed or measured (Key *et al*.,

[1] Over all, transaction costs are assumed to include costs related to the transport of fertilizer input.

2000), they can be accounted for as a function of observable variables such as town functions, network relations or household-specific characteristics.

In this paper, we focus on two hurdles that have to be taken by farm households in order to apply fertilizer.[2] The first hurdle is related to the ability to adopt fertilizer is stated as

$$F = F\left\{\tau_b^f\left(\mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b}\right)\right\} \tag{6.2}$$

The first hurdle of fertilizer adoption is passed when there is sufficient access to information-exchange facilitating town functions. Next, the second hurdle of deciding to adopt and intensity of adoption is taken. In this decision, output price and variable transaction costs play a vital role. The participation and intensity of adoption (F_a) is specified as

$$F_a = F_a\left\{p_b, \tau_b^v\left(\mathbf{TF_v}, \mathbf{TF_f}, \mathbf{NS}, \mathbf{z_b}\right)\right\} \tag{6.3}$$

where p_b is output price and variable transaction costs $\left(\tau_b^v\right)$ are explained as a function of town functions, network relations, social capital and household characteristics.[3] If farm households decide not to adopt fertilizer, we observe zero units of fertilizer applied in the second hurdle (the second hurdle is not taken). Given households pass this second hurdle, positive units of fertilizer application is observed. Town functions are further represented by the distance that rural households would need to travel to reach the functions. On the other hand, network relations and social capital strength are measured by indices computed using Principal Components Analysis (PCA).

$$F = F\left\{\mathbf{NS}, a\left(d, \mathbf{TF_f}\right), g\left(d, \mathbf{TF_v}\right), \mathbf{z_b}\right\} \tag{6.4}$$

$$F_a = F_a\left\{p_b, \mathbf{NS}, a\left(d, \mathbf{TF_f}\right), g\left(d, \mathbf{TF_v}\right), \mathbf{z_b}\right\} \tag{6.5}$$

where d represents the distance to the vector of town functions.

6.3 Method of estimation

In the survey data we used for this chapter, not all households participated in fertilizer adoption. Farm households may not adopt fertilizer for a variety of reasons. Usually, they do not simply decide whether or not to adopt fertilizer. First, they should be able to participate in

---

[2] The full household model with transaction costs is presented in Appendix 5.1A of chapter 5. The reduced forms in (6.2) and (6.3) can be derived from the model.

[3] The full household model with transaction costs that shows how the reduced forms are derived is available from the authors.

fertilizer adoption. Then, they decide on adopting fertilizer. Conditional on this participation decision, households decide on how much to fertilizer to apply.

The argument we make is that town functions contribute to the series of decision-making. Apart from household and farm-specific characteristics, town functions may affect non-adopting and adopting households differently in the decision-making process. In examining the role of town functions on fertilizer adoption and intensity therefore, both adopting and non-adopting households should be considered. Economic and non-economic factors may also lead to adoption or non-adoption. Based on this, appropriate models can be used to estimate relationships. If the reason for adoption or non-adoption is solely based on economic factors (such as prices and income), the Tobit model can be used as a method of estimation.

However, fertilizer markets in developing countries are highly imperfect and farm households decision on adoption and the intensity of adoption can also be affected by non-economic factors (such as access to town functions). One major importance of town functions is they influence ability of participation in adoption. They can also influence decision-making (both, whether or not to adopt, and if so, the intensity of adoption). We argue that the ability to adopt and decision to adopt and the intensity of fertilizer adoption may involve two different processes. In this situation, the double hurdle model originally due to Cragg (1971) becomes useful as it distinguishes between the effects of different factors on the ability to participate in fertilizer adoption on the one hand and the participation decision and amount of fertilizer applied on the other.

The model assumes that two separate hurdles must be passed before a positive level is observed. In the context of fertilizer use, the first hurdle is related to the ability of farm households to adopt fertilizer (i.e. being able to participate in the fertilizer market - the *participation ability decision*). Once households pass this hurdle, the next is the decision of whether or not to adopt and if so, how much to adopt (the second hurdle). The second hurdle concerned with *decision to adopt and intensity of adoption*. A probit model is used to specify the ability of participation and a Tobit model to determine the decision and intensity of adoption. The method of estimation used in this chapter is similar to the previous one. However, the estimation strategy in a fertilizer application framework is presented in Appendix 6.1A.

6.4 Data description

For the purpose of this chapter, data from the Ethiopian Rural Household Survey (ERHS) is used. The data are collected from 15 rural areas in 4 major regional states of Ethiopia. These rural areas are situated in the highlands of Ethiopia where mixed farming dominates the livelihood. These areas are characterized by different endowments of town functions. Some of the major town functions (such as telephone facilities, major markets, electricity, non-elementary schools, banks, postal and health institutions) were not available in the rural areas. And many households would need to travel to the nearest rural towns or towns and other urban areas to reach the town functions.

From the dataset, 1290 sample households yielded complete information for the purpose of this chapter. A wide range of issues affecting rural households' livelihood and living standards were covered in the dataset, including access to town functions, marketing of crop outputs, adoption and use of production inputs, land use practices, labor-sharing arrangements, off-farm participation, business activities, agricultural credit, networking and social capital, asset ownership and food expenditure. The dataset involves historical recall of data on fertilizer adoption and use. This is used to analyze who is adopting and how much, and which town functions are influential, thereby identifying the factors that facilitate and constrain fertilizer adoption behavior and intensity of adoption.

Fertilizer adoption is observed to be moderate in that 43.6 percent of the farm households adopted fertilizer. For the full sample, the average amount of fertilizer used is 33.8 kg (23 kg per hectare). Among the adopting households, the average amount of fertilizer used is 75.6 kg. Summary statistics of the variables used in the econometric estimation is provided in table 6.1. It can be seen from the table that households that adopt fertilizer cultivate larger plots. It is also shown that adopters have higher credit access, which can be one source of liquidity for loan purchases of fertilizer. Households adopting fertilizer are distinctively shown to own more livestock while there is similar participation in off-farm activities among adopters and non-adopters. The index for network relations is observed to be stronger for fertilizer adopters. On the other hand, the social capital index measure shows that adopters and non-adopters have similar stocks of capital. On average, non-adopters are observed to be situated farther away from many of the major town functions than adopting households (with the exception of extension and agricultural cooperative centers, see table 6.1).

As variables of main concern, town functions are among the explanatory variables that are hypothesized to influence fertilizer application. We use town functions and social networks as proxies for transaction costs. One the one hand, distance indices of major town functions including roads, markets, telephone and banking services is considered. It is hypothesized that the higher the index the lower the transaction costs and the higher the adoption and application of fertilizer. Moreover, knowledge-generating, processing and disseminating functions (such as schools, extension and agricultural cooperative centers) are considered. These functions help in promoting learning, facilitating information exchange and lowering other fixed transaction costs. In other words, the shorter the distance to these town functions, the higher the probability of fertilizer adoption and intensification. On the other hand, indices from network relations and social capital are used to explore the effect of the number and frequencies of interactions that households make with different economic agents. Higher indices of network relations refer to greater number and frequencies of interactions, which can help households obtain more information and learn about fertilizer. This is hypothesized to increase probability of fertilizer adoption and intensification.

Higher crop prices are hypothesized to encourage farm households to adopt fertilizer since higher production (productivity) as a result of using fertilizer would bring higher profits. Other factors such as livestock size, credit access and off-farm employment are considered. These are expected to ease liquidity constraints and increase probability of fertilizer adoption. Agricultural infrastructure such as irrigation can complement fertilizer application in boosting production by increasing moisture content. As a result, access to irrigation is hypothesized to encourage fertilizer adoption and intensification. Attributes related to land and land characteristics are also considered. With land size, it is hypothesized that fertilizer application would increase since the scale of economies created by land size would increase profitability of fertilizer use.

In table 6.1, the summary statistics of some of the variables used in the double hurdle model is presented. In the regression model, the town functions, including roads, markets, telephone services, electricity and banks are represented by their indices. The summary statistics of these indices which are computed using the same approach as those in chapter 5 is presented in Appendix 6.3A. Other functions such as junior schools, secondary schools, agricultural extension and cooperative centers showed high degree of multicollinearity. To circumvent this, the functions are aggregated to 'source of knowledge' index using Principal Component Analysis. Moreover, the different indicators that are used to construct network relations and social capital indices using Principal Component Analysis are provided in chapter 5. The network relations index is constructed from different forms of network interaction indicators that rural households establish with neighbors, relatives, input suppliers and output customers. These network partners may be located in the same village, another village, rural town or other urban centers. On the other hand, different forms of social norms and values are used as indicators for social capital index.

Table 6.1: Summary statistics of variables

Variables	Full sample		Adopters		Non-adopters	
	Mean	SD	Mean	SD	Mean	SD
Fertilizer adoption (1= the household adopted fertilizer; 0= otherwise)	0.44	0.49	1.00	0.00	-	-
Fertilizer intensity adopted (kilogram)	33.8	79.8	75.6	106	-	-
Gender of the household head (1= male; 0= female)	0.78	0.41	0.82	0.38	0.76	0.43
Age of the household head (years)	50.4	13.7	50.2	13.3	50.6	13.9
Education of the household head (years of schooling)	1.40	2.60	1.75	2.86	1.18	2.42
Education dummies of the household head						
(1= primary education; 0= otherwise)	0.30	0.46	0.37	0.48	0.25	0.44
(1= secondary or above education; 0= otherwise)	0.08	0.27	0.10	0.30	0.06	0.24
(1= illiterate; 0= otherwise)	0.62	0.49	0.53	0.50	0.68	0.47
Household size (Number of members in the household)	5.63	2.50	6.20	2.60	5.20	2.40
Access to credit (1= the household has access to credit; 0= otherwise)	0.56	0.50	0.67	0.47	0.47	0.50
Plot (land) size (hectares)	1.47	1.69	1.95	2.16	1.10	1.08
Composite price for crop outputs (Birr per kilogram)	2.84	2.60	3.34	2.34	2.44	2.59
Use of irrigation practices (1= yes; 0= otherwise)	0.21	0.40	0.25	0.43	0.17	0.38
Soil fertility (1= the household has fertile plot; 0= otherwise)	0.52	0.49	0.53	0.50	0.51	0.50
Slope of the plot (1= plot is plainly level; 0= otherwise)	0.71	0.45	0.80	0.39	0.64	0.48
Livestock size (Tropical Livestock Unit)	3.88	5.52	5.78	7.44	2.40	2.52
Off-farm participation (1= yes; 0= otherwise)	0.50	0.50	0.49	0.50	0.51	0.50
Distance to bank and microfinance institutions (km)	34.2	52.2	15.1	29.4	49.0	60.6
Distance to telephone centers (km)	10.2	5.60	8.00	4.90	11.9	5.50
Distance to secondary schools (km)	15.2	15.2	10.4	10.6	18.9	17.1
Distance to junior schools (km)	4.15	4.37	3.90	4.20	4.30	4.50
Distance to extension and agricultural cooperative centers (km)	4.50	4.60	4.70	5.20	4.40	4.10
Road index (average of both rainy and dry seasons)	0.23	0.14	0.30	0.13	0.18	0.12
Source of knowledge index	2.10	1.44	2.44	1.40	1.66	1.38
Market (periodic) index	0.67	0.29	0.65	0.30	0.68	0.27
Network relations index	3.02	1.50	3.58	1.55	2.58	1.25
Social capital index	6.01	1.86	6.00	1.79	6.02	1.81

Often, economic theory does not provide guidance as to which regressors need to be included in the first and second hurdles of the double hurdle model. The use of the same regressors in both hurdles often makes model identification difficult. In order to alleviate this problem, Yen *et al*. (1996) emphasize that an exclusion restriction must be imposed to facilitate model convergence. An underlying assumption in double hurdle models is that the first hurdle related to household ability to adopt fertilizer is usually specified as a function of noneconomic factors (Aristei and Pieroni, 2008). This argument leads to the exclusion of economic factors such as prices from the first hurdle. Social networks and town functions like telephone centers, educational facilities, extension and agricultural cooperative centers are hypothesized to influence the participation ability of households through reducing the effect of fixed transaction costs. These attributes that facilitate information exchange and other functions (such as, roads and markets) are included in the first hurdle.

Economic factors such as crop prices are hypothesized to influence fertilizer adoption decision and intensity (second hurdle). In addition, town functions that reduce the effect of variable transaction costs associated with fertilizer transport (such as roads and markets) and technology information (social networks, telephone, extension centers, etc.) are included in the second hurdle. Additionally, demographic and farm-specific attributes that may explain adoption behavior are considered in each hurdle. After selecting the relevant variables, some tests were performed. Problems of multicollinearity between different variables (especially some town functions) were observed, which led us to aggregate some *a priori* relevant variables, such as access to junior and secondary schools, agricultural extension and cooperative centers to a 'knowledge source' index. The variables included in the final model show no serious problem of multicollinearity.

Before discussing the results, it has to be underlined that the Box-Cox transformation parameter $(\lambda = 0.579)$ is significantly different from zero or one, implying the usefulness of the Box-Cox transformation (Moffatt, 2005). The use of the Box-Cox transformation significantly reduced the skewness of the dependent variable. Households' predicted probabilities of passing the first and second hurdles provide some insight into the likelihood that households will use a positive amount of fertilizer. The predicted probability for the average household to pass the first hurdle is 0.94 (94%) while that of the second hurdle is only

47 percent.[4] In other words, the predicted probability for the average household to decide and use a positive amount of fertilizer is 47 percent (close to the arithmetic mean). The implication is that not all households who pass the first hurdle actually decide to adopt a positive amount of fertilizer. These predicted probabilities further suggest that even if households are able to adopt fertilizer, market imperfections such as limited or no access to transport infrastructure for instance, may prevent them from passing the second hurdle.

6.5 Results and discussion

Maximum likelihood estimates of the Box-Cox double hurdle model are presented in table 6.2. Results in the first column correspond to the first hurdle (ability of participation in fertilizer adoption) and coefficients in the second column are related to the second hurdle. Elasticities for continuous variables are presented in table 6.3. In addition, the discrete effects of binary variables are reported in table 6.4. For town functions, percentage changes of the effect of 1 km change in distance to town functions are reported in table 6.5. These effects for town functions are computed from index elasticities in table 6.3 based on the indices formulae. Finally, the elasticities show the effect for the average household.

6.5.1 Effect of town functions on fertilizer adoption and use

Farm household access to some of the major town functions are associated with higher ability and probability of fertilizer adoption and intensification. Roads are found to have significant positive effect on enabling and encouraging fertilizer adoption and the intensity of its use. The results indicate that the probability of fertilizer adoption and intensity of use increases with proximity to roads (that usually lead to rural towns or towns).

The elasticities with respect to road index[5] are all positive and significant, with the unconditional elasticity equal to 1.28. The implication is that an increase in road index by 1 percent leads to a 1.28 percent increase in intensity of fertilizer adopted, *ceteris paribus*. Intuitively, these index elasticities do not have direct meaning. For this reason, elasticities that represent the effect of a 1 km reduction in distance to town functions are presented in table 6.5.

---

[4] This figure is calculated from the probability of passing the second hurdle (part of the estimation process).

[5] Road index is constructed by taking into account distance and type of road.

Table 6.2: Box-Cox double hurdle estimates of fertilizer adoption and use

Variables	First hurdle	Second hurdle
Age	-0.001 (0.022)	0.063 (0.045)
Gender of head	-0.343 (0.563)	1.268 (1.527)
Household size	0.218 (0.124)*	0.508 (0.238)**
Primary education	-0.798 (0.546)	0.713 (1.275)
Secondary education	-0.935 (0.944)	-0.334 (2.115)
Access to credit	1.832 (0.607)***	-0.400 (1.284)
Off-farm participation	-0.375 (0.470)	2.400 (1.245)*
Ownership of livestock	0.172 (0.068)**	0.488 (0.110)***
Plot (land) size	-0.036 (0.119)	0.847 (0.321)**
Use of irrigation	4.343 (1.327)***	-0.642 (1.583)
Fertility of plot	-1.058 (0.568)*	-0.300 (1.158)
Slope of plot	2.856 (0.794)***	-2.220 (1.492)
Source of knowledge	0.952 (0.769)	15.85 (1.673)***
Bank services	-2.380 (1.960)	47.74 (4.504)***
Electricity	-3.858 (3.266)	69.37 (8.990)***
Telephone services	14.06 (4.614)***	
Market (periodic)	7.333 (2.409)***	11.14 (3.056)***
Road access and quality	10.82 (4.516)**	52.79 (12.81)***
Network relations	1.533 (0.475)***	1.316 (0.454)***
Social capital	0.429 (0.182)**	-0.111 (0.324)
Average price		0.533 (0.247)**
constant	-18.87 (7.746)***	-148.9 (14.41)***
λ (Box-Cox transformation parameter)		0.579 (0.019)***

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: values in parentheses are standard errors.

Based on this, fertilizer intensification increases (the overall effect) by 2.8 percent[6] when roads that are well accessible to any vehicles are brought closer by 1 km, all else being constant. This suggests that roads have the bigger effect (as compared to the conditional elasticity of 1.3%) of encouraging some non-adopters to adopt fertilizer, which is a strong indication of the importance of expanding good rural road networks. Similarly, the effect on probability of adoption shows the importance of accessible and reliable roads to the dissemination of fertilizer to rural households, which would help them enhance crop yield (the effect being a 1.5% increase in the probability of fertilizer adoption for a 1 km reduction in distance).

[6] These values represent the equivalent effect of a reduction in distance to roads by 1 km from the mean distance to well accessible roads. Similar approaches are used to compute equivalent effects for market, telephone services, electricity and banks.

As useful as closer roads are, distance alone may not account for the effect on fertilizer adoption behavior. In this regard, Lanjouw (1999) emphasizes that proximity to roads that lead to towns may not translate into promoting rural livelihoods unless the quality of those roads is good. The empirical evidence in this regard provide highlights as to how good quality roads (such as *well accessible roads*) are useful in promoting fertilizer adoption and intensive use (see also Dercon and Hoddinott, 2005). The effect of the quality of roads can be seen from the influence that roads with 'less grade' such as *reasonably accessible roads* have on fertilizer adoption. All other things being constant, the distance elasticity for *reasonably accessible roads to any vehicle*[7] suggests that a 1 km reduction in distance to these roads leads to 1.2 and 2.2 percent higher fertilizer adoption probability and intensity, respectively. The results provide insights into the difference that road quality can make to fertilizer adoption behavior. Depending on the technology, however, good road conditions do not always promote the adoption of technologies. For instance, Adegbola and Gardebroek (2007) present empirical evidence that indicates the negative effect of good road conditions on the adoption of a storage technology because it increases market access and profitability (i.e. increased market access boosts profitability and discourages storage).

Similarly, markets are found to have a significant contribution to enabling and encouraging fertilizer adoption and increasing intensity of use. The results confirm the strong and positive effect that shorter distance to markets has in encouraging farm households to adopt fertilizer and increase intensity of use. The elasticities with respect to market index[8] are all positive and significant, with probability and conditional effects equal to 0.42 and 0.35 respectively (table 6.3). In terms of distance effect, these elasticities show that if markets are brought closer by 1 km, the probability of fertilizer adoption ability increases by 3.2 percent, *ceteris paribus*. Similarly, a reduction in market distance by 1 km encourages households to increase intensity by 2.6 percent, all other things being constant (table 6.5). The effect of market access on fertilizer use is even higher when we consider all households, including non-adopters.

---

[7] Elasticity for these roads is computed using the formula specified for road index in appendix 5.3A in chapter 5.

[8] Market indices (specifically periodic market index) are constructed from the distances that households need to travel to the nearest periodic markets. The way periodic market index is constructed is explained in chapter 5: appendix 5.3A. The same approach has been used to construct indices for electricity, banking and telephone services.

Specifically, fertilizer use among all sample households would increase by 5.8 percent if market distance is brought closer by 1 km, *ceteris paribus* (its equivalent effect in terms of market index is 0.77% increase in fertilizer intensification for a 1% increment in market index).

Table 6.3: Elasticities of continuous variables

Variables	*prob.*	*cond.*	*uncond.*
Age	0.179 (1.39)	0.152 (1.37)	0.331 (1.39)
Household size	0.162 (2.15)**	0.136 (2.08)**	0.298 (2.15)**
Livestock size	0.106 (4.77)***	0.090 (3.75)***	0.196 (4.43)***
Plot (land) size	0.070 (2.69)**	0.059 (2.49)**	0.129 (2.64)**
Source of knowledge	1.875 (12.2)***	1.585 (6.39)***	3.460 (10.4)***
Bank services	2.177 (14.9)***	1.840 (6.59)***	4.017 (11.6)***
Telephone services	3.2×10^{-6} (0.14)		3.2×10^{-6} (0.14)
Electricity	2.407 (9.28)***	2.035 (5.67)***	4.442 (8.17)***
Periodic market	0.417 (3.80)***	0.353 (3.36)***	0.770 (3.71)***
Road access and quality	0.693 (4.25)***	0.586 (3.82)***	1.280 (4.23)***
Network relations	0.223 (3.00)***	0.189 (2.75)***	0.412 (2.95)***
Social capital	-0.038 (0.34)	-0.032 (0.34)	-0.070 (0.34)
Average price	0.085 (2.18)**	0.072 (2.10)**	0.157 (2.16)**

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: values represent probability, conditional and unconditional elasticities. The absolute values of t-statistic are reported in parentheses.

Markets improve fertilizer adoption behavior through improving information access related to fertilizer and prices and reducing costs related to information search and transport of fertilizer. In this regard, Alene *et al.* (2008) present empirical evidence that emphasizes the potential opportunity to increase fertilizer adoption and intensity through improved market information and distribution systems, which improves with proximity to markets. By contrast, studies (such as Freeman and Omiti, 2003) present findings that show negligible influence of markets on fertilizer adoption behavior. They argue that this relationship reflects the declining importance of distribution constraints due to the growing availability of fertilizer outlets in rural areas of developing countries.

Other relevant town functions considered include telephone services, electricity and banking centers. Results show that a higher probability of fertilizer adoption is associated with a shorter distance to telephone services. Availability of telephone services at short distance may help farm households in communicating with others and exchanging information about fertilizer. In addition, availability of banks and electricity in closer proximity is found to have a significant positive effect on the intensity of fertilizer use. We could not come up with convincing reason how shorter distance to electricity contributes to fertilizer intensification. But it may help power productive activities that would create employment and income opportunities, which can contribute to covering expenses for fertilizer. Availability of banking services at closer proximity may also create opportunities for households to borrow and ease the cash constraints for fertilizer use (intensification).

Table 6.4: Discrete effects on fertilizer adoption and use

Variables	*prob.*	*cond.*	*uncond.*
Gender of head	0.034 (0.83)	2.124 (0.37)	1.585 (0.29)
Primary education	0.019 (0.56)	1.227 (0.26)	0.949 (0.27)
Secondary education	-0.009 (0.15)	-0.566 (0.07)	-0.429 (0.11)
Access to credit	-0.011 (0.31)	-0.685 (0.15)	-0.525 (0.19)
Off-farm participation	0.064 (1.95)*	4.105 (0.73)	3.147 (0.33)
Use of irrigation	-0.017 (0.40)	-1.085 (0.19)	-0.820 (0.23)
Fertility of plot	-0.008 (0.26)	-0.513 (0.12)	-0.392 (0.17)
Slope of plot	-0.059 (1.49)	-3.900 (0.62)	-3.080 (0.34)

Significance level: *** = 1%; ** = 5% and * = 10%.
Notes: values represent probability, conditional and unconditional effects. The absolute values of t-statistic are reported in parentheses.

