Supply Response and Market Imperfections: the Implications for Welfare Analysis

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Declaration

I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree.

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Summary

In this thesis we investigate the supply side of farm households in the Tanzanian region of Kagera and incorporate the results into a welfare analysis of price shocks and trade policy options. The first chapter discusses the relevance of agriculture as an engine of growth and poverty reduction and introduces the context and the data used for the empirical analysis. The second chapter tests for separability of the households demand and supply sides and then estimates supply functions for the main crops. We find that separability cannot be rejected for this sample and that farmers are only partially responsive to price incentives. The third chapter analyses the role of market participation decisions and transaction costs for food supply. We find that transaction costs play an important role in households supply decisions. Moreover, we show that there is a positive although small supply response to prices once controlling for the unresponsiveness of self-sufficient households. The fourth chapter extends the standard welfare impact analysis of price shocks to incorporate supply and demand responses as well as the role of market participation and transaction costs. We find that the results are sensitive to the introduction of households' output, wage and consumption responses.

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Acronyms

AIDS Almost Ideal Demand System

CGE Computable General Equilibrium

FIML Full Information Maximum Likelihood

FOC First Order Condition

FTC Fixed Transaction Cost

GDP Gross Domestic Product

IFI International Financial Institution

KHDS Kagera Health and Development Survey

MSL Maximum Simulated Likelihood

NBS National Bureau of Statistics

NLSUR Non-Linear Seemingly Unrelated Regressions

OLS Ordinary Least Square

PSU Primary Sampling Unit

PTC Proportional Transaction Cost

SSA Sub-Saharan Africa

SUR Seemingly Unrelated Regressions

TCMB Tanzania Coffee Marketing Board

TZS Tanzanian Shilling

Introduction

This thesis analyses the production decisions of rural households in the Tanzanian region of Kagera. The main aim of the study is to improve our understanding and provide new empirical evidence on how households' supply decisions are formed in a context potentially characterized by the presence of market imperfections. The results of this analysis are then applied to develop a more comprehensive framework to assess the welfare impact of price shocks.

The main motivation behind the study derives from the realization that the literature on the impact of price shocks on household welfare has not focused sufficiently on the supply side of the story when dealing with rural agricultural-based contexts. While the literatures on both households' decisions on the one hand and on the welfare impact of different kind of shocks and policies on the other hand are extended and long dated the two are not often integrated. This thesis is intended to progress this integration.

The first chapter is an introductory chapter that reviews the literature on the role of agriculture in the development process. It puts the subsequent chapters into a broad context which sees agriculture and rural development as an important part of a sustainable growth strategy. In this introductory chapter we also describe the main characteristics of the region that is the focus of the empirical analysis and describe the dataset used in the analysis.

In the second chapter we start the empirical analysis by looking at the role that market imperfection have in shaping households' responsiveness to price and non-price factors. We analyse farmers' supply response to price and non-price factors and test for the separability of the households' demand and supply side. Our contribution lies in the adaptation of the previous techniques used to test for separability and in the estimation of supply responses using a panel dataset which permits controlling for households' unobserved heterogeneity. We can thus obtain more robust and accurate estimates than previous studies which rely on cross-sectional data. We find that separability is rejected for our sample and that households have a low response to prices in particular for food crops.

In the third chapter we analyse the interactions between transaction costs, market participation and supply response using a more complex model. In fact, one of the objections to the model estimated in chapter two is that transaction costs affect market participation as well as supply decisions. A framework that incorporates these decisions is needed to estimate the impact of transaction costs and to obtain unbiased estimates of the households' responsiveness to prices. Our main contribution is the development of a switching regression model for panel data which jointly estimates the market participation and the supply equations taking into account unobserved heterogeneity. We develop a Stata routine to implement the model using maximum simulated likelihood techniques. We find that contrary to the model of chapter two transaction costs do play an important role in shaping food supply decisions. We also obtain unbiased estimates of the supply response and find that once controlling for market participation the price elasticity is higher.

In the fourth chapter we incorporate the results obtained in the previous chapters into a framework to assess the impact of hypothetical price shocks and trade reforms on households' welfare. We start from the standard first-order welfare analysis and then incorporate supply, demand and wage elasticities to obtain a full-model estimate of the impact of different shocks. Having estimated two different models of supply response we can compare the results using the “wrong” model of chapter two and the “right” model of chapter three which accounts for different regimes of market participation. We find that higher food prices have on average a positive impact on households in the Kagera region despite the fact that most of them are net-buyers of food.

Chapter 1

Rural development and the Kagera region

1.1 Introduction

In this introductory chapter we set the stage for the main analysis developed in the following chapters. We first review some of the literature on the role of agriculture in economic development and then introduce the region of Tanzania which will be the focus for the empirical analysis of this thesis. We then present the main characteristics of the dataset we use and derive some descriptive statistics of the main trends of welfare and agriculture coming out from the data.

1.2 The role of agriculture in economic development

The role that agriculture has in the process of economic development has been an important part of the development debate since economists noted long time ago that a common characteristic of higher income economies is that the share of output coming from agriculture and the primary sector is smaller than in low income economies. They further noticed that the process of economic growth is accompanied by a steady reduction in the importance of agriculture relative to manufacturing and services both in terms of the share of output and labour employed.

One of the first economists to point this out was G. B. Fisher (1939). Later, this same generalization was formalized by Kuznets (1955) who showed that this secular decline of the primary sector with development can be observed both across countries and across time. Today there are few doubts about the fact that the achievement of a structural transformation that increases the weight of manufacturing and services in the economy is at the heart of any process of economic development. What is still debated is how this transformation actually starts and which the driving forces behind it are.

A second important consideration made by several authors is that almost all previous successful experiences of economic development show that a strong increase in agricultural productivity preceded a structural transformation of the economy.

The role of increased agricultural productivity in preceding the process of industrialization and economic growth has been documented by several authors in the early experience of England before the industrial revolution (Allen 1999), for the US, for Korea and other Asian countries, and more recently for fast growing countries like China (Huang et al 2008). Johnston and Mellor (1961) were among the first to notice that successful industrialization experiences are usually preceded by periods of strong agricultural growth. Although they did not attempt to establish a causal link, the authors observed that countries that embark in a successful industrialization path, first experience fast agricultural expansion, fueled not by absorbing resources from the rest of the economy, but by rapid increases in productivity. Japan in the early 20th century is taken as evidence of this relationship. Many others have mentioned this feature of development for China, with fast industrialization preceded by fast productivity growth in the agricultural sector, i.e. the “green revolution”.

The "Dual model"

These conclusions, while important on their own, do not tell us much about the factors that cause this transformation process and about the relative role of each sector's growth. Is growth in the agricultural sector which generates surplus that is then invested in the infant manufacturing sector? Or is growth in the non-agricultural sector which "pulls" agricultural growth? These are still central questions in the current development debate.

Economists' views on this respect differ. Some argue that the evidence is in favor of the agriculture-led growth others disagree. Thus, the theoretical debate has long focused on building models able to explain how an increase in agricultural productivity can spread into the rest of the economy and facilitate growth in the non-agricultural sector. Different authors have derived economic models showing the importance of agriculture in the early stages of development.

One of the first analyses of the role of the agricultural sector in the process of economic development and the strong interrelationship between agricultural and industrial development was proposed by Lewis (1954). He introduced a dual sector model characterized by the presence of an infant modern capitalist sector together with a predominant traditional subsistence sector.

The key assumption of the model lies in the existence of an unlimited supply of labour in the subsistence sector at the existing wage. The source of this unlimited supply of labour is, according to Lewis, to be found mainly in the predominant agricultural sector but also in the casual workers, the petty traders, and women working in the household and is reinforced by high population growth. Lewis argues that at an early stage of development these workers have a very low marginal productivity (*"negligible, zero, or* *even negative"*) and can be moved to a different activity without reducing output in the subsistence sector.

The capitalist sector instead is characterized by the use of capital in the production process in exchange for profits. This sector is assumed to maximize profits in line with the neo-classical assumptions and thus employs labour only up to the point where the wage equals the marginal productivity. The wage level in the capitalist sector is in turn determined by what people in the subsistence sector can earn which in an economy with a majority of people involved in subsistence agriculture is the average product of the farmer plus a premium to cover the costs of transfer into the capitalist sector.