The results in table 2 indicate that knowledge-generating, processing and disseminating town functions (such as schools and extension centers, cooperatives) have significant positive effect on increasing intensity of fertilizer use. The higher the index the higher the application of fertilizer. In other words, with proximity to these functions, intensity of fertilizer use increases. Unlike expectations, however, their effect on enabling (increasing probability of fertilizer) adoption was observed to be insignificant. Otherwise, the literature (Kaliba *et al.*, 2000; Croppenstedt *et al.*, 2003; Alene *et al.*, 2008) suggests that agricultural extension and cooperative centers help mitigate households' technology uncertainties and develop confidence in the benefits of using fertilizer. With shorter distance to these functions vital information related to fertilizer can be obtained, which eventually helps encourage fertilizer adoption and intensification. On the other hand, closer educational centers equip farm households with human capital that enable them to learn and better process information and improve the use of fertilizer.

6.5.2 Network relations, social capital and fertilizer application

Estimation results show that the strength of network relations[9] that households build has a significant positive effect on both ability to adopt fertilizer and intensity of use. The elasticities with respect to network relations are all positive and significant. All other things being constant, the probability of fertilizer adoption increases by 0.22 percent when the network relations index increases by 1 percent. In addition, the elasticity of fertilizer use with respect to network relations among adopters suggests that a 1 percent increase in the network relations index increases the intensity of fertilizer use for the average household by 0.19 percent, *ceteris paribus*. The overall effect of the strength of network relations is even higher, which is shown by the unconditional elasticity. This result suggests that strengthening network relations among all households would further encourage some non-adopters to adopt or use fertilizer.

Among the vital network ties that farm households establish are those networks with input supplier and output customers. Such networks can act as a source of marketing information (demand, supply and price) as well as being a source of credit (and also information) that might be used to purchase fertilizer. Different households forge varying levels of network strength, which eventually may help them obtain technology-related information and benefits. These networks can be used mainly to ease households' risk behavior and uncertainties about fertilizer through supplying information about the technology-specific characteristics and benefits of fertilizer. They also promote learning about technologies. In this regard, the empirical results provide sufficient evidence to conclude that networks play useful role in promoting fertilizer application. The frequency with which households meet other people and the number of different associations that households are registered in can help them learn about fertilizer, which leads to fertilizer use. Previous studies (such as Isham, 2002; Matuschke and Qaim, 2009) emphasize this by suggesting that the behavior of network

---

[9] The network relations index is constructed from different forms of network interaction indicators that rural households establish with neighbors, relatives, input suppliers and output customers. These network partners may be located in the same village, another village, rural town or other urban centers. Principal Components Analysis (PCA) has been used to construct network relation and social capital indices, and the different indicators that are used to construct the indices are provided in chapter 5: appendix 5.2A.

members and mechanisms of network establishments appear to be the most important elements in promoting technology adoption.

Similar to personal network relations, the effect of 'common' social capital is assessed on fertilizer adoption and use. Results show that social capital has a significant positive effect on the probability of fertilizer adoption but not on the intensity of use. Social capital elements such as trust (households themselves, neighbors and officials) and established values complement household-specific networks in building confidence about fertilizer benefits and reduce technology uncertainties, thereby encouraging adoption. A conducive social fabric emanating from strong social capital can also help farmers trust neighbors and public officials, which in turn helps facilitate learning (reduce risk behavior and uncertainties) about attributes of new technologies and encourage adoption.

Table 6.5: Elasticities of the effect of a 1 km reduction in distance

Town functions	Elasticities		
	prob.	*cond.*	*uncond.*
Roads			
Well accessible to any vehicle	1.50 (4.25)	1.30 (3.82)	2.80 (4.23)
Reasonably accessible to any vehicle	1.20 (2.23)	1.00 (3.22)	2.20 (2.51)
Reasonably accessible to trucks	0.90 (2.01)	0.80 (2.64)	1.70 (2.37)
Markets	3.20 (3.80)	2.60 (3.36)	5.80 (3.71)
Electricity	1.49 (9.28)	1.26 (5.67)	2.75 (8.17)
Banks	1.50 (14.9)	1.30 (6.59)	2.80 (11.6)

Notes: values represent probability, conditional and unconditional elasticities.
Absolute value of the t-ratios are presented in parentheses.

6.5.3 Household and farm characteristics role on fertilizer adoption and use

With household size, results show that the probability of adoption and amount of fertilizer used increases. A large family could be a source of information and learning that encourages adoption and intensive use of fertilizer. As Croppenstedt *et al*. (2003) on the other hand argue, it may be also due to the higher likelihood that larger size households have to adopt and use fertilizer more intensively during pick seasons.[10] On the contrary, Freeman and Omiti (2003)

[10] Farm households can face labor shortages during peak periods of the farming season. However, they often arrange work parties where they try to pool community farm labor during the peak seasons.

present empirical findings reflecting that households with smaller family size are more likely to adopt and intensively use fertilizer. They argue that fertilizer utilizes less labor per hectare (than alternative fertility management practices) and small sized households may see fertilizer as labor-saving technology (labor saved may be allocated to income-earning off-farm activities). A supporting argument for an inverse relationship between family size and fertilizer intensification is that large-sized farm households that often depend on subsistence agriculture may find it difficult to generate liquidity to cover fertilizer expenses, keeping other things constant.

The results do not support the hypothesis that level of education significantly affects adoption behavior of households. Results show that heads with primary and secondary-level of education do not have a statistically significant different fertilizer adoption behavior as compared to illiterate heads. In the literature, while Isham (2002) conclude that no significant relationship is observed between education and fertilizer adoption, other studies (Croppenstedt *et al*., 2003; Weir and Knight, 2004; Marenya and Barrett, 2009) present empirical evidence that emphasizes the positive effect of education on fertilizer adoption decision-making.

Access to agricultural inputs such as credit has a positive and significant effect on the probability of fertilizer adoption (see table 6.2). Credit access is often important in easing liquidity constraints that farm households face to cover for agricultural input expenses, including fertilizer. Although uncertainties about fertilizer (including its usage) discourage farm households from adopting the technology, cost of fertilizer is usually seen as the reason behind farmers' reluctance to try out and continually use the technology. Access to credit would thus help farm households in securing the liquidity to cover for fertilizer expenses. Related studies such as Asfaw and Admassie (2004) and Marenya and Barrett (2009) similarly highlight the role of credit in encouraging fertilizer adoption.

In relation to this, estimation results in table 6.2 indicate that both off-farm participation and the number of livestock influence fertilizer use in a significant and positive manner (the former only at the 10% level). It could be the case that off-farm participation and larger herd size help households raise the liquidity to cover for higher amounts of fertilizer. In addition, the results show that irrigation practices encourage households to adopt fertilizer. This demonstrates the critical role of support technology and functions in promoting the adoption and intensification of fertilizer.

Plot size is positively related to the intensity of fertilizer use, as the results show. The probability of fertilizer adoption increases by 0.07 percent as plot size increases by 1 percent, keeping other things constant. For the full sample, a 1 percent increase in plot size leads to an increase in the amount of fertilizer used for the average household by 0.13 percent, *ceteris paribus*. The higher overall effect indicates that non-adopters would be encouraged to adopt and use fertilizer if larger plots were made available to them. This is because larger plots may contribute to the economies of scale of adopting and then using higher amounts of fertilizer. In this case, our results are in line with empirical evidences by Isham (2002) and Marenya and Barrett (2009). Other studies (such as Nkonya *et al*., 1997; Croppenstedt *et al*., 2003; Alene *et al*., 2008), however, present empirical findings arguing that small farms (owners of smaller land size) use fertilizer more intensively.

In relation to plot characteristics, results indicate that households who own fertile plots have a lower probability of adopting fertilizer. On the other hand, households whose plots are situated in plain areas (less steep plots) have a higher probability of adopting fertilizer. In this case, the argument is that farm households that own fertile plots may not be encouraged to adopt fertilizer; possibly substituting manure for it. It can also be argued that farmers may be wary of the fact that fertilizer used in steep-sloped plots may be washed away when it rains, which would make the use of fertilizer less attractive.

Consistent with expectations, crop output price has positive and significant effects on the intensity of fertilizer use. The elasticities of fertilizer use with respect to price are all significant and positive. The probability of adoption indicates a 0.09 percent increase in the probability of fertilizer adoption as a result of a 1 percent increase in crop output prices, *ceteris paribus*. The unconditional elasticity of fertilizer use indicates that a 1 percent increase in crop output price leads to 0.16 percent increase in fertilizer use, *ceteris paribus*. The elasticities show that fertilizer use with respect to crop output price is inelastic (see also Alene *et al*., 2008). However, the higher unconditional elasticity suggests that crop output price can be an effective instrument to increase fertilizer use by encouraging some non-adopters.

6.6 Concluding remarks

Adoption literature is rich in the analysis of the effect of household-specific, plot-level and technology-specific characteristics on fertilizer application (see Doss, 2006 for review of adoption studies). Nevertheless, quantitative evidence about the role of a broad spectrum of town functions on the probability of fertilizer adoption and intensity of use is not well developed. In this chapter, we examined how town functions influence not only rural household *ability* of participation in fertilizer adoption but also *decision* to adopt and *intensity* of fertilizer use.

We find that some of the major town functions are useful to fertilizer adoption and use. Accessible and reliable roads play a significant positive role in fertilizer application. If distance to *well accessible roads* (for example, asphalt or paved roads) is reduced by 1 km, results suggest that the probability and intensity of fertilizer use (conditional effect) would increase by 1.5 and 1.3 percent respectively. Comparatively, fertilizer intensification is observed to be strongly affected by roads as they are particularly useful in helping farm households reduce costs related to transporting fertilizer. However, it is not only road distance but also the quality of the roads that significantly determines household decision-making, as is also pointed out by Lanjouw (1999). For instance, fertilizer intensification among adopters would increase only by 0.8 percent (conditional effect) if 'lesser grade' roads (such as those *accessible to trucks*) were brought 1 km closer, indicating the greater effect of roads that are *well accessible to any vehicles*.

Similarly, results indicate that closer markets are likely to increase fertilizer adoption and use. Specifically, a reduction in each kilometer to markets increases fertilizer adoption probability and intensity by 3.2 and 5.8 (overall effect) percent respectively. A shorter distance to markets increases market access, which may be an indicator of risk preference among farm households (reducing risk behavior and uncertainties) and encourage fertilizer adoption and intensity because of the expected future profits (Feder *et al*., 1985). Our analysis furthermore suggests that access to other major town functions such as telephone services also contribute to an increased probability of fertilizer adoption. Other town functions (such as schools, extension and agricultural cooperative centers) that help in generating, processing and disseminating technology knowledge are also found to be instrumental in facilitating fertilizer adoption and use.

Furthermore, results show that household-specific and strong network relations are powerful in enabling farm households to adopt fertilizer by easing technology uncertainties and promoting learning. As the 'social fabric', social capital also plays an influential role in supplementing household-specific networks in creating a conducive environment for increased fertilizer adoption and intensity. However, a word of caution needs to be stressed at this point. If a technology is not fully diffused, studies that estimate the intensive use of the technology may underestimate the true population effect (Diagne and Demont, 2007), suggesting instead the use of treatment effects to evaluate the impact of variables on adoption.

Appendix 6.1A: *Box-Cox double hurdle model in a fertilizer application framework*

Consider the following latent models related to the first and second hurdles:

$$\begin{aligned} d_i^* &= \mathbf{z}_i'\boldsymbol{\alpha} + u_i \\ y_i^{**} &= \mathbf{x}_i'\boldsymbol{\theta} + \varepsilon_i \end{aligned} \qquad (6.1a)$$

where d_i^* is the latent variable describing the farm household's ability to participate in fertilizer adoption; y_i^{**} denotes the latent variable describing adoption decision and intensity of adoption by the farm household. The vectors $\mathbf{z}$ and $\mathbf{x}$, with corresponding vector of coefficients $\boldsymbol{\alpha}$ and $\boldsymbol{\theta}$, represent the independent variables explaining the participation ability and intensity of adoption decisions, respectively. The error terms u_i and ε_i are assumed to be independently distributed with $\begin{pmatrix} u_i \\ \varepsilon_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & \sigma^2 \end{pmatrix}\right]$.

The first hurdle that shows the ability of participation in fertilizer adoption can be elaborated as

$$\begin{aligned} d_i &= 1 \ \ if \ \ d_i^* > 0 \\ d_i &= 0 \ \ if \ \ d_i^* \leq 0 \end{aligned} \qquad (6.2a)$$

The second hurdle that represents the decision and intensity of fertilizer adoption is given by

$$y_i^* = \max\left(y_i^{**}, 0\right) \qquad (6.3a)$$

It follows that the observed intensity of fertilizer applied, y_i, is determined as

$$y_i = (d_i) \cdot (y_i^*) \qquad (6.4a)$$

A positive amount of fertilizer (y_i) is observed only when the farm household is a potential adopter $(d_i = 1)$ and actually applies a specific amount of fertilizer $(y_i^* = y_i^{**} > 0)$.

Maximum likelihood estimation of the standard double hurdle model is built on the assumption of bivariate normality of the error terms. If the normality assumption is violated, maximum likelihood estimates are inconsistent. This is particularly relevant when the model is applied to a dependent variable with a highly skewed distribution, as is the case with our fertilizer use data. One approach to circumvent the non-normality of the error terms is the application of Box-Cox transformation to the dependent variable (see Jones and Yen, 2000; Moffatt, 2005), defined by

$$y_i^T = \frac{y_i^\lambda - 1}{\lambda}, \quad 0 < \lambda \leq 1 \tag{6.5a}$$

where λ is an unknown transformation parameter to be estimated from the model. The Box-Cox double hurdle model implies the following relationship between the transformed dependent variable $\left(y_i^T\right)$ and latent variables d_i^* and y_i^{**}. The first hurdle remains the same. The second hurdle (decision and intensity of fertilizer adoption) becomes

$$y_i^{*T} = \max\left(y_i^{**T}, -\frac{1}{\lambda}\right) \tag{6.6a}$$

And the observed amount of fertilizer adopted $\left(y_i^T\right)$ is given by

$$y_i^T = \begin{cases} y_i^{*T} & if \;\; d_i = 1 \\ -\frac{1}{\lambda} & if \;\; d_i = 0 \end{cases} \tag{6.7a}$$

Based on this, the log likelihood function of the Box-Cox double hurdle model is presented as

$$\begin{aligned} \ell(\boldsymbol{\alpha}, \boldsymbol{\theta}, \sigma, \lambda) = & \sum \ln\left[1 - \Phi(\mathbf{z}_i'\boldsymbol{\alpha})\Phi\left(\frac{\mathbf{x}_i'\boldsymbol{\theta} + 1/\lambda}{\sigma}\right)\right]^{(1-d)} \\ & + \sum \ln\left[\Phi(\mathbf{z}_i'\boldsymbol{\alpha}) y_i^{\lambda-1} \frac{1}{\sigma}\phi\left(\frac{y_i^T - \mathbf{x}_i'\boldsymbol{\theta}}{\sigma}\right)\right]^d \end{aligned} \tag{6.8a}$$

where Φ is the cumulative distribution function (*cdf*) and ϕ is the normal density function (*pdf*) of the standard normal distribution.

The log-likelihood function in (6.8*a*) can then be estimated using maximum likelihood methods. However, the interpretation of coefficients from the Box-Cox double hurdle model is not straightforward. For meaningful interpretation, marginal effects or elasticities of regressors are often computed from the expected value of observed fertilizer adoption (y_i), which can be decomposed into two parts. The relationship between the regressors and intensity of fertilizer adoption can be assessed either conditional on fertilizer adoption, or unconditionally for the whole sample. Conditional elasticities assess the effect of a regressor on the intensity of fertilizer application conditional on adoption. On the other hand, unconditional elasticities capture the joint effect of a regressor on the changes in the probability of fertilizer adoption and intensity of fertilizer application. From the Box-Cox double hurdle model, the unconditional mean of y_i is presented as

$$E(y_i) = \text{Prob}(y_i > 0) \cdot E(y_i | y_i > 0) \qquad (6.9a)$$

The conditional expectation is given by

$$\begin{aligned} E(y_i | y_i > 0) &= E\left(y_i \middle| d_i > -\mathbf{z}_i'\boldsymbol{\alpha}, y_i^{**} > -\mathbf{x}_i'\boldsymbol{\theta} - \frac{1}{\lambda} \right) \\ &= \left[\Phi\left(\frac{\mathbf{x}_i'\boldsymbol{\theta} + 1/\lambda}{\sigma} \right) \right]^{-1} \int_0^{\infty} \frac{y_i^{\lambda}}{\sigma} \phi\left(\frac{y_i^T - \mathbf{x}_i'\boldsymbol{\theta}}{\sigma} \right) \mathrm{d}y_i \end{aligned} \qquad (6.10a)$$

It follows that the probability of passing both hurdles is

$$\text{Prob}(y_i > 0) = \Phi(\mathbf{z}_i'\boldsymbol{\alpha}) \Phi\left(\frac{\mathbf{x}_i'\boldsymbol{\theta} + 1/\lambda}{\sigma} \right) \qquad (6.11a)$$

For continuous regressors, elasticities (unconditional, conditional[11] and probability, respectively) can be computed by differentiating equations $(6.9a)$, $(6.10a)$ and $(6.11a)$ with respect to a given regressor (full derivation of the conditional and unconditional marginal effects are provided in Jones and Yen, 2000). For binary regressors, the discrete effects show the change in the dependent variable when the regressor shifts from zero to one, *ceteris paribus*.

[11] Starting from equation $(6.9a)$, the unconditional elasticity of a given continuous regressor x_{ij} is computed using the following formula:

$$\frac{\partial E(y_i)}{\partial x_{ij}} \frac{x_{ij}}{E(y_i)} = \frac{\partial \text{Prob}(y_i > 0)}{\partial x_{ij}} \frac{x_{ij}}{\text{Prob}(y_i > 0)} + \frac{\partial E(y_i | y_i > 0)}{\partial x_{ij}} \frac{x_{ij}}{E(y_i | y_i > 0)}$$

where the left-hand side term denotes the unconditional elasticity. The first term on the right-hand side is the elasticity of the probability of positive observation and the second term on the right-hand side is the conditional elasticity.

Appendix 6.2A: *Lowess curve among town functions and fertilizer adoption and use*

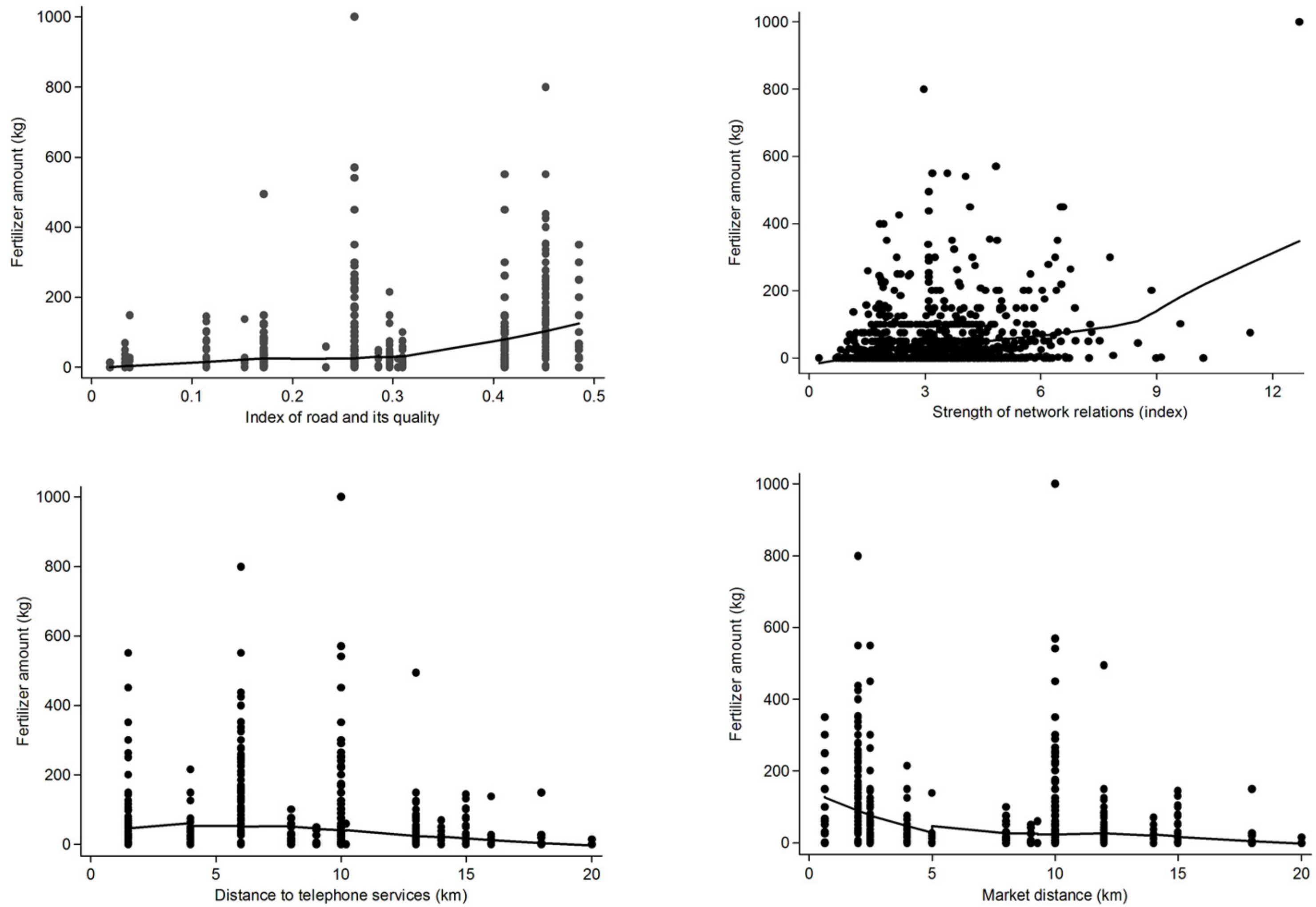

Figure 6.1B: Lowess smoother among major town functions and adoption intensity

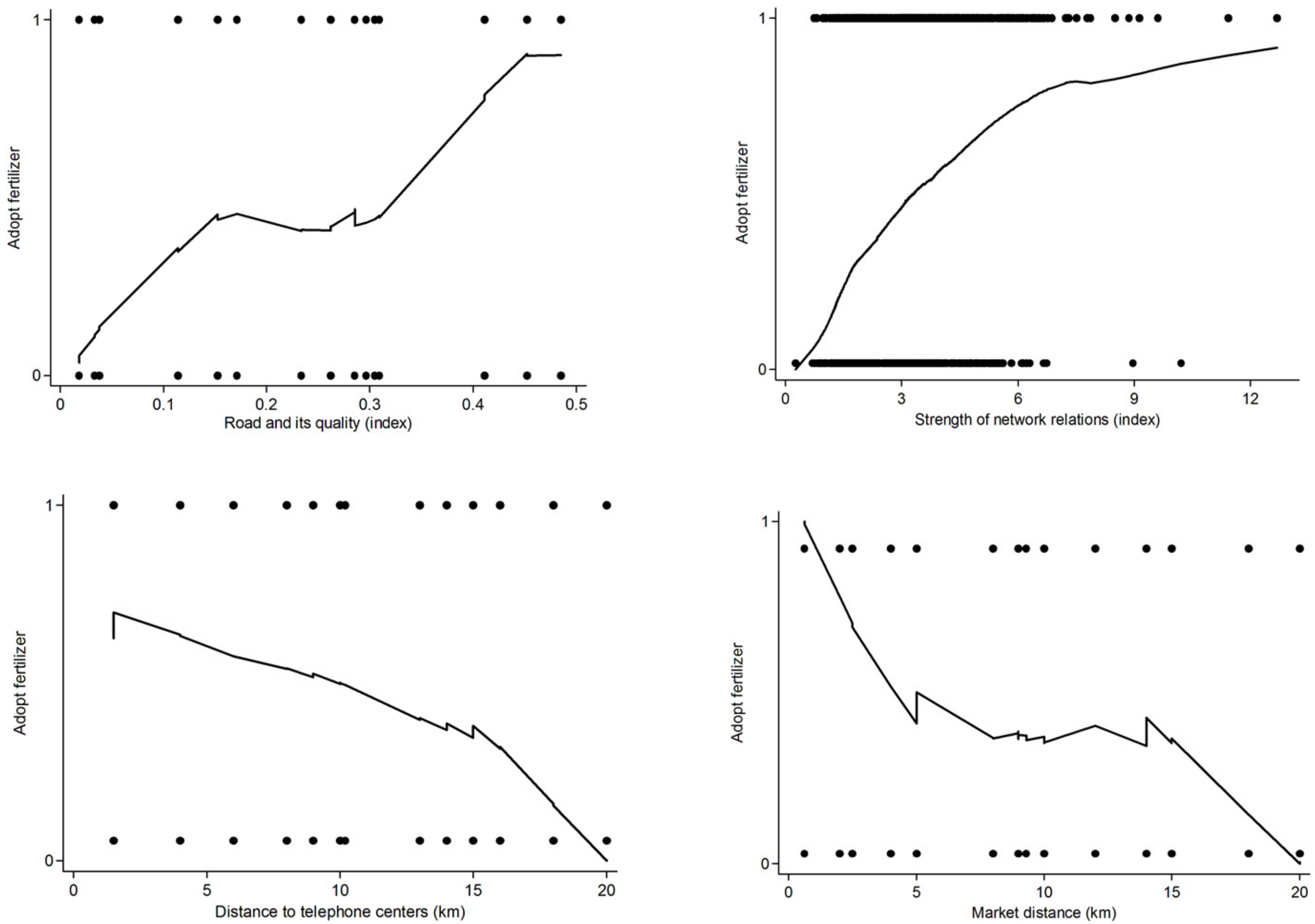

Figure 6.2B: Lowess smoother among major town functions with adoption probability

Appendix 6.3A: *Summary statistics of indices of town functions*

Town functions	Full sample		Adopters		Non-adopters	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Junior school	0.72	0.29	0.74	0.28	0.71	0.30
High school	0.77	0.23	0.84	0.16	0.71	0.26
Telephone center	0.49	0.28	0.60	0.25	0.41	0.28
Electricity	0.62	0.31	0.74	0.25	0.52	0.32
Bank services	0.81	0.29	0.92	0.16	0.73	0.34
Extension and agricultural cooperatives	0.72	0.29	0.76	0.24	0.68	0.36
	$n = 1290$		$n = 562$		$n = 728$	

CHAPTER 7

CHOOSING AMONG ALTERNATIVE EMPLOYMENT OPPORTUNITIES: THE ROLE OF TOWN FUNCTIONS

Abstract

This chapter examines the effect of town functions on the relative choice among alternative employment opportunities. For this purpose, household data collected from the Tigray region in northern Ethiopia are analyzed using multinomial logit model. We find that probability of employment in non-farm waged and home-based enterprises is likely to decrease with distance to markets, roads and telephone services. These town functions take households closer - in terms of physical distance and information access - to towns where most of the non-farm jobs are often concentrated. Moreover, results indicate that employment in non-farm waged and home-based enterprises is likely to increase with electricity connection, another function useful for the continuity of non-farm waged and home-based enterprises, which employ large labor force in towns and higher-order urban centers. It appears that some town functions are more important to employment in some of the alternatives than others.

Keywords: employment choice, town functions, employment in non-farm household enterprises and non-farm wage employment, farm employment, multinomial logit, Tigray

7.1 Introduction

Off-farm wage, non-farm self-employment and remittances altogether account for 30-50 percent of the income earned by rural households in Sub-Saharan Africa (Reardon, 1997). Although this shows the importance of non-farm employment, opportunities in the non-farm sector may vary with geographical location and economic conditions. Primarily, the variation in employment in non-farm wage work, non-farm home-based (household) enterprises and farm employment can be constrained by a poor rural infrastructure (Gibson and Olivia, 2010) and infrastructure linkage with towns and urban areas (Gardner, 2005; Renkow, 2006; Dillon *et al*., 2011).

In many rural areas of developing countries, infrastructures and institutions are limited or lacking. Often, they are physically connected to, and provided from, towns and urban centers where these functions are expected to make household enterprises and formal firms more productive and to enhance labor movement and non-farm employment (Ferreira and Lanjouw, 2001; Fox and Porca, 2001; Fafchamps and Shilpi, 2003). Economic theory postulates that efficient allocation of economic resources is challenging without well-functioning labor markets (de Brauw *et al*., 2002). Often, it is these limited or non-existent town functions that contribute to inefficient labor markets. Glauben *et al*. (2008) for instance argue that poorly developed labor markets contributed to limited Chinese agricultural household participation in both the market for hired on-farm labor and the market for off-farm employment.

The positive influence of proximity to growth poles such as towns and rural towns is highlighted in the literature. Previous studies emphasize the role of proximity to towns in improving non-farm household employment opportunities, where non-agricultural employment was observed to be concentrated (Fafchamps and Shilpi, 2003), or to decline with distance to rural towns and towns (Lanjouw, 2001; Deichmann *et al*., 2009; Jonasson and Helfand, 2010). A more elaborate study by Gibson and Olivia (2010) suggests that better roads and connections to an electricity network contribute to increased employment opportunities (probability) in non-farm home-based enterprises. From an informal institutions perspective, networks established with economic agents in towns and urban areas are also useful in obtaining non-agricultural wage employment, given the geographical location (Kajisa, 2007). Similarly, Micevska and Rahut (2008) for instance present empirical evidence that stresses the significant contribution of access to markets and infrastructures to non-farm employment opportunities in high-return activities and self-employment in household enterprises.

One major concluding point from the literature is that alternative employment opportunities can be stimulated by strengthening rural areas connectivity with towns, where different functions can make significant contributions. Though the literature about town functions is developing, empirical research has so far taken into account a limited number of functions. But this may not give us the full picture of the individual effect of the broad spectrum of town functions. This chapter aims at contributing to the literature by investigating the role that different town functions play on household choice among alternative employment opportunities. In doing so, we aim to examine the relative effect of town functions on the probability of choosing one employment alternative over another. For this purpose, we use household survey data collected from different rural areas and towns in the Tigray region in northern Ethiopia. We use the multinomial logit model to estimate the relative effect of town functions on the probability of choosing employment in non-farm household enterprises and waged activities over employment in farming.

The rest of this chapter is organized as follows. Section 7.2 presents the random utility framework which explains how households go about their choice for a specific employment alternative. In section 7.3, we present the econometric specification of the multinomial logit model used to estimate the relative effect of town functions in choosing among alternative employment opportunities. In section 7.4, we present a concise description of the data used for estimation. Section 7.5 presents the results from the econometric model. In section 7.6, we briefly discuss the key functions that influence household choice on alternative employment opportunities. In section 7.7, we summarize the main results and present concluding remarks.

7.2 Conceptual framework

Labor market participation decisions may be influenced by risk (Fafchamps, 1992), credit constraints (de Janvry *et al.*, 1991), transaction costs (Key *et al.*, 2000) in output and input markets due to non-existent or limited town functions and wage rates (Deichmann *et al.*, 2009). Access to town functions can in one way or another affect the labor market alternative that households decide to participate in. Labor market participation can then be considered as an employment choice variable (Key *et al.*, 2000) where a household, as a decision-making unit, attaches utility to each alternative and selects the alternative that maximizes unobserved utility. Ideally, households may have a preference for a specific employment alternative. This preference reflected by the actual choice and employment depends on different factors, including household-specific and other exogenous factors (such as access to some town functions).

However, not all factors that influence the choice of a specific employment alternative are known. In this case, the random utility model (RUM) serves as the foundation to explain a household's choice from a discrete set of employment opportunities (alternatives) based on a utility comparison between alternatives. An underlying assumption of this model is that a household's choice is the result of its preference and that it chooses the employment alternative with the highest expected utility (Cameron and Trivedi, 2005). The maximum expected utility reflects the actual choice of the employment alternative, which the household chooses probabilistically between employment opportunities based on random utilities. This works by maximizing the probabilities from the household's actual choice of an employment alternative; and it requires estimation of the parameters of the deterministic component of the household's random utility function (Korpi, 1997).

Suppose the household (denoted by i) faces a choice among J alternative employment opportunities. Because we assume that a certain level of utility would be obtained from each employment alternative, the utility that household i obtains from employment alternative n can be labeled as $U_{in}, n = 1,2,\ldots,J$. It follows that the expected utility from a given employment alternative can be stated as

$$U_{in} = V_{in} + \varepsilon_{in} \tag{7.1}$$

where employment alternative n gives rise to utility U_{in}, V_{in} denotes the systematic component of utility (observed utility) for household i associated with choice n and depends on the parameters that are unknown to the researcher and therefore estimated statistically; ε_{in} represents the stochastic component of utility (unobserved utility) for household i associated with choice n. Further, the systematic component of utility from a certain employment alternative is assumed to be a linear function of some covariates.

$$V_{in} = V(x_{in}, z_h) \forall n \tag{7.2}$$

where the systematic component of utility for household i associated with employment alternative n is a function of the attributes of alternatives that the researcher observes $(\mathbf{x}_{in})$ and attributes of the household (z_h). In effect, the utility of household i from employment alternative n can be given by

$$U_{in} = x_{in}\theta_n + \varepsilon_{in} \tag{7.3}$$

In this behavioral set up therefore, household i chooses employment alternative n if and only if $U_{in} > U_{ij}\ \forall n \neq j$. Because the stochastic component of utility is unknown and treated as random, the joint density of the random vector $\varepsilon'_n = \langle \varepsilon_{i1}, ..., \varepsilon_{iJ} \rangle$ is denoted by $f(\varepsilon_i)$. It follows that the probability that household i chooses employment alternative n is

$$\begin{aligned} \text{Prob}_{in} &= \text{Prob}(U_{in} > U_{ij}\ \forall n \neq j) \\ &= \text{Prob}(V_{in} + \varepsilon_{in} > V_{ij} + \varepsilon_{ij}\ \forall n \neq j) \\ &= \text{Prob}(\varepsilon_{ij} - \varepsilon_{in} < V_{in} - V_{ij}\ \forall n \neq j) \end{aligned} \quad (7.4)$$

In equation (7.4), the probability that each random term $(\varepsilon_{ij} - \varepsilon_{in})$ is below the observed household utility, $(V_{in} - V_{ij})$ denotes cumulative distribution (Train, 2009). Using the density function $f(\varepsilon_i)$, this cumulative probability can be specified as

$$\begin{aligned} \text{Prob}_{in} &= \text{Prob}(\varepsilon_{ij} - \varepsilon_{in} < V_{in} - V_{ij}\ \forall n \neq j) \\ &= \int_{\varepsilon} I(\varepsilon_{ij} - \varepsilon_{in} < V_{in} - V_{ij}\ \forall n \neq j) f(\varepsilon_i) d\varepsilon_i \end{aligned} \quad (7.5)$$

where the indicator function $I(\cdot)$ is equal to 1 when the expression in parentheses in (7.5) is not equal to zero, which is a multidimensional integral over the density of the unobserved portion of utility, $f(\varepsilon_i)$. The probability of choosing a specific employment alternative depends on utility from observed factors and an unobserved portion of utility from a given employment alternative. From equation (7.4), this means that household i will choose employment alternative n instead of j if the utility from unobserved factors for alternative j is not sufficiently higher than that of n (i.e., $\varepsilon_{ij} - \varepsilon_{in}$) to outweigh the observed utility difference, $(V_{in} - V_{ij})$. The integral in (7.5) and choice probabilities will then depend on the specification of the density (cumulative probability), which varies with the assumption about the distribution (such as, *iid* extreme values for logit models and families) of the unobserved portion of utility, $\varepsilon_{ij} - \varepsilon_{in}$ (see Train, 2009).

7.3 Method of estimation

Occupational choice such as household preference to alternative employment opportunities represents unordered multinomial choice (Wooldridge, 2002). In this chapter, we investigate the way town functions, household-specific and other factors affect household decision-making in choosing between main alternative employment opportunities. In our data, households normally pursued one occupation as the main employment alternative. Except for a small proportion of the sample households, the main employment alternatives are consistent with major income-earning activities. The major alternative employment opportunities include employment in non-farm household[1] productive activities, employment in non-farm waged productive activities and employment in farm productive activities. Cameron and Trivedi (2005) emphasize that specification of the random component influences the functional forms for the choice probabilities. In this case, McFadden (1974) asserts that multinomial logit models should be used in cases where the alternative outcomes are distinctly and independently weighed by decision makers. Amemiya (1981) similarly suggests that using the multinomial logit model is appropriate when the alternative outcomes are dissimilar.

In this regard, we argue that the employment categories considered are sufficiently dissimilar in nature, and households[2] distinctly choose among major alternative opportunities. Based on this, we assume that household-specific and other exogenous factors influence the choice of a specific alternative. As a result, we use the multinomial logit model to identify the direction and magnitude of effect of town functions and other relevant covariates on choice among alternative employment opportunities.

Let y be a random variable taking on the values $\{n = 1,...,J\}$ for J positive integer values denoting alternative employment opportunities and $\mathbf{x}$ be the vector of conditioning variables. Then, the availability of data on households' choice of employment alternatives allows us to construct the choice set.

In reference to equation (7.3), the observed choice of employment alternative n for household i is denoted as

$$y_i = \begin{cases} 1 & \text{if} \quad U_{i1} > U_{ij} \quad \forall j \neq 1 \\ 2 & \text{if} \quad U_{i2} > U_{ij} \quad \forall j \neq 2 \\ \vdots & \\ n & \text{if} \quad U_{in} > U_{ij} \quad \forall j \neq n \end{cases} \tag{7.6}$$

Our interest lies in how the changes in the elements of $\mathbf{x}$ affect the probabilities of choosing a given employment alternative, $\text{Prob}(y_i = n|\mathbf{x}), n = 1,...,J$. Following Wooldridge (2002), the probability that any one of the major employment alternatives is chosen can be stated as

[1] The terms 'non-farm household productive activities', 'home-based enterprises' and 'household enterprises' mean the same thing.

[2] A few households however were observed to participate in more than one employment alternative though only one was still the dominant employment alternative.

$$\text{Prob}(y_i = n|\mathbf{x}) = \exp(\mathbf{x}_i'\boldsymbol{\theta}_n) \Bigg/ \left\{1 + \sum_{n=1, n\neq j}^{J} \exp(\mathbf{x}_i'\boldsymbol{\theta}_j)\right\}, n = 1,..., J \tag{7.7}$$

where the probability that the household chooses employment alternative n is explained by the vector of explanatory variables ($\mathbf{x}$, the household indicator is suppressed) and $\boldsymbol{\theta}$ denotes the corresponding vector of parameter estimates for the alternative. In this set up, the probabilities of choosing alternative employment opportunities must sum to unity. Hence, the probability that the base category (outcome), $\text{Prob}(y_i = j|\mathbf{x})$ is observed can be stated as

$$\text{Prob}(y_i = j|\mathbf{x}) = 1 \Bigg/ \left\{1 + \sum_{n=1, n\neq j}^{J} \exp(\mathbf{x}_i'\boldsymbol{\theta}_j)\right\} \tag{7.8}$$

The probabilities of all major employment alternatives are expressed in terms of the parameter estimates, $\boldsymbol{\theta}_n$, independently of $\boldsymbol{\theta}_j$. In order to solve equation (7.7) and make identification of $\boldsymbol{\theta}_n$ possible, the usual practice is to impose the restriction that $\boldsymbol{\theta}_j = 0$, for one reference category j (see Wooldridge, 2002; Verbeek, 2008).

In a multinomial logit set up, since

$$\text{Prob}(y_i = n \text{ or } y_i = j|\mathbf{x}) = \text{Prob}_n(\mathbf{x}_i, \boldsymbol{\theta}_n) + \text{Prob}_j(\mathbf{x}_i, \boldsymbol{\theta}_j), \tag{7.9}$$

it follows then that

$$\begin{aligned} &\text{Prob}(y_i = n|y_i = n \text{ or } y_i = j; \mathbf{x}) \\ &= \text{Prob}_n(\mathbf{x}_i, \boldsymbol{\theta}_n) / [\text{Prob}_n(\mathbf{x}_i, \boldsymbol{\theta}_n) + \text{Prob}_j(\mathbf{x}_i, \boldsymbol{\theta}_j)] = \Lambda[\mathbf{x}_i(\boldsymbol{\theta}_n - \boldsymbol{\theta}_j)] \end{aligned} \tag{7.10}$$

where $\Lambda(\cdot)$ is the logistic function implying the probability that either employment alternative n or j is observed follows a logistic distribution. Equation (7.7) can then be solved using maximum likelihood estimation, where the log-likelihood can be derived by defining, for each household i, $d_{in} = 1$ if employment alternative n is chosen and 0 otherwise (Wooldridge, 2002; Greene, 2008).

$$\ell_i(\boldsymbol{\theta}_n) = \sum_{n=1}^{J} d_{in}[y_i = n] \log[\text{Prob}_n(\mathbf{x}_i, \boldsymbol{\theta}_n)] \tag{7.11}$$

In this case, the indicator function selects the appropriate response probability for each household; and parameter estimates for $\boldsymbol{\theta}$ are obtained by maximizing the sum of probabilities for each household.

Interpretation of coefficients from a multinomial logit model is not straightforward. However, more intuitive interpretation can be made by differentiating equation (7.7) with respect to the elements of $\mathbf{x}$, which gives rise to marginal effects on the probabilities. In a multinomial logit model, all the parameter vectors together determine the marginal effect of $\mathbf{x}$ on the probability to choose each alternative. It may even be the case that the marginal effect has the opposite sign of the corresponding parameter. Therefore, we present the outcomes in terms of elasticities (see Wooldridge, 2002; Greene, 2008 for more discussion on this).

7.4 Data description

The data for this chapter come from the Welfare Monitoring Survey administered by the Ethiopian Central Statistical Authority (CSA). The Welfare Monitoring Survey dataset is a sizeable one containing information collected from household surveys in different towns and rural areas of Ethiopia. For the purpose of this chapter however, we specifically focus on the regional state of Tigray in northern Ethiopia and use data collected from a sample of 1660 households. The survey gathered detailed information about household employment and income (both household heads and other members) using recall questions. The vast information contained in the dataset includes data related to major employment opportunities including non-farm household productive activities, non-farm waged productive activities and farm productive activities. The dataset also contains information related to household access and distance to town functions (including roads, transport, schools, telephone and postal services, water utilities, markets and electricity). Other data available in the dataset are access to housing, land and asset ownership and demographic features.

Households were asked to specify their major employment category. The major employment opportunity was identified by asking households (heads) to subjectively indicate the employment alternative from which they earned most of their income. Matching the subjective evaluations (of identifying major employment alternatives by households) with the income earned from the specific alternative provided consistent responses for most of the sample households. For the empirical analysis, the dependent variable represents the major employment alternative for household heads, which indicates multiple choices. Specifically, the dependent variable takes the value 1 if the household head's major employment alternative is farming (including crop farming, livestock rearing, off-farm work); 2 if the major employment alternative is non-farm household enterprises (including non-farm self-employment); 3 if wage employment in formal non-farm activities is the major employment alternative; and 4 for other non-farm employment activities (including temporary jobs such as brokerage, daily labor, freelance workers).

The focus in this chapter is mainly limited to three of the major employment opportunities: non-farm wage employment, farm employment and non-farm employment in household enterprises. This is because a limited number of households are employed in the fourth category of employment alternative and the employment opportunities in this category are not well defined as compared to the other three. As a result, the analysis of the role of town functions in relation to 'other non-farm employment opportunities'- the fourth category - is not presented (interested readers can see Appendix 7.3A to see how town functions influence employment choice in this category).

At this point, we briefly present hypotheses. Town functions may influence choice of employment opportunities differently. Functions including roads and transport services take households closer to non-farm employment opportunities in towns. Hence, shorter distance to roads and transport services is hypothesized to boost probability of employment in non-farm activities (both wage employment and working in home-based enterprises) as compared to farm work. These functions lower costs of travel to working places in towns and other rural areas. Closer proximity to markets is hypothesized to improve employment opportunities in home-based enterprises through access to market information and sales that would eventually affect profitability of the enterprises and employment. Telephone services are hypothesized to facilitate information exchange (flow) about non-farm employment opportunities, and the shorter the distance to telephone services the higher the probability of employment in non-farm home-based enterprises and wage employment.

Schools that households can use to gain knowledge and skills can also influence employment opportunities. In this case, shorter distance to schools is expected to lower costs of building human capital (knowledge and skills), which increases the likelihood of non-farm wage employment. Connection (access) to other major functions such as electricity and tap water that power the production process in both non-farm waged (formal) productive activities and home-based enterprises may also promote non-farm employment. In this regard, the continuity and efficiency in the production process of the non-farm activities may attract employment.

Household-specific factors such as educational achievement are among the major factors that influence labor market choice. In this case, acquired knowledge and skills are expected to increase probability of employment in non-farm jobs as compared to farm employment. This is because non-farm jobs usually require some level of education. Another element of human capital is the health status of workers, which can influence productivity and thereby non-farm employment. For this, the experience of health problems is hypothesized to lower probability of employment in non-farm activities. Farm-specific assets such as land and houses are instrumental for the operations of especially farm and home-based activities. In this case, access to land is hypothesized to have an inverse relationship with non-farm wage employment as compared to farm work. Similarly, home-ownership can be useful to the operations and profitability of home-based enterprises. Access to buildings that can house home-based enterprises therefore is hypothesized to increase employment in home-based enterprises. The summary statistics of variables that characterize the sample households are presented in Appendix 7.1A.

Table 7.1: Hausman test for IIA

Exclusion of employment alternative	Chi-square statistic
Excluding farm employment	9.3
Excluding non-farm employment in household enterprises	8.5
Excluding non-farm waged employment	2.6
Excluding employment in other non-farm activities	6.6
H_0= difference in coefficients is not systematic	
Critical chi-square test statistic $[5\%\ \text{level}; df = 20]$	10.9

Before discussing the results of the model, it is useful to check the robustness of the estimates. One restrictive assumption of the multinomial logit model is the assumption of independence of irrelevant alternatives (IIA). This assumption states that the relative odds of choosing employment alternative n over j are the same no matter what other alternatives are available or what the characteristics (attributes) of other alternatives are (Wooldridge, 2002: 501; Train, 2009). On many occasions, this assumption may not hold when dealing with cases where the alternatives are similar; but Dow and Endersby (2004) argue that the assumption of IIA is more of a logical property of decision-making instead of a statistical property such as consistency or unbiasedness.