Because of the unlimited supply of labour in the subsistence sector the capitalist sector can expand by absorbing workers from the subsistence sector without this exerting any upward pressure on the wage level. At the same time capitalists reinvest profits in expanding the productive capital in the economy. This in turn increases the marginal productivity of labour and permits the expansion of the amount of workers in the capitalist sector while increasing profits of capitalists that are then reinvested in acquiring more capital. This process of transformation goes on until the supply of labour is not so abundant anymore and the economy enters a higher stage of development, a turning point often referred as the "Lewis turning point" where the supply of labour ceases to be unlimited.

There is a key point that Lewis discusses concerning the strict relationship that links agriculture and industrial development. In fact, the process described above can come to an early end if the rising capitalist sector is forced to pay higher wages. This can happen if the terms of trade turn against the capital sector or if the subsistence sector raises its productivity.

Assuming that the capitalist sector will mainly specialize in non-agricultural goods while the subsistence sector will produce food, the expansion of the capitalist sector will increase the demand for food and put upward pressure on food prices. The terms of trade will tend to worsen for the capitalist sector . In this sense simultaneous growth in agriculture is needed for the capitalist sector to expand at least in the essentially closed economy discussed by Lewis.

" ..it is not profitable to produce a growing volume of manufactures unless agricultural production is growing simultaneously. This is also why industrial and agrarian revolutions always go together, and why economies in which agriculture is stagnant do not show industrial development." (Lewis, 1954 p. 20)

On the other end, if the subsistence sector increases its productivity real wages will tend to rise. To avoid an increase in real wages increasing productivity in the subsistence sector needs to be counterbalanced by a reduction in food prices relative to the price of the capitalist goods. The increase in productivity has to be faster than the increase in demand for food.

Johnston and Mellor (1961) building on Lewis' two sector model identify five key areas where agricultural output and productivity can contribute to overall economic development. The first is providing increased food supplies to keep pace to the increasing demand for food caused by population growth and per-capita income growth. As pointed out in Lewis model a failure to expand food output in a context of growing food demand will result in increasing food prices leading to higher wages. This will have adverse effects on industrial profits, investments and economic growth. Covering domestic food needs with an expansion of imports would not solve the problem for countries where foreign exchange is usually in short supply and essential for imports of commodities instrumental to the industrial sector.

The second important contribution is the transfer of labour from agriculture to the non-agriculture sector, a key factor in Lewis model. The third is the contribution of agriculture to capital formation. In particular during the early stage of development when the capitalist sector is still small but there is a growing need of capital to create new industries and investments in key public goods as infrastructure and education, the agricultural sector represents the only source of capital. Raising agricultural productivity is thus a crucial component as crucial is that only a fraction of this increase is transformed in higher consumption levels of the farm population while the rest is used to finance capital formation in the capitalist sector. The fourth contribution is the expansion of agricultural exports to increase income and foreign exchange. Finally, the rural sector can provide an outlet for industrial products. This last point was not emphasized by Lewis as his model assumed that the expansion of the capitalist sector is limited only by shortage of capital. However, demand conditions are likely to influence significantly investments decisions. On this point there seems to be a contradiction between the requirement to the agricultural sector to contribute substantially to capital formation and the need to increase its purchasing power to absorb goods produced by the industrial sector.

The dual sector model has been discussed and extended by several authors (Jorgensen 1961, Fei and Renis 1961, Schultz 1964 among others) and still represents an influential model for the analysis of economies were traditional agriculture is predominant and coexists with and infant manufacturing sector. The key message of these analyses is that growth in the agricultural sector and its transformation is complimentary if not a precursor of growth in other sectors of the economy.

However, opposite conclusions have been reached by other schools of thought who were at best skeptical about the role of agriculture in the process of economic development. Agriculture had a marginal role in the influential development strategy proposed by Rosenstein-Rodan (1943) for eastern and south-eastern Europe after the Second World War. He focused almost exclusively on the need to boost industrialization to absorb the *"disguised unemployment"* in the agricultural sector and achieve a higher growth rate. He argues that at an early stage of development industrialization is hindered by a complementarity problem which makes investments in a single industry alone unprofitable. The best way to speed-up the industrialization process is by a big investment, the "big push", which creates simultaneously several different industries and exploits the external economies generated.

"The industries producing the bulk of the wage goods can therefore be said to be complementary. The planned creation of such a complementary system reduces the risk of not being able to sell, and, since risk can be considered as cost, it reduces costs. It is in this sense a special case of "external economies." [Rosenstein-Rodan (1943), p. 206]

There is very little role for agriculture in this development strategy which instead focuses almost exclusively on a coordinated effort to invest in manufacture to boost industrialization. The implicit assumption is that the manufacturing sector is the main driver of economic growth which will then eventually spill-over to the agricultural sector.

While opposing Rosenstein-Rodan "big-push" argument Hirschman (1958) remains skeptical about the role of agriculture in the development process. Hirschman advised promoting the growth of the sector with the greater capacity to pull the rest of the economy. The production backward linkages, that is the links that one sector has with the rest of the economy as a purchaser of inputs is central in his argument. If a sector with high backward linkages expands, the rest of the economy will consequently experience a larger expansion, as it sells the inputs needed for growth in the main sector.

Hirschman analyzed the input-output matrices of Italy, United States and Japan and showed that agriculture has important forward linkages, but very low backward linkages.

"Agriculture certainly stands convicted on the count of its lack of direct stimulus to the setting up of new activities through linkage effects: the superiority of manufacturing in this respect is crushing". [Hirschman (1958), pp. 109-110]

Prebisch (1950) and Singer (1950) argued that a development strategy focused on producing and exporting primary commodities would have resulted in a failure. They argued that the income elasticity of demand for these commodities was lower than one as opposed to the demand elasticity of the industrial goods produced by the developed countries that have income demand elasticity that is not less than unity. As a consequence of this elasticity differential in the long run the terms of trade of developing countries specializing in exporting primary commodities would have fall.

A predominant interpretation of the dual-sector model focused on the extraction of surplus from agriculture and on its forced contribution to the main objective of a rapid industrialization process prevailed in the development policies for long time (Timmer 1988). The emphasis posed by early economists on the importance of a growing agricultural sector was overlooked. This contributed to generate that "anti-agricultural bias" documented by Krueger et al. (1988).

Extensions of the "Dual model" and the current debate

More recently models of structural transformation have been extended first to avoid the assumption of a non-clearing labour market and then to include the role of demand factors and international trade that had a marginal role in the early models.

Eswaran and Kotwal (1993) develop a theoretical model which retains the dual sector assumption which characterizes Lewis' model but drops the controversial assumption about the existence of labour surplus assuming instead a neo-classical clearing labour market. The key insight of their model is about the role domestic demand plays in the development process. They postulate hierarchic demand schedule in which agents demand food with decreasing income elasticity and only demand manufacture goods after a certain income threshold has been reached. Workers at an early stage of development are assumed to be below this income ceiling and thus only consume food. Landowners instead live above the threshold and demand also manufacture goods. The model shows that if the economy is closed and no trade occurs an increase in productivity in the manufacturing sector which reduces the relative price of manufacture goods does not benefit workers as they do not consume manufacture goods. It benefits only landlords. Demand is thus a serious constraint to growth of the manufacturing sector. Instead, an increase in productivity in the agricultural sector would benefit workers and landlord. Furthermore, as agricultural productivity keeps growing first landlords and then workers will pass the income ceiling and start consuming manufacture goods as well as food giving rise to the emergence of a manufacturing sector. This finding highlights the importance of agricultural productivity:

“This simple observation – that agricultural productivity must be sufficiently high before a demand for industrial goods manifests - underlines the importance of agriculture in the process of industrialization.” [Eswaran and Kotwal 1993, p.252]

A further key insight of Eswaran and Kotwal model is the comparison of the previous results with the ones obtained dropping the closed economy assumption. In an open economy were the developing country can export goods to a developed country an increase in productivity in the manufacturing sector brings an increase in workers’ real wages and a welfare improvement. The demand constraint which in a closed economy prevented manufacturing growth from filtering down to the entire economy is removed if the country can export its products. Trade has a very important role in their model given that the developing country is able to increase productivity faster than its trade partners. The consequence is that the role of agriculture in an export oriented strategy, like the one followed by Taiwan and Korea for example, is less clear-cut. Opening up the economy removes the dependence on agricultural growth for wide economic growth and poverty reduction. Higher productivity growth in any sector can be an engine of growth and development.