The alternative employment opportunities we considered are specified in distinct and dissimilar manner. For robustness checks however, we conducted a test for the IIA assumption using the Hausman test[3] (Hausman and McFadden, 1984). The null hypothesis states that the inclusion of anyone of the alternative employment choices does not change the odds ratio of the other pairs of choices (i.e., differences in coefficients are not systematic). The results of the Hausman test for IIA presented in table 7.1 suggest that the test statistic associated with the null hypothesis has a critical chi-square value that is greater than the estimated chi-square when each of the alternative employment opportunities is included/excluded. Based on this, we cannot reject the null hypothesis. In terms of relative risk therefore, adding or removing an extra employment alternative is found to have no statistically significant effect on the probability of existing choice structures (i.e., no effect on the relative odds of choosing one major employment alternative over another). Consequently, IIA holds. Furthermore, coefficient estimates from multinomial probit are obtained for comparison purposes (see appendix 7.2A). The results from the two models are similar.

7.5 Estimation results

The estimation results where employment in farming is the base outcome are presented in table 7.2. Tables 7.3 and 7.4 present the elasticities and discrete effects of the probability of employment in non-farm wage activities and non-farm household enterprises. One thing to note is that the elasticities (as well as the discrete effects) hold for the average household. In addition, the interpretation of the parameter estimates (including elasticities and discrete effects) are explained with respect to the base category of employment.

---

[3] The Hausman test follows the strategy of estimating the unconstrained model and constrained model (where each one of the outcomes are alternatively excluded from estimation) and checking whether the estimated coefficients from the unconstrained and constrained models of the remaining categories are systematically different. The test statistic is given by:

$$\chi^2 = \left(\hat{\theta}_c - \hat{\theta}_f\right)' \left[Cov\left(\hat{\theta}_c\right) - Cov\left(\hat{\theta}_f\right)\right]^{-1} \left(\hat{\theta}_c - \hat{\theta}_f\right)$$

where $\hat{\theta}_c$ and $\hat{\theta}_f$ are the coefficient estimates from the constrained and unconstrained models; $Cov\left(\hat{\theta}_c\right)$ and $Cov\left(\hat{\theta}_f\right)$ are their estimated covariance matrices. The test statistic associated with the null hypothesis follows a chi-square distribution with the number of degrees of freedom equal to the number of coefficients estimated in the constrained model.

Town functions and choice of employment alternatives

Results show that longer distance to roads is associated with lower probability of employment in non-farm waged and home-based enterprises. The elasticities with respect to distance to roads show that the probabilities of being employed in non-farm waged and household enterprises declines significantly with an increase in distance to roads. *Ceteris paribus*, a 1 percent increase in distance to roads leads to a decline, relative to employment in farming, in the probabilities of employment in non-farm waged and household enterprises by 0.27 and 0.46 percent, respectively. The effect of roads in this case is higher for employment in non-farm waged activities that require frequent commuting and hence its importance to households that have to make frequent use of roads.

With distance to markets, the results indicate that the probability of employment in non-farm household enterprises and non-farm wage employment declines, as compared to employment in farming. The elasticities of the probabilities of employment in non-farm waged and household enterprises with respect to distance to markets are negative and statistically significant (see table 7.3). Elasticities show that employment in non-farm waged and home-based enterprises decreases by about 0.15 percent for each 1 percent increase in distance to markets. This indicates a significant reduction in market distance (50%, for instance) would lead to a much higher (7.5%) probability of non-farm wage employment and employment in home-based enterprises. Profitable and expanding non-farm household enterprises particularly are likely to attract more employment opportunities through increasing market outlets and obtaining market and employment information at lower cost. Furthermore, results show that telephone services increase the likelihood of employment in non-farm waged and household enterprises as compared to employment in farming. In addition, households use telephone services to communicate with economic agents (such as employers) and exchange information with their network for employment information. A reduction in distance to telephone services therefore means lower cost of searching and obtaining employment information.

The estimation results also show that the probability of employment in non-farm household enterprises and non-farm wage employment increases with access (connection) to electricity and tap water. Households that had access to electricity and tap water had higher probability of non-farm wage employment and employment in non-farm household enterprises as compared to employment in farming. The discrete effects on probabilities of employment in non-farm waged activities and household enterprises with respect to access to electricity are 0.246 and 0.06, respectively. This indicates that households that had access to electricity had a 24.6 and 6 percent higher probability of employment in non-farm waged and household enterprises relative to the probability of employment in farming, *ceteris paribus*. Similarly, with access to tap water it is indicated that the probability of employment in non-farm waged and household enterprises increases, relative to employment in farming, by about 13.4 and 11 percent respectively, *ceteris paribus*. This is particularly true for many non-farm household enterprises and waged activities since electricity and tapped water serve as important factors of production. Increased access to electricity and tap water is pivotal for the development and expansion of rural enterprises where households can move out of the less rewarding farming sector.

Table 7.2: Estimates of relative employment choices

Variables	Employment in non-farm household enterprises		Non-farm wage employment	
	Coefficient	Std. error	Coefficient	Std. error
Age	-0.003**	0.002	-0.002	0.007
Female	0.384	0.449	-0.323**	0.130
Household size	-0.058	0.097	0.044	0.034
Married	-0.498***	0.157	-0.233	0.194
Primary education	0.395	0.319	1.136***	0.146
Secondary education	1.369	1.092	3.042***	0.774
College and above education	2.152	1.778	5.057***	1.679
Health problems	-0.191	0.194	-0.475***	0.019
Access to land	-0.715***	0.095	-0.479***	0.078
Home ownership	0.049***	0.016	-0.398***	0.116
Access to electricity	0.642**	0.250	1.245***	0.317
Tap (piped) water	0.632***	0.198	0.670***	0.178
Distance to town functions (km)				
Markets	-0.024***	0.005	-0.016*	0.009
Primary schools	-0.049	0.085	-0.168**	0.073
Secondary schools	0.003	0.008	-0.008**	0.004
Taxi and bus transport	-0.001	0.021	0.002	0.025
Dry-weather road	-0.097***	0.026	-0.038***	0.012
Telephone booth	-0.040***	0.012	-0.026**	0.012
Constant	0.209	0.329	-1.609***	0.225

Significance level: *** =1%, ** =5% and * =10%.

Notes: robust standard errors are presented.

Non-farm waged activities often require knowledge and skills, which are controlled for (through educational achievement). But what would be the effect if the location of knowledge-generating, processing and disseminating educational centers (such as schools) varies? The estimation results suggest that distance to primary and secondary schools matters to choosing among employment alternatives. The results show that the probability of employment in non-farm waged activities declines with distance to primary and secondary schools. The elasticities show that when distance to primary and secondary schools increases by 1 percent, the probability of employment in non-farm waged activities decreases relative to employment in farming by 0.04 and 0.1 percent respectively, *ceteris paribus*. The effect of distance to secondary school being higher in magnitude than that of primary schools indicates the importance of secondary school presence at a closer proximity. This is because many non-farm waged activities employ manpower with relatively better skills and knowledge that secondary schools can provide.

Choice of employment alternatives relationship with household features

Age is observed to have an inverse association with the probability of employment in non-farm household enterprises. The estimation results show that female household heads have a lower probability of getting employment in non-farm waged activities as compared to farming. This may be due to gender differences in unequal asset and resources ownership leading to different opportunities of employment. In many developing countries, female heads and members are often the ones who have the higher likelihood of working in farming and household activities (enterprises).

Educational achievement is important to employment in high-earning non-farm activities. Household enterprises may vary in the nature of rewards but the results show that educational level does not have a statistically significant effect in securing employment in non-farm household enterprises as compared to employment in farming. However, household heads who possess special skills may give them a comparative advantage for entering the non-farm household enterprises market. On the other hand, the education level of heads turns out to be of particular importance to employment in non-farm waged activities compared with farming, which is quite logical. Non-farm wage employment usually requires the possession of knowledge and skills, which is vital to the continuity of employment opportunities in medium and highly rewarding non-farm activities.

Table 7.3: Elasticities on employment choice

Variables	Employment in non-farm household enterprises		Non-farm wage employment	
	Elasticity	Std. error	Elasticity	Std. error
Age	-0.263***	0.031	-0.006	0.365
Household size	-0.220	0.290	0.243***	0.006
Distance to town functions (km)				
Markets	-0.147***	0.017	-0.150***	0.050
Primary schools	-0.014	0.116	-0.040***	0.078
Secondary schools	0.017	0.078	-0.099**	0.041
Taxi and bus transport	-0.017	0.100	0.011	0.152
Dry-weather road	-0.460***	0.028	-0.270***	0.007
Telephone booth	-0.113*	0.063	-0.317***	0.101

Significance level: *** =1%, ** =5% and * =10%.

The discrete effect (change in probability) with respect to primary education is 0.046, indicating that upgrading heads' education from illiterate to primary level leads to an increase in the probability of non-farm wage employment by 4.6 percent as compared to employment in farming, *ceteris paribus*. The discrete effects of secondary and college-level education achievement is even higher on the probability of non-farm wage employment. The discrete effects show that moving from illiterate to secondary education and college education increases the probability of non-farm wage employment relative to employment in farming by 7.6 and 11.6 percent respectively, *ceteris paribus*. The results highlight the importance of equipping household heads and other members with higher education for a higher likelihood of wage employment in non-farm activities. Though not explicitly considered in our empirical analysis, it can be argued that education can help households increase their productivity and hence probability of non-farm wage employment. It can also help households while searching for non-farm wage employment (through acquiring, processing and exchanging employment information). In this regard, higher educated household heads would be able to use their human capital to increase their likelihood of obtaining wage employment in non-farm activities.

Table 7.4: Discrete effects on employment choice

Variables	Employment in non-farm household enterprises		Non-farm wage employment	
	Discrete effect	Std. error	Discrete effect	Std. error
Female	0.042	0.102	-0.016	0.034
Married	-0.210**	0.080	-0.051	0.103
Primary education	0.006	0.047	0.046***	0.016
Secondary education	0.014	0.032	0.076***	0.021
College and above education	0.019	0.018	0.116***	0.015
Health problems	-0.031	0.052	-0.151***	0.038
Access to land	-0.335***	0.013	-0.145	0.126
Home ownership	0.054**	0.027	-0.273***	0.046
Access to electricity	0.060***	0.001	0.246***	0.020
Tap (piped) water	0.109***	0.007	0.134***	0.001

Significance level: *** =1%, ** =5% and * =10%.

Land, being one of the fundamental factors of production, may be an input farming cannot do without as compared to other activities such as non-farm household enterprises and wage employment activities. Controlling for other factors, it can be argued that households that have better access to farming land may be inclined to work in farm activities as compared to working in non-farm household enterprises or non-farm waged activities. The results show that there is a negative relationship, relative to employment in farm activities, between access to land and non-farm wage employment and working in non-farm household enterprises. This evidence suggests that households that have access to land have a lower probability of working in non-farm household enterprises and non-farm waged formal activities relative to working in farm activities. In other words, access to land increases the probability of employment in farming as compared to non-farm wage employment and employment in non-farm household enterprises.

The private ownership of homes influences the probability of non-farm wage employment and employment in non-farm household enterprises differently. Estimation results show that the probability of employment in non-farm household enterprises increases with access to private homes relative to employment in farming. On the other hand, the probability of wage employment in non-farm formal activities decreases with access to private homes (as compared to employment in farming). The evidence in general highlights the significant influence that access to land and private homes exerts in household decision-making while choosing among alternative employment opportunities.

7.6 Discussion: Key functions' influence on choice over employment alternatives

Rural households in developing countries increasingly depend on income diversification from employment in farm and non-farm activities (Reardon, 1997). However, Lanjouw (2001) argues that non-farm employment and income are often neglected in the rural development strategic debates, though rural non-farm employment has been attracting increasing attention since the early 1990s (Lanjouw and Lanjouw, 2001; Jonasson and Helfand, 2010).

Empirical results from this chapter present findings that indicate the relative significant positive influence of access to electricity on non-farm wage employment and non-farm home-based enterprises. In this case, the magnitude of effect is stronger on non-farm wage employment (24.6%) as compared to farming. On the other hand, the probability of employment in non-farm home-based enterprises is higher by 6 percent when there is access to electricity. It is argued that the sustained production process, increased efficiency and profitability that electricity connection or services provides can increase the likelihood of non-farm employment. Small-scale home-based and formal productive activities prosper with access to electricity. This in turn help perpetuate the activities and increase the likelihood of employment in these activities. Lanjouw (2001) also present findings that show the positive association between electricity connection and non-farm employment. However, he was less certain whether the effect was due to electricity or whether electricity was explaining the existence of (proximity to) nearby towns and urban areas where the non-farm jobs are often concentrated (Fafchamps and Shilpi, 2003). By controlling the other key functions that exist in towns, the findings in this chapter indicate a positive association of higher non-farm employment probability with electricity connection. Similarly, Jonasson and Helfand (2010) present evidence that shows the higher relative probability of getting a job in non-farm activities when access to electricity increases (with the effect on agricultural employment declining with access to electricity). In addition, other studies such as Isgut (2004) and Deichmann *et al*. (2009) emphasize the significant contribution electricity makes to non-farm wage and self-employment (in household enterprises). Similar to previous studies, results in chapter 4 indicated that electricity connection is positively associated to non-farm wage and home-based employment (and negative with employment in farming). Our findings in this chapter corroborate those results and indicate the positive effect of electricity connection to a higher relative probability of employment in non-farm waged and home-based enterprises.

The empirical evidence also indicates the positive role that shorter distances to telephone services play in increasing the probability of employment in non-farm activities (waged and home-based). The major role telephone services play is to facilitate the flow of information at a relatively lower cost (Lanjouw, 2001; Jonasson and Helfand, 2010). Households would then be able to obtain information related to non-farm wage employment more easily. The importance of telephone services is reflected by the comparatively higher proportion (0.32%) of reduction in the probability of non-farm wage employment when distance increases by 1 percent. Telephone services can also be instrumental in facilitating sales of non-farm home-based products, which may in turn positively influence profitability and employment. The effect in this case is less strong (0.11% reduction in the probability of employment in non-farm home-based enterprises) than on the probability of non-farm wage employment. Our findings support the empirical evidence presented by Lanjouw (1999) and Jonasson and Helfand (2010) that conclude that telephone access increases the relative probability of employment in non-farm wage employment and self-employment or home-based enterprises, in which case the effect on the former is higher (see also the results in chapter 4 about the effect of telephone services to employment in farm activities).

The other key function is closer roads. Our findings show that a shorter distance to roads is instrumental to a higher likelihood of employment in non-farm activities. Elasticities indicate that the effect of roads is stronger on employment in non-farm home-based enterprises (0.46% reduction in employment with each 1% increase in distance) than non-farm wage employment (reduction by 0.27% for each 1% increase in distance to roads). This may be due to the significant role that roads play in the operations, profitability and sustainability of home-based non-farm enterprises. Accessible roads with transport systems can help households search for and obtain non-farm employment opportunities (such as, wage employment). In relation to this, proximity to (rural) towns and higher-order urban areas also matters and is useful in obtaining non-farm jobs (Ruben and van den Berg, 2001; Fafchamps and Shilpi, 2003; Jonasson and Helfand, 2010). In a more specific examination for instance, Deichmann *et al.* (2009) present evidence that a shorter distance to towns and urban areas leads to higher employment probability on low-return non-farm waged activities. In addition, they show that the less the travel time to towns, the higher the probability of employment in high-return non-farm waged and self-employment (home-based) activities. These findings present an interesting idea about the role that shorter distances to towns and road quality (that can have a significant effect on travel time) play to employment in different activities. However, the effect of proximity (shorter distance) to towns may not have a relatively significant effect on non-farm employment if the quality of the roads (influencing travel time) is poor (Lanjouw, 1999).

Market access is one of the key functional services found to positively influence relative employment in non-farm waged and household enterprises. Quantitative estimates show that an increase in distance to markets by 1 percent leads to a 0.15 percent lower probability of employment in non-farm waged and home-based enterprises. In other words, increasing market distance by 10 percent would lead to a 1.5 percent reduction in the probability of employment in both non-farm activities. Different non-farm activities may require good market access for profitable and sustainable operations. Shorter distances to major markets in this case can contribute to a higher likelihood of obtaining non-farm employment opportunities through market information systems that contribute to acquiring information about the availability of non-farm wage work at lower costs (Escobal, 2001; Calderón and Chong, 2004).

Finally, the availability of schools in close proximity can help equip households with skills and develop employment processing and management capabilities that increase the probability of employment in high-earning non-farm jobs (wage employment and home-based enterprises). The evidence particularly highlights the role of secondary schools located in close proximity that have a higher effect (0.10%) on non-farm wage employment than primary schools (0.04%). Closer schools can mean a lower cost of developing the human capital that eventually may increase the likelihood of non-farm wage employment. This would suggest that bringing schools closer help equip households with the skills required to increase their chances of getting employment in non-farm waged activities.

7.7 Concluding remarks

Empirical research about the choice among employment opportunities so far considered only a limited number of town functions in isolation of each other. In this paper, we examined the effect of a number of town functions on the probabilities of choice among alternative employment opportunities, thereby identifying the relative effect the town functions play in improving household employment opportunities. For this purpose, we used household data collected from the Tigray region in northern Ethiopia. A multinomial logit model was used to estimate the effect of town functions on the probability that households choose employment in non-farm waged and household enterprises over employment in farming.

The analysis focusing on alternative employment opportunities yields three major results. One, results suggest that wage employment in non-farm activities is likely to be lower if the distance to markets, roads and telephone services is greater. In this case, the effect of dry-weather roads (0.27%) and telephone centers (0.32%) are observed to be higher in reducing the probability of employment in non-farm wage work when distance to each function increases by 1 percent (in reference to farm employment). Distance to markets (0.15%) and secondary schools (0.10%) were also observed to have a relatively significant effect in reducing the probability of employment in non-farm waged activities.

Similarly, distances to roads, markets and telephone services significantly influence the likelihood of employment in non-farm home-based activities. Specifically, if a 10 percent increase in distance to roads, markets and telephone centers were made, the probability of employment in non-farm home-based activities would fall by 4.6, 1.5 and 1.1 percent, respectively. These results suggest that roads are particularly useful in increasing the likelihood of obtaining non-farm home-based employment opportunities (see also, Lanjouw, 1999). These functions help households in reducing the transport costs and bring households closer to the market, obtaining market and employment information relatively easily and serving as market outlets for outputs of household enterprises (which increase the probability of employment). Moreover, access to electricity and tap water that contributes to the production process is more likely to increase employment in non-farm wage and home-based enterprises.

Second, educational achievement was found to have a significant relationship with employment in non-farm waged activities. Household heads with a higher educational level (primary, secondary and college) are more likely to get employment in non-farm waged activities. In this case, possessing college and secondary education increases the likelihood of non-farm wage employment by 11.6 and 7.6 percent. These effects do not seem 'significantly large' (in reference to employment in farming), given the role that education plays in obtaining non-farm jobs. Nevertheless, they highlight the contribution that a higher level of education makes to increasing the probability of wage employment in non-farm activities that often bring higher income than farm activities. Third, farm attributes such as access to land and home ownership have a significant relationship with the probability of employment in non-farm waged and household enterprises. Access to land decreases the probability of employment in household enterprises and non-farm waged activities relative to employment in farming. As the most important input in farming, households who have better access to land are more likely to work in farming than in non-farm waged activities or household enterprises. The role of land in farming is indicated by the fact that heads with access to land had a 33.5 percent lower probability of employment in home-based enterprises, as compared to farm work. In other words, the likelihood of working in farm activities would be higher by the same proportion (33.5%) if households had access to land. Ownership of private homes increases the probability of employment in non-farm household enterprises relative to farm employment. Homes are instrumental for the establishment, profitability and continuity of non-farm household enterprises. Better (higher) access to private homes may encourage the establishment and expansion of household enterprises and hence a higher probability of employment (5.4% higher than employment in farming). Relative to farm employment, home ownership in contrast decreases the likelihood of wage employment in non-farm activities. This may be due to the higher opportunities created to establish and expand household enterprises.

Appendix 7.1A: *Summary statistics of variables*

Specification of dependent and independent variables	Full sample		Urban		Rural	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age (age of household head in years)	47.2	15.6	45.7	16.1	48.2	15.4
Female (gender of head: 1= female; 0= male)	0.43	0.49	0.55	0.50	0.36	0.48
Household size (number of household members)	4.53	2.23	4.31	2.38	4.66	2.13
Married (1= yes; 0= otherwise)	0.62	0.49	0.50	0.50	0.69	0.46
Illiterate (1=yes; 0= otherwise)	0.80	0.39	0.57	0.49	0.91	0.27
Primary education (1=yes; 0= otherwise)	0.15	0.34	0.26	0.43	0.08	0.26
Secondary education (1=yes; 0= otherwise)	0.04	0.17	0.11	0.28	0.01	0.05
College and above education (1=yes; 0= otherwise)	0.03	0.18	0.10	0.28	0.01	0.05
Health problems (1= have had health problems; 0= no)	0.41	0.49	0.34	0.47	0.56	0.50
Access to land (1= yes; 0= otherwise)	0.81	0.40	0.69	0.46	0.88	0.34
Home ownership (1= yes; 0= otherwise)	0.72	0.43	0.66	0.47	0.77	0.42
Access to electricity (1= yes; 0= no)	0.32	0.46	0.53	0.50	0.18	0.39
Access to piped water (1= yes; 0= no)	0.35	0.48	0.59	0.49	0.22	0.41
Access to town functions (distance in km)						
Markets	7.43	7.14	4.52	5.14	9.10	7.57
Primary schools	3.24	3.35	1.94	2.17	4.00	3.68
Secondary schools	16.3	17.1	8.94	13.1	20.5	17.7
Taxi and bus for transport	10.6	12.5	7.20	11.0	12.5	12.9
All-weather road	7.25	11.3	4.44	9.00	8.86	12.1
Dry-weather road	6.10	10.4	4.24	9.05	7.15	11.0
Telephone booth	14.1	16.7	9.60	14.2	16.9	17.7
Dependent variable: major employment alternatives						
Employment in farming (employment alternative = 1)	0.54	0.50	0.35	0.47	0.65	0.54
Employment in non-farm household enterprises (employment alternative = 2)	0.22	0.27	0.26	0.36	0.20	0.24
Employment in waged non-farm formal activities (employment alternative = 3)	0.18	0.21	0.27	0.32	0.13	0.17
Employment in other non-farm activities (employment alternative = 4)	0.06	0.12	0.09	0.15	0.04	0.08
	$n = 1660$		$n = 605$		$n = 1055$	

Appendix 7.2A: *Multinomial probit estimates of relative employment choices*

Variables	Employment in non-farm household enterprises		Non-farm wage employment	
	Coefficient	Std. error	Coefficient	Std. error
Age	-0.002	0.002	-0.002	0.005
Female	0.318	0.330	-0.232**	0.086
Household size	-0.041	0.072	0.035	0.031
Married	-0.372***	0.113	-0.189	0.140
Primary education	0.333	0.263	0.855***	0.121
Secondary education	1.010	0.776	2.275***	0.511
College and above education	1.395	0.916	3.605***	0.892
Health status	-0.134	0.159	-0.367***	0.018
Access to land	-0.562***	0.065	-0.373***	0.041
Home ownership	0.051***	0.011	-0.274***	0.073
Access to electricity	0.507***	0.122	0.922***	0.203
Tapped (piped) water	0.505***	0.154	0.533***	0.119
Distance to town functions (km)				
Markets	-0.017***	0.003	-0.010*	0.006
Primary schools	-0.042	0.063	-0.116**	0.057
Secondary schools	0.003	0.007	-0.006**	0.003
Taxi and bus for transport	-0.001	0.016	0.001	0.019
Dry weather road	-0.073***	0.021	-0.029***	0.013
Telephone booth	-0.034***	0.011	-0.017**	0.008
Constant	0.055	0.236	-1.258***	0.142

Significance level: *** =1%, ** =5% and * =10%.