More recently Dercon (2009) and Collier and Dercon (2009) building on the basic insight of the Eswaran and Kotwal model have criticized the mainstream paradigm that growth in today’s Africa has to come from improvement in agriculture. This view in fact, after being neglected for many years, has come back as the main focus of policy makers (World Bank, 2008) and economists (Sachs 2005, Staatz and Dembele 2007) advocating for a green revolution for Africa. Collier and Dercon argue that in light of the trend toward openness and market reforms in Africa the necessity to focus on agriculture as the main engine of growth lacks a sound theoretical basis. They advocate for a wider range of strategies depending of the specific characteristic of each country. They distinguish between resource-rich countries, coastal and well-located countries and landlocked resource-poor countries. For the first group managing revenues from resource exploitation is going to be the key factor determining their success. They should be able to diversify their economic activities and in this sense investment in agriculture and rural areas can be an important strategy but it is unlikely that agriculture can be considered the main engine of growth for these countries. For coastal and well located countries the key challenge is going to be integration with the rest of the world to take advantage of their location. They are open economies and can take advantage of trade opportunities by removing the institutional and infrastructural constraints that prevent their manufacturing sector to take advantage of globalization. As predicted by Eswaran and Kotwal model an exclusive focus on an agricultural-led growth strategy is not necessarily the best strategy for these countries. Finally, landlocked and resource-poor countries which for their position can be considered as closed economies are the ones which correspond to the classical dual-sector models were agriculture growth can be the engine of development.

Some empirical work has also been undertaken to test the causality direction from higher agricultural productivity to growth in the other sectors of the economy. Tiffin and Irz (2006) test empirically the direction of causality between agricultural value added per worker and GDP per capita on a panel of 85 countries using a Granger causality test and find that for developing countries agricultural value added is the causal variable driving overall economic growth. Gardner (2000) instead concludes that growth in the non-farm sector is the most important factor explaining US farm income growth while agricultural specific variables play a marginal role.

Today's challenges in SSA

The previous discussion highlights the importance that a clear understanding of the role of agriculture and its interactions with the urban economy and the non-farm sector has for today's developing countries in particular in Sub-Saharan Africa. Should these countries direct their efforts in increasing agricultural productivity or should they focus more in the non-agricultural urban sector?

Today in most sub-Saharan African countries agriculture still suffers from low productivity, low investment in capital and technology, low commercialization and a high degree of subsistence farming. The current prevalent policy stance is mainly summarized by the last World Development Report to be dedicated to agriculture in 2008. This report advocates for an agricultural led growth strategy for most of developing countries and for SSA in particular. The emphasis is posed on the need for more public investments in agriculture and the rural sector and on the key role of smallholders in driving the change towards a more sustainable and competitive agricultural sector.

An exclusive focus of the debate on the direction of causality between agricultural and manufacture growth seems to be unsatisfactory. In fact, this exclusive focus overlooks what is the main insight of all the dual sector models that independently of whether agriculture is the engine of growth or not, the interaction between the two sectors of the economy is the main dynamic force of any development process. The key challenges remain to increase production and income in rural areas and to integrate the vast rural population into the rest of the economy. In this sense removing barriers to trade, favoring market exchange, improving connections between the rural and urban economy and between the domestic and international markets appear as important aspects of a development policy.

During the nineties development economists and IFIs have identified internal and external market liberalization as the key instrument to achieve this transformation. Restoring the right price signals to farmers would have increased allocative efficiency, eliminated distortions and given the right incentive to boost productivity, commercialization, output and rural incomes. Countries embarked in a profound transformation of the agricultural policy by dismantling or severely reducing the role of state control into food and export crop markets. This entailed the elimination of state marketing boards' monopoly in purchasing, transporting, processing and exporting crops. Pan-territorial fixed prices were abolished and private traders were allowed to freely purchase crops from farmers at the ongoing market price. Input subsidies in the form of credit, fertilizers and seeds provision were abolished as well as consumer price subsidies. Also the implicit anti-agriculture bias implied by overvalued exchange rates was addressed by a wave of currency devaluations.

However, this liberalization wave, which in great part was unavoidable given the collapse and the excessive distortion generated by the previous state monopolistic system, seems to have failed in generating that agricultural transformation needed.

Rural poverty is still high and rural incomes have stagnated. Yields are still very low compared to other regions in the world. Input use, a key factor to increase yields, has actually decreased after the elimination of input subsidies.

One important trend seems to be the increase in diversification of income generating activities (Bryceson 1999). Households have been shown in various studies to have increased reliance on non-farm activities to generate income (Davis et al 2010). This trend can be positive if it signals the opening of new income opportunities and new markets where comparative advantages can be exploited. But diversification can be also negative as it reduces the gains from specialization and can negatively affect productivity and growth in agriculture. If the trend of increasing diversification is households' reaction to increased risk and lack of infrastructure it has to be seen with concern and the reasons behind it need to be addressed.

In light of the importance that agriculture and the rural economy have for development we analyse in this thesis some critical aspects of the rural markets in the Tanzanian region of Kagera. We focus mainly on the production side of the household and its interaction with local market conditions. We analyse what factors can promote higher farmers' production and give rise to a more market oriented agriculture. In particular we will look at the role of market imperfection in the form of high transaction costs. We then incorporate the findings of this analysis in the assessment of the impact that price shocks and trade policies have on income and welfare of the rural population.

We have discussed the importance that increased productivity in agriculture can have for economic growth and poverty reduction. However, we will not focus directly on productivity as measuring productivity requires an amount of information not available in our dataset. We will instead focus on farm output as the key variable for our analysis. However, if productivity is loosely interpreted as output per unit of land, factors that increase output can be considered to increase productivity as well.

1.3 The Kagera region

Kagera region is located in the extreme north-western part of Tanzania. The region lies just below the Equator and has a common border with Uganda to the north and Rwanda and Burundi to the west. The region's large water area of Lake Victoria provides the border to the east (Figure 1.1).

Kagera region covers a total area of 40,838 square kilometers of which 11,885 square kilometers is covered by water bodies. The region is divided into six administrative districts namely Biharamulo, Ngara, Muleba, Karagwe, Bukoba Rural and Bukoba Urban. Bukoba is the regional capital and major business town.

Kagera region is among the five most populated regions in the country and had the lowest per capita GDP among all Tanzania's regions in 2001. The region had a population of 2,033,888 in 2002 about 6.0 percent of the total Tanzania Mainland population. Population density is estimated at 71 persons per square kilometer.

Kagera is a predominantly rural region with 94% of the population living in rural areas compared to an average of 70% in the all Tanzania according to the 2002 population census. The agricultural sector is the dominant productive activity accounting for about 50 per cent of the region's GDP. Around 90% of the region's economically active population is engaged in the production of food and cash crops. Livestock is the second most important economic activity in the region while fishing provides employment for people along the lakeshore. The industrial base in the region is mainly limited to some coffee processing plants.