Notes: robust standard errors are presented.

Appendix 7.3A: *Estimates of other non-farm employment (relative to farm employment)*

Variables	Employment in other non-farm activities	
	Coefficient	Std. error
Age	0.004	0.005
Female	0.444**	0.225
Household size	-0.018	0.038
Married	0.014	0.235
Primary education	-0.179	0.248
Secondary education	0.931	0.610
College and above education	2.151*	1.110
Health problems	-0.082	0.155
Access to land	-0.482*	0.270
Home ownership	-0.505**	0.209
Access to electricity	1.990***	0.291
Tapped (piped) water	0.704**	0.241
Distance to town functions (km)		
Markets	-0.036**	0.015
Primary schools	-0.013	0.027
Secondary schools	-0.008	0.006
Taxi and bus for transport	0.002	0.011
Dry weather road	-0.031*	0.017
Telephone booth	-0.014*	0.008
Constant	0.147	0.504

Significance level: *** =1%, ** =5% and * =10%.
Notes: robust standard errors are presented.

CHAPTER 8

CONCLUSIONS AND DISCUSSION

8.1 Introduction

In developing countries, agriculture and population have strong connections to rural areas. This is because agriculture is the major economic activity and the vast majority of the population lives in rural areas. It can be argued therefore that development that does not duly incorporate these two core elements may not help reduce poverty and improve the standard of living of rural population. This is particularly true in the early stages of economic development, where the promotion of agricultural and rural development is crucial to pro-poor income growth and poverty reduction (Ravallion, 2009; de Janvry, 2010).

The question is then how to stimulate and facilitate agricultural and rural development. In developing countries, agriculture supported by agricultural technologies can be the engine of long term development (Tiffin and Irz, 2006; Self and Grabowski, 2007; Diao *et al*., 2010) but cannot sustain itself if it is not harmoniously integrated with other non-farm sectors in towns and urban areas (Todaro and Smith, 2009; Valdés and Foster, 2010). This is because forward and backward linkages of agriculture with non-farm activities in urban areas are pivotal to agricultural and rural development (Tacoli, 2002). Nevertheless, the contribution of these linkages can only be significant to agricultural and rural development if 'certain conditions in the built-in environment', that include the necessary infrastructures and institutions, are met (Hinderink and Titus, 2002; de Janvry, 2010).

Unfortunately, many rural areas in developing countries suffer from the lack of a built-in environment, in terms of useful functions such as infrastructures and institutions. If these necessary functions are not in place to support and facilitate the interaction among rural and urban economic activities (or agents), rural-urban linkages may be impaired. What can then (partly) compensate for the 'missing link'? In developing countries, several rural towns and towns that possess some of the most important functions exist at a varying distance from rural areas. Obtaining quantitative information about the role that the functions in towns play in contributing to rural development is useful. This helps us understand the contribution of each major function and identify the most important ones that lead to the improvement of household livelihood or economic activities.

The objective of this thesis is therefore to investigate the role of town functions in household livelihood (economic) activities. Specifically, this thesis mainly aims at empirically examining the effect of town functions on income from productive activities (chapter 4); rural household crop output marketing (chapter 5); rural household fertilizer adoption and use (chapter 6) and choice of alternative employment opportunities (chapter 7). Standard household models, which assume that households aim to maximize utility, were used as a theoretical background. Based on this, income and employment, crop output supply and fertilizer adoption models were used as conceptual frameworks in the empirical chapters to estimate relationships among town functions and income, input-output marketing and employment choice.

In conclusion to this thesis, this chapter aims at presenting and discussing the major results before pointing out the implications and outlining issues for further research. A summary of the main results is presented in section 8.2. Next, section 8.3 discusses the results *vis-à-vis* the stock of literature in rural-urban interaction and the role of town functions. In section 8.4, implications of the major findings and issues for further research are presented.

8.2 Summary of main conclusions

Rural-urban linkage is manifested in labor movement and employment leading to income, agricultural product supply to towns or urban centers and the transfer of agricultural technologies from towns and urban centers to rural areas. In chapter 2 of this thesis, the conceptual framework outlined discusses the pivotal role that forward and backward linkages can play in contributing to rural household livelihood (economic) activities. It sets the background about how (rural) towns and their functions contribute to improvements in farm income, non-farm income, crop output marketing and adoption and use of fertilizer. The chapter concludes by displaying the approach followed in the empirical chapters for the effect of town functions on outcomes (income, crop marketing, fertilizer adoption and use and employment choice). Each empirical research question (objective) of the thesis is addressed in part 2, running from chapters 4 through 7.

Chapter 4 aims at addressing issues related to the second research question. In this chapter, the objective was to examine if (and, in what way) town functions have an effect on income from productive activities, distinguished as non-farm household, non-farm waged and farm productive activities. Farm income is low, and one reason is the inability to measure farm production used for own consumption. Non-farm home-based and waged productive activities and transfers were observed to provide both rural and urban households with relatively higher income. From the estimation results, town functions were observed to have varying effect on income from productive activities. The transport infrastructure (roads and transport services) is one component of town functions that plays a pivotal role in promoting income from particularly farm and non-farm household productive activities. Functions that power the production process, such as electricity and tap water, were useful in increasing income from productive activities. Findings also show that educational centers, as institutions of knowledge-generation and dissemination were pivotal in promoting waged non-farm employment and income thereof. However, distance to schools was found to be positively associated with income from farm and non-farm household productive activities. It may be that households living near schools would be able to equip themselves with skills and knowledge that would increase non-farm wage employment and lower the likelihood of working in, and income from, farming and household enterprises. It is also suggested that shorter distance to telephone centers contribute to higher income from productive activities that may be attributed to a better flow of information (at lower cost) related to employment or prices (of farm products and household enterprises).

Among the major aspects of rural-urban linkage is the flow of agricultural products to towns and urban centers (forward linkage). The strength of this linkage can be useful to agricultural output marketing and commercialization. Among the different factors that can have a significant influence on this linkage are functions provided from towns. In chapter 5, the third research question aiming at addressing the role that town functions play in crop output marketing is examined. The results suggest that a large proportion of the farm households participate in crop marketing. Different factors, such as price and non-price elements were observed to play a role in promoting crop output marketing and commercialization. Town functions determine whether or not farm households are able to participate in the market for crops. It was not only ability of market participation that was found to be influenced by some of the major functions, but also decision and intensity of crop marketing.

Access to town functions greatly reduces transaction costs, which then paves the way for increased crop marketing. It is indicated that telephone facilities, extension and agricultural cooperative centers located in closer proximity are among the functions that reduce excessive fixed transaction costs. Reduced fixed transaction costs enable rural households to participate in crop output marketing (creating the possibility of market participation). In this context, findings suggest that social capital plays a crucial role in facilitating market participation by enabling access to faster and cheaper market information. Where markets are highly imperfect, social capital as the 'social fabric' can be instrumental in creating the necessary platform for increased market access.

Roads and markets were observed to increase crop marketing. Closer roads and markets can lead to lower transport cost per unit of crop output. This would mean lower costs in taking higher crop shares to the market for sale. In addition, proximity to roads and markets can also lead to higher farm gate prices (hence higher profits), which encourage farm households to engage more in crop output marketing. Apart from this, plot size and agricultural technologies such as fertilizer use and irrigation practices were observed to result in higher sales share. This can be attributed to the surplus production from owning bigger plots or higher productivity from fertilizer application or access to irrigation. On the other hand, it is shown that larger livestock size may ease the cash constraints of households through substituting the liquidity that would otherwise have been obtained from crop sales.

Another major aspect of rural-urban linkage is the backward linkage, which involves the flow of mainly agricultural inputs and technologies from towns (and urban centers) to rural areas. Transfer of agricultural inputs or technologies can be determined by town functions, among others. In chapter 6, the fourth research question aims at shedding some light on how functions in (rural) towns contribute to rural household fertilizer adoption and use. Major town functions such as roads, market, telephone services and electricity were found to play an important role in promoting fertilizer adoption and use. Roads and markets are usually known for physically bringing rural households closer to towns and urban centers, which serve as sources of technologies and technology-related information and knowledge. It is suggested that fertilizer adoption and use increases with accessible roads and markets due to reduced variable transaction costs. Telephone services were also found to promote adoption through enabling faster and cheaper communication about fertilizer and prices. In this context, knowledge-generating, processing and disseminating functions such as extension, agricultural cooperative centers and schools were also found to play positive roles in fertilizer use. Where town functions that facilitate information exchange are lacking, the role of network relations may be pivotal in promoting fertilizer adoption and use. In this regard, the results indicate the strong positive influence that network relations have in promoting fertilizer adoption and use.

Labor movement and employment in different productive activities is another major aspect of the rural-urban linkage. Through casual, seasonal and/or permanent movement, rural and urban households participate in non-farm productive activities in towns and urban centers. Rural towns or towns contain more diverse non-farm productive activities than rural areas. This gives households a greater opportunity to diversify income sources through alternative employment opportunities. Town functions can play a significant role in contributing to the choice of alternative employment opportunities. In chapter 7, the fifth research question is addressed. It aims to empirically test household behavior of choosing among employment alternatives in response to access to town functions. It is indicated that roads, markets and telephone services increase the likelihood of employment in non-farm wage employment relative to the probability of employment in farming. One major reason is that improved connectivity by increasing physical proximity (through markets and roads) and reducing communication barriers (by bringing telephone facilities closer) help create non-farm employment opportunities. The evidence also shows that closer proximity to schools and connection (access) to electricity and tap water are likely to increase wage employment in non-farm activities. Promoting education is also likely to expand non-farm employment opportunities as it would develop competency (skills and knowledge) that increase the probability of wage employment in non-farm activities.

Table 8.1: Percentage change of a 1 km reduction in distance to town functions

Town functions	Total income	Non-farm employment[a]		Crop marketing		Fertilizer application	
		Wage	Home-based	Participation	Sales share	Adoption	Intensification
Roads							
Well accessible roads to any vehicle				5.0	1.6	1.5	1.3
Reasonably accessible roads to any vehicle				4.1	1.3	1.2	1.0
Reasonably accessible roads to trucks/buses				3.1	1.0	0.9	0.8
Dry-weather roads	2.8	4.6	7.8				
Transport services	0.4[c]	-0.1[c]	0.2[c]				
Markets	0.7	2.1	2.0	0.6	1.9[c]	3.2	2.6
Telephone centers	0.5[c]	2.3	0.8	0.8	2.8	0.01[c]	*n.a.*
Secondary schools	1.2	1.6	-0.3[c]	0.5	1.5	*n.a.*	*n.a.*
Electricity	124[b]	24.6[b]	6.0[b]	0.2[c]	0.7[c]	1.5	1.3

[a] the figures under this column represent employment probabilities (percentage changes) in reference to farm employment.
[b] these figures denote the effect of going from 0 to 1.
[c] figures are not statistically significant.
n.a. refers to figures that could not be computed due to either not being used in estimating models or due to the fact that they are aggregated to an index where computing separate effect was not possible.
Otherwise, the effects on total income, sales share and fertilizer intensification are conditional effects.

8.3 Discussion: Contribution of town functions

In this thesis, town functions are assumed to be exogenous. However, this assumption may be stronger for some town functions than for others. To elaborate the exogeneity assumption, we started from the definition of town functions. Take for instance markets. In this thesis, markets are meant to represent specific locations where buyers and sellers gather and exchange goods and services.[1] Usually, these markets are locationally connected to rural towns and towns. It can be argued that where there is more output, there would be more markets. However, from the perspective of the nature of market definition in this thesis (and the reality in the Ethiopian context), households still need to travel to markets in towns to sell crop outputs or buy agricultural inputs. In this context, it means that more output or income acting as a (reverse) causal effect for new markets to develop is less likely. Nevertheless, more virtual markets (such as transport facilities by local traders or local gathering stations) might develop though this is more of a long run phenomenon, given the Ethiopian setting. In another instance, it can be argued that households that earn higher income may relocate themselves closer to town functions. We reckon that this is a more likely outcome. However, in a country where rural-to-urban migration is discouraged and the flow of factors of production is highly imperfect, the problem of reverse causality is limited. Nevertheless, unobservable factors related to these phenomena may violate the exogeneity assumption, an element which is not further investigated in this thesis.

On a similar note, agricultural potential (or other favorable conditions) may lead to endogeneity. This possibility has been considered in the analyses. In chapters 5 and 6, none of the dummy specifications used to control for village endowments and other favorable conditions is significant. We compared how crop sales share and fertilizer application vary across villages by alternatively using the two semi-arid villages in Tigray and one in Amhara, Shumsha, as comparison villages (which are considered to be of less agricultural potential). The specific results indicated that village dummies do not have significantly different crop

[1] In purely institutional economics context, markets are considered to be the 'rules of the game' or 'arrangements used to facilitate transactions'. Here, 'physical location' of markets or 'the distance element' is not incorporated in the definition.

sales or fertilizer adoption patterns when compared to the across-village agro-climatic and other favorable conditions.

In relation to this, another point that may be argued to lead to endogeneity is that town functions such as roads may be expanded (the notion of program placement) to those areas where there is more agricultural potential. In our study villages, those sites (including Sirbana Godeti and Turufe Ketchema) believed to have favorable agro-climatic conditions and relatively more agricultural potential have similar endowment of roads and markets (as compared to the villages with less potential). Specifically, the average distance for these two areas to markets is 9.3 km as compared to the overall average of 11 km and 6.2 km to roads as compare to the full sample average of 8.1 km. The point is the data did not exhibit systematic difference in the endowment of town functions (and thus no systematic correlation with input-output exchange). Comparisons of endowment of other town functions (such as telephone, electricity and extension and agricultural cooperative centers) indicate similar distances except in Yetmen, which is located on the outskirts of Yetmen town. Nevertheless, there can still be unobservable factors that could not be controlled for in this thesis. For these and other uncontrolled observables, recent advances in randomization or evaluation methods can single out the causal effect of town functions and significantly reduce the problem of endogeneity (see Heckman, 2010), but this path has not been followed in this thesis. In the literature, there has been no systematic micro analysis of town functions that attempts to investigate the causality of town functions on income, employment and input-output marketing. Related research in the role of institutions on income, employment and input-output marketing have a much bigger problem to handle causality where processes are much less exogenous.

Town functions as a whole may be accepted as being useful for the facilitation of development activities. But one of the major attributes of a failing development policy is manifested by its poor emphasis on regional linkages and prioritized investment in public services (Tacoli, 2004). One conclusion that can be drawn from the stock of literature is that effects of town functions are mixed. As our findings show, the influence of town functions varies with outcome (variable of main interest), and even location (different effects in different areas, see Hinderink and Titus, 2002).

The empirical analysis in this thesis began in chapter 4 by examining the effect of town functions on income from productive activities. The results suggest that proximity to roads and transport services (transport infrastructure) has a bigger effect on income from non-farm household productive activities. With each 1 km reduction in distance to dry-weather roads, non-farm income from home-based enterprises would increase by 3.6 percent. Comparatively, the effect of road distance is less strong on non-farm wage income and farm income. However, the crucial role that roads play in influencing total income from productive activities is stressed by the decline in income by 28 percent if road distance were increased by 10 km. This effect is indeed significant. It shows the contribution that expansion of road infrastructure can make to increased income. In this regard, different empirical studies have also emphasized the importance of proximity to roads to (rural) household income. Among others, Isgut (2004) and Deichmann *et al*. (2009) stress that physical location and road access significantly matter for creating opportunities for non-farm wage income.

Transport services (such as bus, taxi or freight services) can be equally important to non-farm and farm income. Given accessible roads, transport services are useful for increasing income through enabling affordable commuting to non-farm working places or lowering the cost of transporting products of farm and home-based productive activities. In fact, estimates suggest that farm income would comparatively be severely affected when distance to transport services is increased (a reduction by 1.4% for a 1 km increase). Furthermore, the quality of the roads that may influence availability of transport services can determine income. In this regard, Lanjouw (1999) and Gibson and Olivia (2010) underline that access to non-farm jobs and income may be critically constrained by poor road infrastructure (low quality roads) even for households living closer to roads that lead to towns and urban areas. This may partly explain our finding that wage income from non-farm productive activities does not exhibit a significant association with road proximity. Shorter distance to transport services exhibits a positive association with higher non-farm wage income; but if the roads that lead to towns where most of the non-farm jobs are concentrated (Fafchamps and Shilpi, 2003) are of poor quality, the contribution of roads to non-farm wage income may not materialize.

Although we could not verify the effect of road quality from our analysis in chapter 4 due to data limitations, findings in chapter 5 and 6 show the significant difference that road quality can make to crop commercialization and fertilizer application. The effect on income could be equally significant. Rural households usually engage in seasonal/temporary non-farm employment in rural towns and towns. For such employment and income opportunities, the presence of good quality roads and availability of transport services is vital (Tacoli, 2004). In a broader sense, the role that transport infrastructure plays toward the overall goal of poverty reduction is emphasized. In particular, roads especially can play a pivotal role in consumption growth or poverty reduction through increasing agricultural income (Dercon and Hoddinott, 2005; Khandker *et al*., 2009; Dillon *et al*., 2011) and non-farm income (Gunasekera *et al*., 2008). In this regard, chapter 4 presents highlights of the crucial role that roads and transport play in increasing income (both farm and non-farm income) though some studies (such as, Matshe and Young, 2004) present empirical findings that suggest that 'infrastructure'- a dummy indicator for access to roads and transport - has negligible influence on non-farm income.

One major function of roads and transport is to link households to markets in towns. Beside playing their 'marketing' role, markets can be instrumental in diffusing information (obtaining and processing) related to employment. Findings in chapter 4 suggest that proximity to markets leads to more farm and non-farm income (from non-farm household enterprises and waged productive activities). While the effect on total income is comparatively small (only a 0.7% increase for a 1 km reduction in distance to markets), the contribution of closer markets to income from home-based enterprises is relatively higher (5.1%). Markets are outlets for products of home-based enterprises. Shorter distance and access to markets therefore is vital for income from these enterprises. Markets are also useful for income from farm activities, which largely depends on farm sales (though the effect is comparatively small, 1.5%). Fafchamps and Shilpi (2003) suggest that non-farm waged and household enterprises (including self-employment activities) are usually situated in towns and urban areas. Furthermore, these centers possess major markets that can create opportunities for higher employment and income from non-farm household enterprises, including self-employment (Ruben and van den Berg, 2001; Deichmann *et al*., 2009) and farm productive activities. This in fact can be decisive because market outlets are extremely useful; and closer markets can mean lower cost of transport per unit of farm output or higher 'farm-gate' prices that lead to higher profitability and farm income.

Functions that power the production process, such as electricity and water, enhance income from non-farm household enterprises and waged productive activities. Quantitative estimates indicate that total income and income from home-based enterprises more than doubles with access to electricity. On the other hand, non-farm wage income grows by about four-fifth (about 84%) when access to electricity changes from zero to one. These functions are among the useful inputs that increase profitability and sustainability of non-farm productive activities. With relatively good access to electricity and clean water, small-scale home-based and formal productive activities can flourish. In the process, they create non-farm employment opportunities and boost income. Other studies similarly indicate that electricity (Lanjouw, 1999; Deichmann *et al*., 2009) and electricity and water (Isgut, 2004) ensure sustained operation of productive activities and are useful for earning higher income from non-farm waged and home-based enterprises. Additionally, chapter 4 presents indications that while electricity and water discourage employment in farming, they help boost income earned from farm productive activities. This is expected *a priori*, especially since households would opt to engage in high-rewarding non-farm activities when they have access to electricity and tap water (also pointed out by Isgut, 2004).

The evidence also shows that secondary schools and telephone services can facilitate employment and help boost income from productive activities as proximity to such services can mean better access to employment and market-related information. Better jobs and hence higher income can be earned by bringing telephone facilities closer, as this would reduce costs incurred while searching for and processing employment-related information (Lanjouw, 1999; Key *et al*., 2000). According to the quantitative estimates, a 1 km reduction in distance to telephone services was observed to have a similar effect on each income category (a rise of 0.7% while it is slightly smaller for total income, 0.5%, which is not significant). Since the second half of the last decade, mobile phone use in Ethiopia is growing and penetrating deep into many rural areas and rural towns. This expansion is expected to further lower cost of communication, which can facilitate especially non-farm employment and income opportunities.

On the other hand, a shorter distance to secondary schools was observed to boost non-farm wage income and total income (0.2% and 1.2% respectively for each 1 km reduction in distance). Despite the fact that the effect on non-farm wage income is unexpectedly small, the contribution to total income of closer secondary schools that help build skills and knowledge at lower cost is emphasized. However, income from farm and home-based enterprises was observed to increase with distance to secondary schools. Although this may not be conclusive, it could be the case that closer secondary schools encourage households to concentrate on building the knowledge that increases the likelihood of non-farm wage employment. In this case, households are less likely to work in farm and home-based enterprises, which leads to less income from each of these activities.

Chapters 5 and 6 partly capture the role that town functions play in forward and backward linkages. Both chapters contribute to the largely missing role of *functions physically located in rural towns and towns* on crop output marketing and fertilizer adoption and use. Most of the existing studies focus on the contribution of rural infrastructure to rural economic activities (including input and output marketing). In many rural areas of developing countries, however, these functions are usually lacking or very limited. An interesting issue examined in these chapters is the role that functions in towns play in bridging the missing link and contributing to the promotion of crop output marketing and fertilizer application. These chapters contribute to the literature by dealing not only with *decision-making and intensity of decisions* but also the *ability* of farm households to participate in crop output marketing and fertilizer use. The latter effect is often ignored in the literature. As much as town functions influence decision-making and intensity of decisions, they also significantly affect the ability to participate in different activities (such as crop marketing and fertilizer application). However, previous research (Alene *et al*., 2008; Shilpi and Umali-Deininger, 2008; Gebremedhin *et al*., 2009) that studied the influence of rural infrastructure on crop marketing and fertilizer use ignored this phenomenon (and followed single hurdle approaches). Such approaches limit the opportunity to fully understand the role of town functions by effectively assuming that different functions have no effect on the *ability* to perform a given activity (such as marketing). In chapters 5 and 6, this thesis followed approaches that take into account this situation while studying household decision-making in relation to crop output marketing and fertilizer application *vis-à-vis* access to town functions.