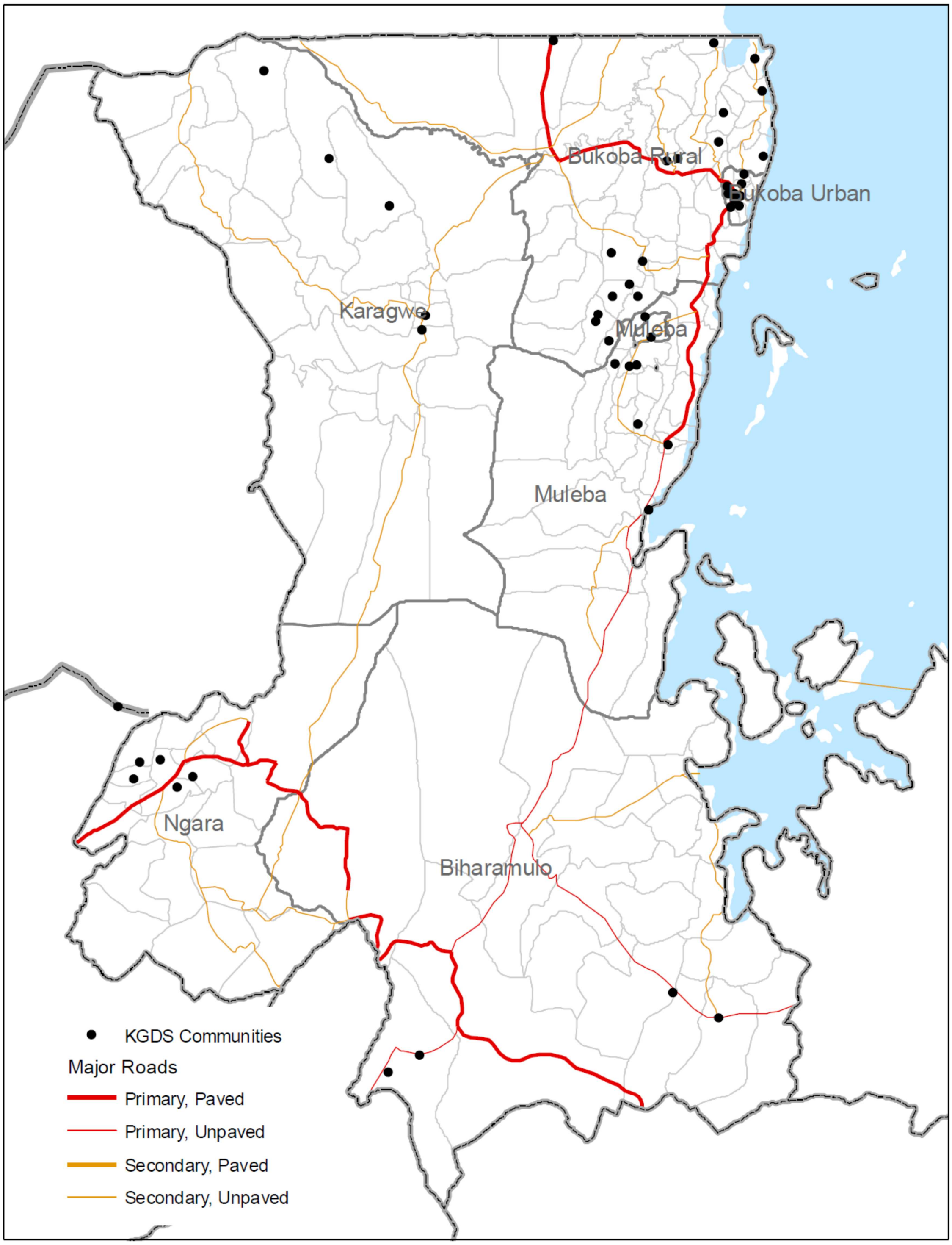
Kagera region has a pleasant climate, with temperatures between 26ºC and 16ºC. The main rains come twice a year (bimodal) in March to May and during the months of October to December. The average annual rainfall for the whole regions ranges between

800 mms and 2000mms. The dry period begins in June and ends in September. There is also a short and less dry spell during January and February.

The region could be divided into three broad agro-ecological zones. The Lake shore and islands with high rainfall, a soil with low available nutrients and an altitude of 1300ms to 1400ms above sea level. Crops grown are mainly bananas, cassava, beans, coffee and tea. Average household farm size ranges between 1 to 2 acres. The zone covers Bukoba Urban, most of Muleba and Bukoba Rural districts and the eastern parts of Biharamulo district (Figure 1.2).

Figure I.1: Kagera Region, Tanzania

Figure 1.2 : Kagera region, districts and roads



The Plateau area characterized by moderately high rainfall with annual rainfall reaching 1000 mms to 1400mms with an altitude of 1300 to 1900 meters above sea level. Crops grown for food in the zone are mainly bananas, beans, maize and cassava. Coffee is the main cash crop in the zone. The farm size ranges between 2 and 10 acres. Karagwe and Ngara district fall within this zone.

The Lowland includes areas at 1100 to 1200 meters above sea level. These are flat plains with occasional ridges an annual rainfall averaging between 500mms to 1000mms which come in a single season. The principal food crops grown in the zone include cassava, rice, sorghum, millet and maize. Cotton is the main cash crop. Average farm size ranges from 3 to 5 acres. The lowland zone covers some small parts of Muleba and Bukoba Rural districts, most of Biharamulo and part of Ngara district.

Overall, the major food crops cultivated in the region are bananas, beans, maize and cassava while coffee, tea and cotton are the main cash crops. Bananas accounts for 60 per cent of food crops harvested followed by cassava at 17 per cent. Banana is in fact the major staple food for households in the region. The production is seasonal with a peak in the period of June – October and lower production during the remainder of the year. The excess production of banana is mainly disposed of in local markets and in neighboring regions of Mwanza and Shinyanga.