As one major element of forward linkage, crop output marketing *vis-à-vis* town functions is specifically examined in chapter 5. At the center of the forward linkage is the role that town functions play in crop marketing and promoting commercialization. Theoretical studies related to crop marketing (Key *et al*., 2000, Tacoli, 2004; Renkow *et al*., 2004; Barrett, 2008) emphasize the contribution of town functions in reducing transaction costs and promoting marketing and market access. The empirical evidence in this chapter provides insight into how major town functions such as roads, markets and telephone centers contribute to promoting crop marketing. The evidence suggests that telephone centers and secondary schools contribute mainly to enabling participation through improved access to, and processing of, market information. In this regard, a 1 km reduction in each of these functions was observed to increase ability (probability) of market participation by 0.8 and 0.5 percent respectively. These results highlight how market participation can be effectively increased if a significant reduction in distance is made (8% and 5% increase, respectively for a 10 km reduction in distance).

It is indicated on the other hand that closer and good quality roads and markets contribute to encouraging participation and even increase share of crop output marketed. Recent empirical research on maize marketing in Kenya by Renkow *et al*. (2004) and Alene *et al*. (2008) show that isolation (large distance) to roads and markets has a negative effect on marketed share. Chapter 5 puts forward additional evidence about the varying effect of roads in influencing participation ability, decision and intensity of decision in crop marketing. Road quality also positively contributes to crop marketing. The effect on probability (ability) of market participation varies between 3.1 percent (roads accessible to trucks) and 5 percent (roads well accessible to any vehicle) for a 1 km reduction in distance. Consistent with theoretical arguments, reducing distance from roads with different qualities translates into more crop output being transported for sale (varying from an increase in sales share of between 4.1 and 6.6% for a 1 km reduction in distance). In addition, cross-category comparisons indicate that roads have a higher effect on promoting crop marketing and non-farm employment choices. The strong influence of roads on crop marketing and non-farm employment may benefit rural and rural town households, whose income often depends on farm production, sales and diversification into non-farm employment opportunities. In this regard, empirical evidence in this thesis and related research highlights that opportunities created by town functions helps promote not only crop marketing but also rural household income (Gebremedhin *et al*., 2009) and crop diversification and rural welfare (De and Chattopadhyay, 2010).

In addition, chapter 5 disentangles what is otherwise known as ‘social networks’ in the literature into household-specific network relations (flow variable) and social capital (a common ‘stock variable’). Disentangling the two informal institutions allows us to study not only the number of connections but also their nature, which can render better information as to how these forms of informal institutions promote crop marketing. The empirical evidence shows that these institutional elements influence crop output marketing. While social capital contribute to increased market participation, network relations help increase sales share. These institutional elements are particularly useful in the absence of communication town functions such as telephone services in rural areas of developing countries. Depending on their strength, network relations can be conceived as 'informal human capital' that can be used to obtain and process market information relatively quickly (at lower cost). In this regard, Johnson *et al*. (2002) argue that strong network contracts can be the source of price information, liquidity, inputs, technical support and farm output outlets. Moreover, the social capital (rules and norms, trust, etc.) as the 'social fabric' can act like the 'institutional environment' that creates the necessary platform for higher crop marketing. In this regard, previous studies (such as Fafchamps and Minten, 2002) emphasize the role of social networks in promoting crop marketing. The analysis in chapter 5 provides an insight into the strong contribution of network relations and social capital to crop marketing, but the role of these informal institutions can go beyond crop marketing in influencing overall rural development as well (Casson *et al*., 2010).

In a different outcome, chapter 6 picks up the backward linkage in terms of rural households' fertilizer adoption and use in response to access to town functions. This chapter identifies town functions that influence the *ability* to adopt, *adoption decision* and *intensity* of fertilizer adoption. There is a dearth of knowledge in this regard (Doss, 2006) and the evidence in this chapter adds knowledge to the literature by identifying the most relevant infrastructural facilities that influence fertilizer adoption and behavior. The findings suggest that roads, markets and knowledge-generating, processing and disseminating functions (including schools, extension and agricultural cooperative centers) play significant roles in enabling and encouraging the adoption and use of fertilizer by rural households.

The results suggest that as distance to roads and markets gets shorter, the ability to adopt fertilizer and the probability of adopting fertilizer (including the amount) increases, other things being constant. Adoption probability would increase by between 0.9 percent (reasonably accessible to trucks) to 1.5 percent (well accessible to any vehicle) if roads are brought closer by 1 km. For the average household, fertilizer intensification would similarly increase by between 0.8 to 1.3 percent for a similar reduction in distance to roads. It can be seen from these effects that a significant reduction in distance to roads would bring sizable change to fertilizer application. This can be attributed to the lower cost of obtaining technology-specific information and transport costs with shorter distances to roads and markets. A study by Dercon and Hoddinott (2005) reports a higher effect of road distance on the probability of adoption (an increase of between 29 to 34% for a 10 km reduction in distance to roads with different qualities). Furthermore, Ahmed (2005) and Dorosh *et al.* (2010) emphasize the crucial role that shorter travel time to town centers and town markets plays in increasing the adoption of high-productive technologies, including fertilizer.

Depending on the technology however, good access to roads may also lead to dis-adoption (discourage adoption). For instance, Adegbola and Gardebroek (2007) present empirical evidence that suggests good road conditions lead to the dis-adoption of storage technologies. This is because good road conditions increase access to markets, which is an indicator of risk preference among farm households in different locations (Feder *et al.*, 1985); and farm households requiring high risk premiums for uncertain future benefits as a result of the increased access to markets tend to be less motivated to adopt storage technologies (Adegbola and Gardebroek, 2007). Otherwise, empirical research emphasize the importance of expanding rural road infrastructure and market information systems not only for the expansion of fertilizer use but for rural economic development (Jayne *et al.*, 2003).

On the other hand, empirical results partly support the findings by Alene *et al.* (2008) that the probability of adopting fertilizer decreases with distance to markets (with no effect on intensity and ability, the latter being ignored). Closer markets can also have the advantage of moderating risk behavior and trust on technologies. Cavatassi *et al.* (2011) for instance stress the positive role of closer markets in relaxing technology risk perception and promoting the adoption of modern varieties. In this regard, households are more likely to adopt fertilizer with closer markets (3.2% higher for each 1 km reduction in distance to markets). Similarly, intensification would increase by 2.6 percent for each 1 km market distance reduction. These results indicate the benefits of closer major markets in promoting fertilizer adoption by bringing households closer to towns (where the major markets are located) and having better information, which also reduces uncertainties and increases confidence in the technology.

In relation to this, functions that are important in training, demonstrating and disseminating technologies (such as extension services and schools) lead to higher fertilizer application through positively influencing households' perception (reducing risk behavior and uncertainties). In this regard, the empirical evidence supports findings by previous studies (Nkamleu and Adesina, 2000; Moser and Barrett, 2006; Marenya and Barrett, 2009) that emphasize the importance of extension services to fertilizer adoption. However, Xu *et al*. (2009) find that fertilizer use profitability decreases with contacts with extension agents, recommending for 'more effective extension messages'.

Chapter 6 also examined the role that network relations and social capital play in promoting fertilizer adoption and use. The approach is the same as in chapter 5, where network relations are considered as 'flow variable' and social capital as 'stock variable'. Empirical results presented evidence on the significant effect these two informal institutions have on adoption behavior and use. The indicators used to proxy network relations show that rural household communication frequencies and membership in different associations act as sources of technology-specific information. These networks help reduce uncertainties and risk behavior related to fertilizer technology and promote learning. Similarly, trust and confidence (in neighbors, officials and oneself) that proxy social capital are instrumental in reducing uncertainties and facilitate learning. Social networks partially fill the gap left by a lack of infrastructure in diffusing information, reducing transaction costs and increasing risk mitigation (Isham, 2002). In this thesis, network relations and social capital are represented by indices. However, Isham (2002) argues that the approach of using indices for social networks limits the opportunity to understand how outcomes are affected by different (blocks) of network mechanism. Otherwise, the empirical evidence in chapter 6 supports findings by previous studies that indicate the significant contribution social networks play in promoting the adoption and use of technologies (Isham, 2002; Matuschke and Qaim, 2009). As opposed to our results, Bandiera and Rasul (2006) studied the adoption of a new crop and indicate that network strengths have a negative effect on adoption. They argue that the existence of many households in the network creates an incentive for potential adopters to strategically postpone adoption in order to exploit knowledge accumulated at a later stage.

In chapter 7, an attempt to investigate the relative effect of town functions on households' choice of alternative employment opportunities was made. The evidence suggests that roads, markets, telephone services and electricity increase the likelihood of employment in non-farm activities (waged and household enterprises) as compared to working in farming.

Comparatively, shorter distances to dry-weather roads has a greater effect on employment in non-farm home-based enterprises (7.8%). On the other hand, the probability of non-farm wage employment would increase by 4.6 percent if road distance decreases by 1 percent (as compared to farm work). These results emphasize the role that roads can play in boosting employment in non-farm activities due to the fact that most of the non-farm jobs are concentrated in towns (Fafchamps and Shilpi, 2003; Deichmann *et al*., 2009). Proximity to roads that lead to towns and other urban centers therefore is useful to increase the likelihood of non-farm employment opportunities. Lanjouw (1999), however, stresses that proximity to towns does not necessarily translate into better access to off-farm jobs (or non-farm employment) if the transport infrastructure providing access to such towns is poor.

Empirical results also indicate that electricity connection is more likely to increase non-farm employment as compared to farm work. Households connected to electricity are more likely (by 24.6%) to be employed in non-farm wage work. As compared to farm work, the probability of employment in home-based enterprises similarly would rise by 6 percent with electricity connection. In this regard, the evidence presented is consistent with findings by Deichmann *et al*. (2009) that suggest electricity access increases the probability of employment in high-rewarding non-farm wage work. However, some studies (such as Lanjouw, 2001) could not establish the causal link between electricity connection and a higher probability of employment in non-farm activities, suggesting it may be explaining for proximity to towns. In this thesis however, we have controlled for the other functions that may explain proximity to towns and the role of electricity to non-farm wage employment cannot be emphasized enough. This is consistent with arguments from other studies (including, Isgut, 2004; Deichmann *et al*., 2009; Jonasson and Helfand, 2010) that point out that electricity connection creates opportunities where non-farm self-employment (and other home-based enterprises), small-scale and formal medium-size productive activities thrive. This eventually contributes to creating more non-farm employment opportunities for households.

Shorter distances telephone services and secondary schools were also observed to increase the probability of employment in non-farm wage works. These functions help facilitate information exchange about non-farm wage employment and build skills that increase the chances of obtaining non-farm wage work. Compared with farm work, these functions also comparatively boost the chances of employment in home-based enterprises; but their effect is stronger in increasing the likelihood of non-farm wage employment (a 2.3% increase for telephone services and 1.6% increase for secondary schools for a 1 percent reduction in distance to each of these functions).

To conclude then, the empirical analyses in this thesis examined some core elements of the rural-urban linkage. Specifically, the relationship between town functions and employment and income, crop marketing and fertilizer application was investigated. The evidence suggested that some major town functions (such as roads, markets and telephone services) are more important than others. Taking note of the varying contributions of towns and their functions, the positive effect to rural areas development can be enhanced through meeting some 'rural development conditions' first (Hinderink and Titus, 2002), which can include selectively expanding most important town functions such as roads and transport, markets and telecommunication facilities. Revising some current economic policies at the macro level may also be useful in facilitating rural development. Jayne *et al*. (2003) for instance emphasize that investment in *selected* functional services has a more powerful effect than subsidies on fertilizer marketing at both macro level (such as general market performance) and the micro level of household fertilizer adoption behavior. Hinderink and Titus (2002) however, stress that the selective investment of functions in towns so far has been biased to the needs of the urban middle class, thus neglecting the needs of the rural and urban poor. This suggests that divergence of limited public funds for the reinforcement of town functions (town structure and functioning) should be carefully made if it is to promote pro-poor rural or overall development.

8.4 Implications and future outlook

8.4.1 Implications

This thesis dealt with the micro-econometric study of household employment and income, crop marketing and fertilizer application (and use) *vis-à-vis* access to town functions. In an attempt to single out the most important functions, a relatively broad spectrum of town functions was considered. The evidence suggests that some of the major town functions such as roads, markets, telephone services, electricity and schools play significant roles in promoting employment, income and input-output marketing. However, our results show that some functions (especially roads, markets and telephone services) have a greater influence on income or input-output marketing than others. For instance, roads and markets are found to have stronger effects on income from non-farm household enterprises, total income and farm income. On the other hand, the evidence suggests that closer distance to roads and markets is observed to increase the likelihood of employment in non-farm wage work as compared to farm employment.

One implication is that the role of town functions differs for different sectors or activities. In this thesis, it is indicated that accessible roads and markets are useful in increasing farm income and income from home-based enterprises. Currently in Ethiopia, strong investment activities in rural roads are observed and this is expected to help contribute to higher farm income. However, this largely depends on the quality of the roads, transport and marketing-information systems (supply chain system). Lanjouw (1999) for instance emphasizes that proximity to towns may not lead to higher farm income or bring more non-farm jobs if the availability and quality of the transport infrastructure leading to the towns is poor. Rural road quality in Ethiopia is not really dependable and the marketing-process information is poorly developed. This is one major area where interventions can be made for physical roads and markets to have an effective result in promoting farm and non-farm income, expanding rural non-farm employment or contribute to input-output marketing.

In Ethiopia, agriculture and rural development take center stage in policy setting. For rural development to prosper, the potential of forward and backward linkages should be exploited. Many of the major functional services that are expected to serve as wheels of the linkage are missing however. Therefore, selective investment in the most important functions such as market information systems and transport infrastructure will help reduce supply costs (related to crop marketing) and increase farm level demand (fertilizer demand decisions). Kelly *et al.* (2003) and Jayne *et al.* (2003) emphasize the significant importance of investing in *selected vital functional services* for increased crop marketing and fertilizer adoption and use. Selective investment in the transport infrastructure and input-output market information systems therefore is pivotal in marketing, technology adoption and diffusion and non-farm employment. Equally important is the focus that should be given to the rural and urban poor when making investments in such functions. This is particularly relevant as previous studies (such as, Hinderink and Titus, 2002) stress that the effect of such selective investment in developing countries is negligible when it is geared towards the needs of the middle-class population. In addition, expanding agricultural infrastructure (such as irrigation) are among the important functions that potentially can increase the adoption and use of agricultural technologies such as fertilizer, agricultural production (hence surplus crop output marketing) and income.

Town functions positively affecting employment in non-farm productive activities (directly or as compared to farming) may indicate that the promotion (expansion) of these town functions would help pool part of the vast rural labor force to non-farm activities. While this can help rural households earn more non-farm income, it may also bring other benefits. If rural labor force can be consistently pooled to non-farm activities, pressure on agricultural land can be reduced, leading to reduction in land fragmentation and an increase in agricultural productivity. It would also contribute to the transformation from farming to rural town or town-based non-farm activities. In this regard, Christiaensen and Todo (2009) emphasize that transformation from an agricultural-based rural economy to a town-based rural non-farm economy can be effective in reducing poverty and promoting rural development.

Results related to social networks indicate that they help in the diffusion of market information and may function as a substitute for lacking a proper institutional environment - the necessary platform for efficient exchanges. Some of the network connections that rural households establish are located in towns (agents, customers or suppliers). Policies that aim to strengthen this network can be useful to rural households in facilitating and transferring information and knowledge related to technologies; reducing technology-related risk behavior and uncertainties, and achieving a better exchange of market information (input-output prices, demand and supply). Traditional associations such as Equb, Iddir and rural work parties have existed for a long time now in Ethiopia. However, the opportunities to communicate and disseminate information related to marketing and agricultural technologies through these informal institutions have been limited. Policies that encourage these institutions to give more focus on the exchange of information and collaboration (for instance, subsidizing poorer rural households for agricultural technologies) can promote the use of agricultural technologies and crop output marketing.

8.4.2 Further research

The empirical analyses in this thesis identified some gaps in the relationship between town functions and employment and income, crop marketing and fertilizer adoption. The insights from the empirical findings can be further strengthened through future research on the treatment of town functions. The empirical analyses in this thesis did not consider the potential interaction among functions. It may well be the case that the existence of one function (for instance, roads) leads to the establishment of other functions. In this case, disentangling the effect of each function can be complex. One area for further research can be to take interaction among functions into consideration, to draw better information about the effect of each function on income and employment or input-output marketing. The literature provides some studies related to the impact of functions on welfare indicators. However, a large proportion of the functions have not received due attention and nor has the interaction. In this regard therefore, impact studies of different town functions on welfare indicators (using recent evaluation methods) can give a clearer message about the role of each major town function, thereby helping to make an objective evaluation of existing policies, and focusing and promoting interventions on functions that benefit especially the rural poor.

Analyses in this thesis were made based on static models. This approach does not however lend itself to capturing the changes in functions and outcomes over time. The collection of longitudinal data paves the way for dynamic analysis that helps capture the change over time in the density (quantity) and quality of the functions. In this regard, the literature is particularly limited in the micro-level dynamic analysis of the role of town functions in rural household economic activities. An interesting area for future research therefore is the analysis of dynamic change of functions that helps capture the change over time on entry and exit (for example, in technology adoption or labor markets or crop marketing), capture shocks (in harvest for example and role on crop marketing), over time migration to towns and non-farm employment opportunities in, and income from, productive activities. The literature provides some studies that use longitudinal data to examine the impact of functions (mainly rural roads) on welfare improvement based on relatively recent evaluation techniques or randomization methods (such as: Propensity Score Matching, PSM). However, the other functions are mainly ignored. There is therefore an opportunity to do some sort of impact assessment for the dynamic contribution of other major functions as well.

This thesis also followed a unimodal approach in trying to study the role of town functions on economic activities. In other words, only the nearest town functions from the perspective of households were considered. However, there could be other functions in different directions (which can have an influence on outcomes). In addition, rural areas can be linked with different lower-order rural towns or higher-order towns that have different distributions of functions. Future research that integrates the spatial distribution of these functions in studying their influence on different economic activities can present useful insights. The existence of spatial dependence and heterogeneity in the distribution of functions (or households) *vis-à-vis* the relationship with outcomes such as crop marketing, fertilizer application or employment can be examined to better understand the role of functions. In this case, integrating spatial issues to micro-econometric household analyses would help promote understanding of the relationship between functions and employment, income, crop marketing and fertilizer adoption and use.

Abdulai, A. and Delgado, C. (1999) Determinants of nonfarm earnings of farm-based husbands and wives in Northern Ghana. *American Journal of Agricultural Economics*, 81(1): 117-130.

Abdulai , A. and CroleRees, A. (2001) Determinants of income diversification amongst rural households in Southern Mali. *Food Policy*, 26(4): 437-452.

Adegbola, P. and Gardebroek, C. (2007) The effect of information sources on technology adoption and modification decisions. *Agricultural Economics*, 37(1): 55-65.

Ahmed, A. (2005) The impact of finance and funding on technology adoption in Africa. *Journal of African Development*, 7(1): 20-41.

Ahmed, A. U.; Hill, R. V.; Smith, L. C.; Wiesmann, D. M. and Frankenberger, T. (2007) The world's most deprived: Characteristics and causes of extreme poverty and hunger. 2020 Discussion Paper 43, International Food Policy Research Institute (IFPRI), Washington, D. C., US.

Alene, A. D.; Manyong, V. M.; Omanya, G.; Mignouna, H. D.; Bokanga, M. and Odhiambo, G. (2008) Smallholder market participation under transaction costs: maize supply and fertilizer demand in Kenya. *Food Policy*, 33(4): 318-328.

Alston, M. (2002) Inland rural towns: are they sustainable? Paper presented at the Academy of the Social Sciences Session on "Rural Communities at the Outlook 2002 Conference", 5-7 March 2002, Canberra, Australia. http://www.assa.edu.au/Workshop/Papers/alston.PDF (accessed on January 8, 2007)

Amemiya, T. (1981) Qualitative response models: A survey. *Journal of Economic Literature*, 19(4): 1483-1536.

Aristei, D. and Pieroni, L. (2008) A double-hurdle approach to modelling tobacco consumption in Italy. *Applied Economics*, 40(19): 2463-2476.

Asfaw, A. and Admassie, A. (2004) The role of education on the adoption of chemical fertilizer under different socioeconomic environments in Ethiopia. *Agricultural Economics*, 30(3): 215-228.

Asselin, L-M. (2002) Composite indicator of multidimensional poverty. Institut de Mathématique Gauss, Québec, Canada.

http://www.pep-net.org/fileadmin/medias/pdf/CBMS_training/composite_ind.pdf (accessed on October 11, 2011)

Bandiera, O. and Rasul, I. (2006) Social networks and technology adoption in northern Mozambique. *The Economic Journal*, 116(514): 869-902.

Barrett, C. B. (2008) Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy*, 33(4): 299-317.

Baulch, B. and Hoddinott, J. (2000) Economic mobility and poverty dynamics in developing countries. *Journal of Development Studies*, 36(6): 1-24.

Berhane, G. (2009) *Econometric Analyses of Microfinance Credit Group Formation, Contractual Risks and Welfare Impacts in Northern Ethiopia*. PhD Thesis, Wageningen University, Wageningen, The Netherlands. http://edepot.wur.nl/12479 (accessed on October 11, 2011)

Bianchi, S. M. (2000) Maternal employment and time with children: Dramatic change Or surprising continuity? *Demography*, 37(4): 401-414.

Binswanger, H. P. and Townsend, R. F. (2000) The growth performance of agriculture in Subsaharan Africa. *American Journal of Agricultural Economics*, 82(5): 1075-1086.

Calderón, C. and Chong, A. (2004) Volume and quality of infrastructure and the distribution of income: An empirical investigation. *Review of Income and Wealth*, 50(1): 87-106.

Cameron, A. C. and Trivedi, P. K. (2005) *Microeconometrics: Methods and Applications*. Cambridge University Press, Cambridge, UK.

Casson, M. C.; Giusta, M. D. and Kambhampati, U. S. (2010) Formal and informal institutions and development. *World Development*, 38(2): 137-141.

Cavatassi, R.; Lipper, L. and Narloch, U. (2011) Modern variety adoption and risk management in drought prone areas: Insights from the sorghum farmers of eastern Ethiopia. *Agricultural Economics*, 42(3): 279-292.

Central Statistical Authority (CSA) (2001) Report on the year 2000 Welfare Monitoring Survey. Statistical Bulletin 259, Volume 1, Addis Ababa, Ethiopia.

Central Statistical Authority (CSA) (2005) Welfare Monitoring Survey, WMS 2000-2001. Addis Ababa, Ethiopia. http://www.csa.gov.et/surveys/Welfare_Monitoring_Survey/Welfare_Monitoring_Survey_2000/survey0/index.html (accessed on March 12, 2008)

Central Statistical Authority (CSA) (2007) Rural investment climate survey: Basic information document. Addis Ababa, Ethiopia. http://www.csa.gov.et/index.htm (accessed on February 20, 2011)

Central Statistical Authority (CSA) (2008) Summary and Statistical Report of the 2007 Population and Housing Census. Population Census Commission, Addis Ababa, Ethiopia.

Christiaensen, L. and Todo, Y. (2009) Poverty reduction during the rural-urban transformation : The role of the missing middle. Paper presented at the "Poverty, Equity and Growth" Inaugural Conference, 1-3 July 2009, University of Goettingen, Goettingen, Germany.

Corral, L. and Reardon, T. (2001) Rural non-farm incomes in Nicaragua. *World Development*, 29(3): 427-442.

Cragg, J. G. (1971) Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica*, 39(5): 829-844.

Croppenstedt, A.; Demeke, M. and Meschi, M. M. (2003) Technology adoption in the presence of constraints: the case of fertilizer demand in Ethiopia. *Review of Development Economics*, 7(1): 58-70.

De, U. K. and Chattopadhyay, M. (2010) Crop diversification by poor peasants and role of infrastructure: Evidence from west Bengal. *Journal of Development and Agricultural Economics*, 2(10): 340-350.

De Brauw, A.; Huang, J.; Rozelle, S.; Zhang, L. and Zhang, Y. (2002) The evolution of China's rural labor markets during the reforms. *Journal of Comparative Economics*, 30(2): 329-353.

Deichmann, U.; Shilpi, F. and Vakis, R. (2009) Urban proximity, agricultural potential and rural non-farm employment: Evidence from Bangladesh. *World Development*, 37(3): 645-660.

de Janvry, A; Fafchamps, M. and Sadoulet, E. (1991) Peasant household behaviour with missing markets: Some paradoxes explained. *Economic Journal*, 101(409): 1400-1417.

de Janvry, A. (2010) Agriculture for development: New paradigm and options for success. *Agricultural Economics*, 41(S1): 17-36.

Dercon, S. and Krishnan, P. (2000) Vulnerability, seasonality and poverty in Ethiopia. *Journal of Development Studies*, 36(6): 25-53.

Dercon, S. and Hoddinott, J. (2005) Livelihoods, growth and links to market towns in 15 Ethiopian villages. Discussion Paper No. 194, International Food Policy Research Institute (IFPRI). http://www.ifpri.org/divs/fcnd/dp/papers/fcndp194.pdf (accessed on January 22, 2007)

Dercon, S.; Gilligan, D. O.; Hoddinott, J. and Woldehanna, T. (2009) The impact of agricultural extension and roads on poverty and consumption growth in fifteen Ethiopian villages. *American Journal of Agricultural Economics*, 91(4): 1007-1021.

Dercon, S. and Hoddinott, J. (2011) The Ethiopian rural household surveys: Introduction. International Food Policy Research Institute (IFPRI), Addis Ababa, Ethiopia.

Diagne, A. and Demont, M. (2007) Taking a new look at empirical models of adoption: Average treatment effect estimation of adoption rates and their determinants. *Agricultural Economics*, 37(2-3): 201-210.

Diao, X. and Pratt, A. N. (2005) Growth options and poverty reduction in Ethiopia: A spatial economy-wide model analysis for 2004-15. EDRI-ESSP Policy Working Paper No. 2, Ethiopian Development Research Institute (EDRI), Addis Ababa, Ethiopia. http://www.ifpri.org/themes/essp/pubs/EDRIESSPWP2.pdf (accessed on August 10, 2008)

Diao, X.; Hazell, P. and Thurlow, J. (2010) The role of agriculture in African development. *World Development*, 38(10): 1375-1383.

Dillon, A.; Sharma, M. and Zhang, X. (2011) Estimating the impact of rural investments in Nepal. *Food Policy*, 36(2): 250-258.

Dorosh, P. and Schmidt, E. (2010) The rural-urban transformation in Ethiopia. Ethiopia Strategy Support Program 2 (ESSP2), ESSP2 Discussion Paper No. 13, International Food Policy Research Institute (IFPRI), Addis Ababa, Ethiopia.

Dorosh, P.; Wang, H.; You, L. and Schmidt, E. (2010) Crop production and road connectivity in Sub-Saharan Africa: A spatial analysis. Policy Research working paper 5385, Sustainable Development Division, the World Bank, Washington, D. C., US.

Doss, C. R. (2006) Analyzing technology adoption using micro studies: Limitations, challenges and opportunities for improvement. *Agricultural Economics*, 34(3): 207-219.

Douglass, M. (1998) A regional network strategy for reciprocal rural-urban linkages: An agenda for policy research with reference to Indonesia. *Third World Planning Review*, 20(1): 1-33.

Dow, W. H. and Norton, E. C. (2003) Choosing between and interpreting the Heckit and Two-Part models for corner solutions. *Health Services & Outcomes Research Methodology*, 4(1): 5-18.

Dow, J. K. and Endersby, J. W. (2004) Multinomial probit and multinomial logit: A comparison of choice models for voting research. *Electoral studies*, 23(1): 107-122.

Escobal, J. (2001) The determinants of nonfarm income diversification in rural Peru. *World Development*, 29(3): 497-508.

Escobal, J. (2005) *The Role of Public Infrastructure in Market Development in Rural Peru*. PhD Thesis, Wageningen University, Wageningen, The Netherlands. http://edepot.wur.nl/121647 (accessed on October 11, 2011)

Fafchamps, M. (1992) Cash crop production, food price volatility and rural market integration in the third world. *American Journal of Agricultural Economics*, 74(2): 90-99.

Fafchamps, M. and Quisumbing, A. (1999) Human capital, productivity and labor allocation in rural Pakistan. *Journal of Human Resources*, 34(2): 369-406.

Fafchamps, M. and Minten, B. (2002) Returns to social capital among traders. *Oxford Economic Papers*, 54(2): 173-206.

Fafchamps, M. and Shilpi, F. (2003) Spatial division of labor in Nepal. *Journal of Development Studies*, 39(6): 23-66.

Fafchamps, M. and Hill, R. (2005) Selling at the farmgate or traveling to market. *American Journal of Agricultural Economics*, 87(3): 717-734.

Fan, S. and Zhang, X. (2004) Infrastructure and regional economic development in rural China. *China Economic Review*, 15(2): 203-214.

Fan, S.; Chan-Kang, C. and Mukherjee, A. (2005) Rural and urban dynamics and poverty: Evidence from China and India. FCND Discussion Paper 196 (DSG Discussion Paper 23), International Food Policy Research Institute (IFPRI), Washington, D.C., US.

Feder, G.; Just, R. E. and Zilberman, D. (1985) Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change*, 33(2): 255-297.

Federal Democratic Republic of Ethiopia (FDRE) (2000) Interim Poverty Reduction Strategy Paper-Ethiopia, 2000/01-2002/03. Addis Ababa, Ethiopia.

Federal Democratic Republic of Ethiopia (FDRE) (2008) Federal Negarit Gazeta: Urban Planning Proclamation. Proclamation No. 574/2008, 14th Year, No. 29, Addis Ababa, Ethiopia.

Ferreira, F. and Lanjouw, P. (2001) Rural nonfarm activities and poverty in the Brazilian northeast. *World Development*, 29(3): 509-528.

Fox, W. F. and Porca, S. (2001) Investing in rural infrastructure. *International Regional Science Review*, 24(1): 103-133.

Freeman, H. A. and Omiti, J. M. (2003) Fertilizer use in semi-arid areas of Kenya: Analysis of smallholder farmers' adoption behavior under liberalized markets. *Nutrient Cycling in Agroecosystems*, 66(1): 23-31.

Gardner, B. L. (2005) Causes of rural economic development. *Agricultural Economics*, 32(S1): 21-41.

Gebremedhin, B.; Jaleta, M. and Hoekstra, D. (2009) Smallholders, institutional services, and commercial transformation in Ethiopia. *Agricultural Economics*, 40(S1): 773-787.

Gibson, J. and Olivia, S. (2010) The effect of infrastructure access and quality on non-farm enterprises in rural Indonesia. *World Development*, 38(5): 717-726.

Glauben, T.; Herzfeld, T. and Wang, X. (2008) Labor market participation of Chinese agricultural households: Empirical evidence from Zhejiang province. *Food Policy*, 33(4): 329-340.

Government of Regional State of Amhara (GRSA) (2004) General Laws: Book 1, Chapter 1-5. Amhara Regional State Justice Bureau, Bahir Dar, Ethiopia.

Government of Regional State of Tigray (GRST) (2006) Negarit Gazeta Tigray: Proclamation on organization, authority and responsibilities of towns in the Government of Regional State of Tigray. Proclamation No. 107/1998, Vol. 14, No. 14, Mekelle, Ethiopia.

Greene, W. H. (2008) *Econometric Analysis*, 6th *edition*. Prentice Hall, New York, US.

Gronau, R. (1974) Wage comparisons: A selectivity bias. *Journal of Political Economy*, 82(5): 1119-1143.

Grootaert, C.; Narayan, D.; Jones, V. N. and Woolcock, M. (2004) Measuring social capital: An integrated questionnaire. Working Paper No. 18, the World Bank, Washington, D. C., US.

Gunasekera, K.; Anderson, W. and Lakshmana, T. R (2008) Highway-induced development: Evidence from Sri Lanka. *World Development*, 36(11): 2371-2389.

Haggblade, S.; Hazell, P. and Brown, J. (1989) Farm-nonfarm linkages in rural Sub-Saharan Africa. *World Development*, 17(8): 1173-1201.

Haggblade, S.; Hazell, P. and Reardon, T. (2002) Strategies for stimulating poverty-alleviating growth in the rural nonfarm economy in developing countries. EPTD Discussion Paper No. 92, International Food Policy Research Institute (IFPRI), Washington, D. C., US.

Hagos, F.; Pender, J. and Gebresselassie, N. (1999) Land degradation in the highlands of Tigray and strategies for sustainable land management. Socioeconomic and Policy Research Working Paper No. 25, International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

Hausman, J. A. and McFadden, D. (1984) Specification tests for the multinomial logit model. *Econometrica*, 52(5): 1219-1240.

Heckman, J. (1979) Sample selection bias as a specification error. *Econometrica*, 45(1): 153-161.

Heckman, J. (2010) Building bridges between structural and program evaluation approaches to evaluating policy. *Journal of Economic Literature*, 48(2): 356-398.

Himaz, R. (2010) Intrahousehold allocation of education expenditure: The case of Sri Lanka. *Economic Development and Cultural Change*, 58(2): 231-258.

Hinderink, J. and Titus, M. (2002) Small towns and regional development: Major findings and policy implications from comparative research. *Urban Studies*, 39(3): 379-391.

Hoff, K. and Stiglitz, J. E. (2001) 'Modern economic theory and development.' In: G. M. Meier and J. E. Stiglitz (*Eds*.) *Frontiers of Development Economics: The Future Perspective*. Oxford University Press, Oxford, UK.

Hoffmann, R. and Kassouf, L. A. (2005) Deriving conditional and unconditional marginal effects in log earnings equations estimated by Heckman's procedure. *Applied Economics*, 37(11): 1303-1311.

Isgut, A. E. (2004) Non-farm income and employment in rural Honduras: Assessing the role of locational factors. *Journal of Development Studies*, 40(3): 59-86.

Isham, J. (2002) The effect of social capital on fertilizer adoption: Evidence from rural Tanzania. *Journal of African Economies*, 11(1): 39-60.

Jagwe, J.; Ouma, E. and Machethe, C. (2009) Transaction costs and smallholder farmers' participation in Banana markets in the Great Lakes Region. CEGA Working Paper Series No. AfD-0909, Center of Evaluation for Global Action, University of California, Berkeley, US.

Jayne, T. S.; Govereh, J.; Wanzala, M. and Demeke, M. (2003) Fertilizer market development: A comparative analysis of Ethiopia, Kenya, and Zambia. *Food Policy*, 28(4): 293-316.

Johnson, N.; Suarez, R. and Lundy, M. (2002) The importance of social capital in Colombian rural agro-enterprises. CAPRi Working Paper No. 26, International Food Policy Research Institute (IFPRI), Washington, D. C., US.

Jonasson, E. and Helfand, S. M. (2010) How important are locational characteristics for rural non-agricultural employment? Lessons from Brazil. *World Development*, 38(5): 727-741.

Jones, A. M. and Yen, S. T. (2000) A Box-Cox double-hurdle model. *The Manchester School*, 68(2): 203-221.

Kajisa, K. (2007) Personal networks and nonagricultural employment: The case of a farming village in the Philippines. *Economic Development and Cultural Change*, 55(4): 669-707.

Kaliba, A. R. M.; Verkuijl, H. and Mwangi, W. (2000) Factors affecting adoption of improved Maize seeds and use of inorganic fertilizer for Maize production in the intermediate and lowland zones of Tanzania. *Journal of Agricultural and Applied Economics*, 32(1): 35-47.

Kammeier, H. D. (2002) Rural-urban linkages and the role of small and medium sized towns in development: Issues, concepts and policies. Background Paper for the ESCAP and UN-Habitat Workshop on "Poverty Alleviation through Rural-Urban Linkages: The Role of Small and Medium-Sized Towns", 16-18 September 2002, Siem Reap, Cambodia.

Kebede, B. (2002) Land tenure and common pool resources in rural Ethiopia: A study based on fifteen sites. *African Development Review*, 14(1): 113-149.

Kelly, V. A.; Adesina, A. A. and Gordon, A. (2003) Expanding access to agricultural inputs in Africa: A review of recent market development experience. *Food Policy*, 28(4): 379-404.

Kelly, V. A. (2006) Factors affecting demand for fertilizer in Sub-Saharan Africa. Discussion Paper 23, Agriculture and Rural Development, the World Bank, Washington, D. C., US. http://siteresources.worldbank.org/INTARD/Resources/ARD_DP23_FINAL.pdf (accessed on December 1, 2010)

Key, N.; Sadoulet, E. and de Janvry, A. (2000) Transaction costs and agricultural household supply response. *American Journal of Agricultural Economics*, 82(2): 245-259.

Khandker, S. R.; Bakht, Z. and Koolwal, G. B. (2009) The poverty impact of rural roads: Evidence from Bangladesh. *Economic Development and Cultural Change*, 57(4): 685-722.

Korpi, T. (1997) Is utility related to employment status? Employment, unemployment, labor market policies and subjective well-being among Swedish youth. *Labour Economics*, 4(2): 125-147.

Lanjouw, P. (1999) Rural nonagricultural employment and poverty in Ecuador. *Economic Development and Cultural Change*, 48(1): 91-122.

Lanjouw, P. (2001) Nonfarm employment and poverty in rural El Salvador. *World Development*, 29(3): 529-547.

Lanjouw, J. and Lanjouw, P. (2001) The rural non-farm sector: Issues and evidence from developing countries. *Agricultural Economics*, 26(1): 1-23.

Lanjouw, P.; Quizon, J. and Sparrow, R. (2001) Non-agricultural earnings in peri-urban areas of Tanzania: Evidence from household survey data. *Food Policy*, 26(4): 385-403.

Lopez, R. E. (1986) 'Structural models of the farm household that allow for interdependent utility and profit maximization.' In: I. Singh; L. Squire and J. Strauss (*Eds.*) *Agricultural Household Models: Extension, Applications and Policy*. Johns Hopkins University Press, Baltimore, US.

Martínez-Espiñeira, R. (2006) A Box-Cox double-hurdle model of wildlife valuation: The citizen's perspective. *Ecological Economics*, 58(1): 192-208.

Matsumoto, T.; Kijima, Y. and Yamano, T. (2006) The role of local nonfarm activities and migration in reducing poverty: Evidence from Ethiopia, Kenya, and Uganda. *Agricultural Economics*, 35(S3): 449-458.

McFadden, D. (1974) 'Conditional logit analysis of qualitative choice behavior.' In: P. Zarembka (*Ed*.) *Frontiers of Econometrics*. Academic Press, New York, US.

Marenya, P. P. and Barrett, C. B. (2009) Soil quality and fertilizer use rates among smallholder farmers in western Kenya. *Agricultural Economics*, 40(5): 561-572.

Matshe, I. and Young, T. (2004) Off-farm labour allocation decisions in small-scale rural households in Zimbabwe. *Agricultural Economics* 30(3): 175-186.

Matuschke, I. and Qaim, M. (2009) The impact of social networks on hybrid seed adoption in India. *Agricultural Economics*, 40(5): 493-505.

Micevska, M. and Rahut, D. B. (2008) Rural nonfarm employment and incomes in the Himalayas. *Economic Development and Cultural Change*, 57(1): 163-193.

Ministry of Finance and Economic Development (MoFED) (2008) Dynamics of growth and poverty in Ethiopia (1995/96-2004/05). Development Planning and Research Department (DPRD), Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (MoFED) (2010) Growth and Transformation Plan (GTP): First draft report on Five-year Plan, 2011-2016. Federal Democratic Republic of Ethiopia (FDRE), Addis Ababa, Ethiopia.

Moffatt, P. (2005) Hurdle models of loan default. *Journal of the Operational Research Society*, 56(9): 1063-1071.

Moser, C. M. and Barrett, C. B. (2006) The complex dynamics of smallholder technology adoption: The case of SRI in Madagascar. *Agricultural Economics*, 35(3): 373-388.

Mukherjee, A. and Zhang, X. (2007) Rural industrialization in China and India: Role of policies and institutions. *World Development*, 35(10): 1621-1634.

Njong, A. M. and Ningaye, P. (2008) Characterizing weights in the measurement of multidimensional poverty: An application of data-driven approaches to Cameroonian data. OPHI Working Paper No. 21, University of Dschang, Cameroon.

Nkamleu, G. B. and Adesina, A. A. (2000) Determinants of chemical input use in peri-urban lowland systems: Bivariate probit analysis in Cameroon. *Agricultural Systems*, 63(2): 111-121.

Nkonya, E.; Schroeder, T. and Norman, D. (1997) Factors affecting adoption of improved maize seed and fertilizer in northern Tanzania. *Journal of Agricultural Economics*, 48(1-3): 1-12.

Nurkse, R. (1953) *Problems of Capital Formation in Underdeveloped Countries*. Oxford University Press, New York, US.

Oostendorp, R. H.; Trung, T. Q. and Tung, N. T. (2009) The changing role of non-farm household enterprises in Vietnam. *World Development*, 37(3): 632-644.

Pender, J. and Gebremedhin, B. (2004) 'Impacts of policies and technologies in dryland agriculture: Evidence from northern Ethiopia.' In: S. C. Rao (*Ed.*) *Challenges and Strategies for Dryland Agriculture*. American Society of Agronomy and Crop science, CSSA Special Publication 32, Madison, US.

Pender, J. and Gebremedhin, B. (2008) Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia. *Journal of African Economies*, 17(3): 395-450.

Perkins, D. H.; Radelet, S.; Snodgrass, D. R.; Gillis, M. and Roemer, M. (2001) *Economics of Development*, 5th *edition*. W.W. Norton & Company, New York, US.

Pretty, J. N.; Morison, J. L. and Hine, R. E. (2003) Reducing food poverty by increasing agricultural sustainability in developing countries. *Agriculture, Ecosystems and Environment*, 95(1): 217-234.

Ravallion, M. (2009) Are there lessons for Africa from China's success against poverty? *World Development*, 37(2): 303-313.

Reardon, T. (1997) Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Development*, 25(5): 735-747.

Reardon, T.; Berdegue, J. and Escobar, G. (2001) Rural nonfarm employment and incomes in Latin America: Overview and policy implications. *World Development*, 29(3): 395-409.

Renkow, M.; Hallstrom, D. G. and Karanja, D. D. (2004) Rural infrastructure, transaction costs and market participation in Kenya. *Journal of Development Economics*, 73(1): 349-367.

Renkow, M. (2006) 'Cities, towns and the rural nonfarm economy.' In: S. Haggblade; P. Hazell and T. Reardon (*Eds.*) *Transforming the Rural Nonfarm Economy*. Johns Hopkins University Press, Baltimore, US.

Rietveld, P. (1990) Infrastructure planning and rural development: Reflections on the urban functions approach. *International Regional Science Review*, 13(3): 249-255.

Rosenstein-Rodan, P. (1943) 'Problems of industrialization of eastern and southeastern Europe.' In: A. N. Agrawal and S. P. Singh (*Eds*.) *The Economics of Underdevelopment*. Oxford University Press, Bombay, India.

Royston, P. (1991) Lowess smoothing. *Stata Technical Bulletin*, STB-3: 7-9.

Ruben, R. and van den Berg, M. (2001) Nonfarm employment and poverty alleviation of rural farm households in Honduras. *World Development*, 29(3): 549-560.

Rogers, E. (1962) *Diffusion of Innovations*. Free Press of Glencoe, New York, US.

Sadoulet, E. and de Janvry, A. (1995) *Quantitative Development Policy Analysis*. Johns Hopkins University Press, Baltimore, US.

Satterthwaite, D. and Tacoli, C. (2003) The urban part of rural development: the role of small and intermediate urban centers in rural and regional development and poverty reduction. Working Paper Series on "Rural-Urban Interactions and Livelihood Strategies", Working Paper 9, International Institute for Environment and Development (IIED). http://www.worldbank.org/urban/urbanruralseminar/papers/urban-rural-dev-satt-tacoli.pdf (accessed on January 16, 2007)

Self, S. and Grabowski, R. (2007) Economic development and the role of agricultural technology. *Agricultural Economics*, 36(3): 395-404.

Shilpi, F. and Umali-Deininger, D. (2008) Market facilities and agricultural marketing: Evidence from Tamil Nadu, India. *Agricultural Economics*, 39(3): 281-294.

Singh, I.; Squire, L. and Strauss, J. (1986) 'The basic model: Theory, empirical results, and policy conclusions.' In: I. Singh; L. Squire and J. Strauss (*Eds.*) *Agricultural Household Models: Extensions, Applications and Policy*. Johns Hopkins University Press, Baltimore, US.

Start, D. (2001) The rise and fall of the rural non-farm economy: Poverty impacts and policy options. *Development Policy Review*, 19(4): 490-501.

Tacoli, C. (1998a) Bridging the divide: rural-urban interactions and livelihood strategies. Sustainable Agriculture and Rural Livelihoods Programme, Gatekeeper Series No. 77 International Institute for Environment and Development (IIED), London, UK. http://www.iied.org/pubs/pdf/full/6144IIED.pdf (accessed on April 1, 2007)

Tacoli, C. (1998b) Rural-urban interactions: A guide to the literature. *Environment and Urbanization*, 10(1): 147-166.

Tacoli, C. (2002) Changing rural-urban interactions in Sub-Saharan Africa and their impact on livelihoods: A summary. Working Paper Series on "Rural-Urban Interactions and Livelihood Strategies", Working Paper No. 7, International Institute for Environment and Development (IIED). http://www.iied.org/pubs/pdf/full/9153IIED.pdf (accessed on March 12, 2007)

Tacoli, C. (2003) The links between urban and rural development. *Environment and Urbanization*, 15(3): 3-12.

Tacoli, C. (2004) The role of small and intermediate urban centres and market towns and the value of regional approaches to rural poverty reduction policy. Prepared for the "OECD DAC POVNET: Agriculture and Pro-Poor Growth Task Team", 17-18 June 2004, Helsinki Workshop, Finland.

Taylor, J. E. and Adelman, I. (2003) Agricultural household models: Genesis, evolution and extensions. *Review of Economics of the Household*, 1(1): 33-58.

Tesfay, G. (2006) *Agriculture, Resource Management and Institutions: A Socioeconomic Analysis of Households in Tigray, Ethiopia*. PhD Thesis, Wageningen University, Wageningen, The Netherlands. http://edepot.wur.nl/24190 (accessed on October 11, 2011)

Tiffin, R. and Irz, X. (2006) Is agriculture the engine of growth? *Agricultural Economics*, 35(1): 75-89.

Todaro, M. P. and Smith, S. C. (2009) *Economic Development*, 10th *edition*. Prentice Hall, New York, US.

Train, K. E. (2009) *Discrete Choice Methods With Simulation*, 2nd *edition*. Cambridge University Press, New York, US.

Valdés, A. and Foster, W. (2010) Reflections on the role of agriculture in pro-poor growth. *World Development*, 38(10): 1362-1374.

Verbeek, M. (2008) *A Guide to Modern Econometrics*, 3rd *edition*. John Wiley & Sons, Ltd., Chichester, UK.

von Braun, J. (2008) 'Rural-urban linkages for growth, employment, and poverty reduction.' In: G. Alemu and E. Wale (*Eds*.) *Proceedings of the Fifth International Conference on the Ethiopian Economy*. Ethiopian Economic Association, Addis Ababa, Ethiopia.

Wandschneider, T. (2004) Small rural towns and local economic development: Evidence from two poor states in India. International Conference on Local Development, Session on "Bringing Rural and Urban Together for Local Development", 16-18 June 2004, Washington, D.C., US. http://www.nri.org/projects/reed/docs/wandschneider_2004_icld.pdf (accessed on April 1, 2007)

Weir, S. and Knight, J. (2004) Externality effects of education: dynamics of the adoption and diffusion of an innovation in rural Ethiopia. *Economic Development and Cultural Change*, 53(1): 93-113.

Woldehanna, T. (2000) *Economic Analysis and Policy Implications of Farm and Off-farm Employment: A Case Study in the Tigray Region of Northern Ethiopia*. PhD Thesis, Wageningen University, Wageningen, The Netherlands. http://edepot.wur.nl/121239 (accessed on October 11, 2011)

Wooldridge, J. M. (2002) *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, Cambridge, Massachusetts, US.

Xu, Z.; Guan, Z.; Jayne, T. S. and Black, R. (2009) Factors influencing the profitability of fertilizer use on maize in Zambia. *Agricultural Economics*, 40(4): 437-446.

Yen, S.; Jensen, H. and Wang, A. (1996) Cholesterol information and egg consumption in the US: A nonnormal and heteroscedastic double hurdle model. *European Review of Agricultural Economics*, 23(3): 343-356.

Yen, S. and Rosinski, J. (2008) On the marginal effects of variables in the log-transformed sample selection models. *Economics Letters*, 100(1): 4-8.

Recent literature places agricultural and rural development at the forefront of the development paradigm. This development agenda focuses not only on GDP growth but also poverty and income disparity reduction, household food security and environmental sustainability. To achieve this multidimensional goal, agricultural and rural development alone may not be sufficient. What is also important is the mutual influencing of the various sectors of the economic process: the forward and backward linkages that contribute to growth. Strong linkages between rural and urban areas are of crucial importance for taking advantage of forward and backward linkages.

In many rural areas of developing countries however, the necessary infrastructure and institutions are lacking. Town functions in developing countries are largely physical (roads, markets, schools, water supply systems, electricity, etc.) and create the linkages between rural areas and towns. The core of this thesis deals with a broad spectrum of town functions. The general objective of the thesis is to analyze and quantify the contribution that different town functions make to promoting household livelihood (economic) activities. The general objective is divided into five specific research questions:

1. What is the conceptual model for the contribution of major town functions to the economic activities of rural and urban households?
2. What is the effect of town functions on income from productive activities?
3. How do town functions and network relations influence (especially) rural household crop output marketing?
4. What is the influence of town functions and network relations on the adoption and use of fertilizer by (especially) rural households?
5. What is the role of town functions on the choice of households with regard to alternative employment opportunities?

Chapter one sets the background and presents the objectives for the thesis. Chapter two presents the conceptual framework of town functions. It starts by identifying and discussing the hierarchical classification and definition of settlements (rural towns and towns). Next, the so-called town functions are characterized and discussed in terms of their nature and diversity in towns and contribution to employment and income and input-output marketing. In the

process, this chapter elaborates and develops the research questions by discussing the way they are accounted in the empirical chapters.

Chapter three characterizes and describes the study areas. It also presents and discusses the two major datasets used in some detail and presents some preliminary statistics in relation to access to town functions. The Ethiopian Welfare Monitoring Survey (WMS) dataset from the regional state of Tigray was used in chapters 4 and 7 to investigate the role of town functions on income and the choice of alternative employment opportunities. The Ethiopian Rural Household Survey (ERHS) dataset from four major regional states of Ethiopia was used in chapters 5 and 6 to examine the influence of town functions on rural household crop marketing and fertilizer application.

Chapter 4 focuses on the contribution of town functions to boosting income from productive activities. In addition to total income from productive activities, three income categories are distinguished: (1) income from farming activities (excluding production for own consumption); (2) income from non-farm wage employment and (3) income from non-farm enterprises or non-farm small-scale enterprises. Using the Heckman models, whether or not income was generated or whether a specific activity was participated in is explained. The focus lies predominantly on the role played here by town functions. The data originates from rural and urban households from the Tigray region. The results show that total income and non-farm wage income increase in response to a reduction in distance to secondary schools, markets and roads. Moreover, each reduction in distance to markets, roads, transport services and telephone centers was found to contribute to higher farm income. Similarly, income from non-farm home-based enterprises was found to decrease with distance to market, roads and telephone services. These major town functions are instrumental in enabling households to access the market for their products (farm or home-based) on which income largely depend. Better access to such functions is therefore useful for increasing farm income and non-farm income from home-based enterprises.

In chapter 5, the contribution that town functions make to rural household crop output marketing is examined. The chapter takes into account the fact that town functions not only influence decision to take crop outputs to the market but also ability to participate. As a result, this phenomenon is explicitly modeled by estimating a Box-Cox double hurdle model for crop marketing. Major town functions and informal institutional elements such as household-specific networks and social capital were found to influence crop marketing by rural households. The evidence shows that it is not only road proximity that contributes positively to increased crop marketing but also the quality of the road. Well accessible roads do have a greater effect on promoting crop marketing than lower-grade roads. The results also suggest that if rural households are brought closer to markets, telephone centers and schools, their ability as well as decision to participate in crop marketing increases. Strong household networks help increase sales share while social capital make significant contribution to promoting crop marketing (in terms of enabling and increasing participation). While strong networks help rural households access market information faster and cheaper, strong social capital acts as the 'social fabric', which creates the necessary conducive environment that is useful for promoting crop output marketing.

Chapter 6 on the other hand focuses on examining the role of town functions in promoting fertilizer application. Following a similar approach to that of chapter 5, the empirical results indicates that major town functions such as markets, roads and telephone significantly contribute to enabling farm households to adopt fertilizer. On the one hand, shorter distances to roads and those with higher quality tend to positively influence adoption decisions. On the other hand, bringing markets, roads, schools, extension and agricultural cooperative centers closer encourages households to adopt fertilizer and increase intensification. The possession of strong network relations is also found to enable and encourage households to adopt fertilizer. The contribution of network relations is particularly emphasized in that it helps households relax technology-specific uncertainties and risk behaviors (as well as promoting learning), which eventually encourages fertilizer adoption and application.

In chapter 7, the relative effect of town functions on household choice of alternative employment opportunities is examined. First, four major employment opportunities were identified. These include farm employment (including farm wage employment), non-farm employment in household enterprises (including self-employment), non-farm wage employment and other non-farm employment opportunities. A multinomial logit model is then used to investigate the way town functions influence relative probabilities of employment. For estimation purposes, farm employment was considered as the base category (outcome). The empirical evidence shows that better access to schools, roads, markets and telephone centers (i.e., shorter distances) increases the likelihood of non-farm wage employment over farm employment. Shorter distances to markets, roads and telephone services also increase the relative probabilities of employment in non-farm home-based activities as compared to farm employment. Similarly, major functions such as electricity and tap water increase households' relative odds of obtaining non-farm jobs (both wage employment and home-based activities). These town functions are instrumental to the operations of home-based activities and formal firms that contribute largely to the non-farm employment opportunities. Chapter 7 also concludes with some quantitative interpretations.

In conclusion to this thesis, chapter 8 summarizes the most significant findings from each chapter. In addition, the discussion of the results focuses on the most important town functions and their effect on income, input-output marketing and employment. In general, the discussion emphasizes not only the importance of reducing the distances to important functions such as roads and markets, but also the improvements in quality of roads and the promotion of effective market information systems. This stimulates employment, market participation and, consequently, household incomes. The thesis provides the quantitative ingredients for the income side of the expansion of town functions. Attention is paid to the problem that arises due to the limited availability of data. Causal relationships prove more difficult to establish using cross-sectional data. However, town functions are in many cases – and certainly in a microanalysis as used here –to a great extent exogenous. A longitudinal analysis can be useful in such cases, but changes in town functions need to take place over an extremely long period, and during such a period, many variables (such as technology, institutes and social capital) will also change. For the time being, this thesis provides a good starting point for the planning of town functions in Ethiopian provinces.

Recente literatuur plaatst landbouw- en plattelandsontwikkeling hoog op de ontwikkelingsagenda. Deze agenda richt zich niet alleen op de groei van het Bruto Binnenlands Product (BBP) maar ook op vermindering van armoede en inkomensongelijkheid, voedselzekerheid van huishoudens, en ecologische duurzaamheid. Om deze meervoudige doelstelling te bereiken, zijn agrarische- en rurale ontwikkeling alléén niet voldoende. Het gaat ook om de wederzijdse beïnvloeding van de verschillende sectoren van het economisch proces: de voor- en achterwaartse activiteiten die bijdragen aan de groei. Sterke verbindingen tussen plattelands- en stedelijke gebieden zijn van cruciaal belang voor de benutting van voor- en achterwaartse verbanden.

In veel rurale gebieden van ontwikkelingslanden ontbreekt echter de benodigde infrastructuur - en ook instituties. Stedelijke functies in ontwikkelingslanden zijn grotendeels fysiek (wegen, markten, scholen, waterleiding, elektriciteit, etc.) en leggen de verbinding tussen platteland en stad. In dit proefschrift staat een breed spectrum van stedelijke functies centraal. Het doel van dit proefschrift ligt in analyseren en kwantificeren van de bijdrage die verschillende stedelijke functies leveren aan de economische activiteiten van huishoudens. De algemene doelstelling is opgesplitst in vijf specifieke onderzoeksvragen:

1. Wat is het conceptuele model voor de bijdrage van stedelijke functies aan de economische activiteiten van rurale en stedelijke huishoudens?
2. Wat is het effect van stedelijke functies op het inkomen uit productieve activiteiten?
3. Hoe beïnvloeden stedelijke functies en netwerkrelaties het vermarkten van plantaardige gewassen van (vooral) rurale huishoudens?
4. Welke invloed gaat er uit van stedelijke functies en netwerkrelaties op het toepassing en gebruik van kunstmest bij (vooral) rurale huishoudens?
5. Wat is de rol van stedelijke functies op de keuze van huishoudens voor alternatieve werkgelegenheid?

Hoofdstuk 1 schetst de achtergrond van het onderzoek, formuleert de onderzoekdoelstelling en geeft de hierboven genoemde onderzoekvragen. Hoofdstuk 2 presenteert het conceptuele kader van stedelijke functies. Het hoofdstuk begint met het identificeren en bespreken van de hiërarchische classificatie en definitie van verschillende stedelijke gebieden (rurale stadjes, steden en grote steden). Vervolgens worden de stedelijke functies gekenmerkt en besproken in termen van hun aard en diversiteit en hun bijdrage aan de werkgelegenheid, inkomen en input-output marketing. In dit hoofdstuk wordt verder ingegaan en op de onderzoeksvragen, die aan de orde komen in de empirische hoofdstukken.

Hoofdstuk 3 bevat een korte karakterisering van de onderzoeksgebieden. Tevens presenteert het hoofdstuk een tweetal grote datasets die zijn gebruikt en die gedetailleerde informatie bevatten over stedelijke functies. De dataset 'Ethiopische Welzijn Monitor' (WMS) betreft hier de regionale staat van Tigray en is gebruikt in de hoofdstukken 4 en 7 om de rol van stedelijke functies op inkomen en werkgelegenheid te onderzoeken. De dataset Ethiopische Rurale Huishoud Survey (ERHS) betreft data van vier grote regionale staten van Ethiopië en is gebruikt in de hoofdstukken 5 en 6 voor het onderzoeken van de invloed van stedelijke functies en netwerken op de vermarkting van gewassen en de toepassing en het gebruik van kunstmest.

Hoofdstuk 4 richt zich op de bijdrage van stedelijke functies aan het inkomen van productieve activiteiten. Naast het totale inkomen uit productieve activiteiten worden drie inkomenscategorieën zijn onderscheiden: (1) inkomen uit agrarische activiteiten (waarbij productie voor eigen consumptie buiten beschouwing blijft); (2) loon voor werk buiten de landbouw en (3) inkomen van niet-agrarische bedrijfjes of ondernemingen, die veelal vanuit de woonplek worden gedreven. Met behulp van Heckman modellen wordt in twee stappen eerst het al of niet genereren van inkomen of de participatie in een bepaalde activiteit verklaard en vervolgens het betreffende inkomen. De belangrijkste interesse gaat uit naar de wijze waarop stedelijke functies dit beïnvloeden. De gegevens zijn ontleend aan plattelands- en stedelijke huishoudens in Tigray. Uit de resultaten blijkt dat het totale inkomen en het loon voor werk buiten de landbouw toeneemt bij een vermindering van de afstand tot wegen, markten en middelbare scholen. Bovendien, gaat een vermindering van de afstand tot de markten, wegen, vervoerdiensten en telefoon centra gepaard met een hoger landbouwinkomen. Inkomsten uit niet-agrarische bedrijfjes of ondernemingen bleek evenzo hoger bij een geringere afstand tot de markten, wegen en telefoondiensten. Deze belangrijke stedelijke functies zijn instrumenteel in het realiseren van de afzet en daarmee het inkomen van dit type bedrijvigheid. De resultaten zijn niet alleen afhankelijk van afstand, maar bij sommige functies ook van de kwaliteit. Relaties zijn kwantitatief gemaakt middels marginale effecten van afstand, of van het al of niet aanwezig zijn van stedelijke functies. Weergave via bijvoorbeeld elasticiteiten vergemakkelijkt te interpretatie.

In hoofdstuk 5 wordt de bijdrage van stedelijke functies aan het vermarkten van gewassen onderzocht. Het gehanteerde model en de analyse houdt niet alleen rekening met het feit dat de stedelijke functies de *beslissing beïnvloeden* om gewassen te vermarkten, maar ook met de *mogelijkheid* om naar de markt te gaan. Dit is expliciet gemodelleerd met behulp van een 'Box-Cox double hurdle model', in dit geval toegepast op het vermarkten van gewassen, waarbij dus de data van de ERHS zijn gebruikt. Belangrijke stedelijke functies en informele instituties zoals specifieke netwerken en sociaal kapitaal waarin huishoudens functioneren, bleken positief bij te dragen aan het vermarkten van gewassen door rurale huishoudens. Niet alleen de aanwezigheid van een weg op enige afstand, maar ook de kwaliteit van weg draagt daaraan bij. De resultaten geven aan dat huishoudens op het platteland, die zich op geringere afstand bevinden van markten, telefooncentra en scholen, eerder *in staat zijn* om gewassen te vermarkten en ook eerder het *besluit* nemen om dat te doen. Terwijl sterke netwerken van rurale huishoudens de toegang tot marktinformatie sneller en goedkoper maken, fungeert meer sociaal kapitaal als 'sociale structuur' die nuttig is voor met vermarkten van gewassen. De resultaten worden zoveel mogelijk kwantitatief weergegeven en ook van relativerende opmerkingen voorzien omdat bij cross-sectie data oorzaak en gevolg nu eenmaal moeilijk zijn vast te stellen.

Hoofdstuk 6 gebruikt dezelfde methodologie en data als hoofdstuk 5, maar richt zich nu op de keuze om kunstmest te gebruiken alsmede op de omvang van dit gebruik. De rol van stedelijke functies staat daarbij weer centraal in de analyse. De empirische resultaten laten zien dat belangrijke stedelijke functies zoals markten, wegen en telefoon, aanzienlijk bijdragen tot de mogelijkheid van huishoudens in de landbouw om kunstmest te gaan gebruiken. Kortere afstanden tot wegen en wegen van hogere kwaliteit dragen positief bij aan de beslissing kunstmest te gebruiken. Geringere afstanden tot markten, wegen, scholen, voorlichting en coöperatieve centra, gaat gepaard met meer kunstmestgebruik. Het bezit van sterke netwerkbanden stimuleert huishoudens in de omvang van het kunstmestgebruik. De bijdrage van netwerkbanden wordt met name benadrukt omdat de aanwezigheid van een netwerk de gevolgen van onzekerheden en van risicomijdend gedrag (evenals scholing) positief kan beïnvloeden. Resultaten zijn kwantitatief en inzichtelijke weergegeven.

In hoofdstuk 7, wordt het relatieve effect van stedelijke functies op de huishoudelijke keuzes voor alternatieve werkgelegenheid onderzocht, waarbij – evenals in hoofdstuk 4 - de WMS dataset voor Tigray is gebruikt. Vier alternatieve vormen van werkgelegenheid zijn geïdentificeerd: agrarische werkgelegenheid (zowel op het eigen bedrijf als in loondienst bij andere agrarische bedrijven), niet-agrarische werkgelegenheid in huishoudelijke ondernemingen (waaronder zelfstandige arbeid), loon van de niet-agrarische werkgelegenheid en andere niet-agrarische werkgelegenheidsalternatieven. De laatste categorie is weinig homogeen en blijft in de empirische analyse buiten beschouwing. Gebruik makend van een multinomial logit-model (met agrarische werkgelegenheid als de basiscategorie) wordt vervolgens geanalyseerd hoe stedelijke functies de relatieve waarschijnlijkheid beïnvloeden om te participeren in een werkgelegenheidscategorie. De resultaten van het empirisch onderzoek geven aan dat een betere toegang (d.w.z. geringere afstanden) tot scholen, wegen, markten en telefoon centra de waarschijnlijkheid verhoogt van niet-agrarische werkgelegenheid ten opzichte van agrarische werkgelegenheid. Kortere afstanden tot markten, wegen en telefoondiensten verhogen ook de relatieve waarschijnlijkheid van werkgelegenheid in niet-agrarische en huis-gebaseerde activiteiten ten opzichte van agrarische werkgelegenheid. Belangrijke functies zoals elektriciteit en leidingwater verhogen voor huishoudens relatieve kans op het verkrijgen van niet-agrarische banen of werkgelegenheid in zelfstandige activiteiten. Deze stedelijke functies zijn dus instrumenteel in het bevorderen van niet-agrarische werkgelegenheid. Ook in hoofdstuk 7 is de analyse afgesloten met kwantitatieve interpretaties.

Het slothoofdstuk van dit proefschrift (hoofdstuk 8) bevat de belangrijkste empirische resultaten van elk hoofdstuk. Bovendien, wordt in de bespreking van de resultaten de nadruk gelegd op de belangrijkste stedelijke functies en hun effect op inkomen, input-output marketing en werkgelegenheid. In het algemeen benadrukt de discussie niet alleen het belang van een vermindering van de afstand tot belangrijke functies zoals wegen en markten, maar ook verbetering van de kwaliteit van wegen en het bevorderen van doeltreffende marktinformatiesystemen. Dit bevordert werkgelegenheid, marktparticipatie en daarmee het inkomen van huishoudens. Het proefschrift levert de kwantitatieve ingrediënten voor de opbrengstenkant van het uitbreiden van stedelijke functies. Daarbij wordt aandacht besteed aan de problematiek die voortvloeit uit de beperkte beschikbaarheid van data. Oorzakelijke verbanden zijn moeilijker vast te stellen met behulp van cross-sectie data. Anderzijds zijn – zeker in een microanalyse zoals hier gebruikt – stedelijke functies in vele gevallen in hoge mate exogeen. Een longitudinale analyse kan hierbij behulpzaam zijn, maar dient zich voor veranderingen van stedelijke functies over een zeer lange termijn uit te strekken en over zo'n lange periode veranderen ook vele andere variabelen (zoals technologie, instituties, sociaal kapitaal). Voorlopig biedt dit proefschrift een uitgangspunt voor de planning van stedelijke functies in Ethiopische provincies.

Wageningen School of Social Sciences

Description	Department/Institute	Year	ECTS*
Courses:			
Mansholt introduction course	Mansholt Graduate School	2007	1.5
Techniques for writing and presenting scientific paper	Wageningen Graduate Schools	2007	1.2
Advanced econometrics	AEP/NAKE	2005	6
Discrete choice modeling	Mansholt Graduate School	2007	1.5
Panel data analyses in theory and practice	Mansholt Graduate School	2007	1.5
Spatial econometrics	Wageningen School of Social Sciences	2011	1.5
Economic models	AEP	2007	6
Rural economic analysis	AEP	2007	6
New institutional economics: Governance of transactions, incomplete contracts, and bargaining	Mansholt Graduate School	2007	4
PhD proposal development	AEP	2007	6
Presentation at conferences and workshops:			
WASS Multidisciplinary Seminar: PhD Day 'Challenges of multidisciplinary research'		2011	1
8th International Conference on the Ethiopian Economy, Addis Ababa: Ethiopia		2010	1
Second AGRIMBA-AVA Congress 2011 on 'Dynamics of international cooperation in rural development and agribusiness', Wageningen: the Netherlands		2011	1
Total (minimum 30 ECTS)			38.2

*1 ECTS is on average equal to 28 hours of course work.

Tewodros Tadesse was born on August 21 1980 in the town of Maichew, northern Ethiopia. He went to school in his home town; and upon completing high school he joined the then Mekelle Business College (now, Mekelle University) in September 1998. In Mekelle University, he studied Economics and obtained his Bachelor degree in July 2003. In August 2003, he joined the department of Natural Resources Economics and Management, (NREM), Mekelle University as a Graduate Assistant. As part of the capacity development program by MU-LIAC project, he studied *Economics, Environment and Policy* between 2004-2006 at the Environmental Economics and Natural Resources (ENR) Group, Wageningen University. As a requirement for the MSc degree in Economics, Environment and Policy, he wrote a thesis on the economics of household behavior in solid waste management. Based on this, he published two articles in *Waste Management* (2008) and *Resources, Conservation and Recycling* (2009).

Starting January 2007, he was appointed as a PhD researcher at the Agricultural Economics and Rural Policy (AEP) Group, Wageningen University. His PhD research largely focused on the contribution that rural towns and towns make to welfare improvement in rural areas. During the period of his appointment as a PhD candidate, he has successfully completed the training and supervision plan (TSP) of Wageningen School of Social Sciences (WASS). In this period, he was also actively involved in collaborative research, teaching, training and capacity development and supervision of graduate (albeit informally) and undergraduate students in his home institution, Mekelle University.

Tewodros lives in Mekelle and currently works both as a teaching and research faculty at Mekelle University, Ethiopia.

Funding

The research described in this thesis was financially supported by Wageningen University, International Foundation for Science (grant no. AS/20381, Ref. no. S/4801-1) and the Netherlands Fellowship Program (NFP).

Cover page

Theme: two gears portraying interlinked rural and urban economies whereby the transport infrastructure, represented by the gears themselves, harnessing the linkage, and electricity denoted by the shining lights powering the local economy.

Design: Ridderprint BV, Pottenbakkerstraat 15-17 2984 AX: Ridderkerk, The Netherlands