Maize is gaining importance as a major food package with beans in the region. Much of the crop is grown in Karagwe and Biharamulo. The two together accounted for 78 per cent of the crop in 2002. Maize is normally intercropped with beans. Karagwe district leads in beans production at 41 percent of regional production.

Coffee is the main cash crop which is normally intercropped with bananas. The region leads in coffee production in the country. Coffee accounted for about 89 percent of hectares under cash crops and 91% of all cash crops harvested. Robusta coffee is the variety grown in the region and is grown principally by small holders in all the region's districts representing and important source of income for most of rural households.

Coffee is harvested in the region between April and July and then it is marketed in the period between August and December. Farmers sell their coffee un-hulled, as unprocessed dry cherry.

The Tanzanian coffee sector has been characterized by government intervention for a long period before the government embraced pro-market policies at the end of the eighties with the implementation of several structural adjustment programs. The turning point for the coffee sector was the season 1994/95 where major reforms were introduced.

The system, before the reforms introduced in the nineties, was based on primary societies and state-controlled cooperatives. Farmers were associated at the village level in primary societies of 100 to 1000 members. Several primary societies joined together to form a cooperative union. All post-harvest functions of procurement, transportation and processing of coffee were attributed to primary societies and cooperatives. Farmers were delivering the harvested coffee to primary societies and received a first payment based on a government previously announced price which basically served as a minimum guaranteed price. Coffee was then brought to a cooperative curing factory for processing and after it was delivered to the Tanzania Coffee Marketing Board (TCMB) which was the only body allowed to sell it at auctions to private exporters.

Once the coffee was sold through the auction, the Coffee Board deducted its fees and sent the revenues to the cooperatives unions. The cooperatives, after deducting all costs and input credits paid the difference to primary societies which after a further deduction for their own costs made the final payment to farmers. The whole process took at least a year. Winter-Nelson and Temu report that in the eighties the second payment occurred typically after nine months followed by a final payment a year to 15 months after delivery (Winter-Nelson and Temu 2002). During the six seasons between 1988/89 and 1994/95 farmers' share of the export price kept falling while costs along the chain increased, (Baffes, 2003).

Each primary society obtained a payment linked to the quality of the output delivered. *"Societies that delivered bigger beans with lower defect count were paid more. Their farmers were paid more as well.*" (Ponte 2001, p.18).

The decisive reform took place in 1993 when a new bill was approved which allowed the private sector to take part in marketing and processing coffee reducing significantly government control on the coffee sector. In the 1994/95 season private buyers were allowed to buy and process coffee in competition with the cooperative unions. The Coffee Board remained as a regulatory body and operates the coffee auctions where all exports have to be sold.

1.4 The KHDS dataset

The survey design

The dataset used for the empirical analysis is the Kagera Health and Development Survey (KHDS), a panel of households in the Kagera region[1]. The KHDS started with four rounds (wave 1 to 4) between 1991 and 1994 and was followed in 2004 by a fifth

[1] The survey is publicly available on the World Bank or Economic Development Initiative (EDI) websites. We are sincerely grateful to Joachim De Weerdt of the EDI, Kathleen Beegle (World Bank) and Kalle Hirvonen (University of Sussex and EDI) for answering to our queries and providing additional information on the survey.

round (wave 5). The main objective of the KHDS was to analyze the economic impact of the death of prime-age adults on surviving household members. The KHDS 2004 was designed to provide data to understand economic mobility and changes in living standards of the sample of individuals interviewed in the first four waves. The KHDS 2004 aimed at re-interviewing all respondents ever interviewed in the KHDS 91-94. This implied tracking these individuals, even if they had moved out of the village, region or country.

The KHDS used a random sample that was stratified geographically and according to several measures of adult mortality risk to obtain an adequate number of households with an adult death in the sample while maintaining the ability to extrapolate the results to the entire population.

The KHDS household sample was drawn in two stages, with stratification based on geography and mortality risk. In the first stage the 550 primary sampling units (PSUs) in Kagera region were classified according to eight strata defined over four agronomic zones and, within each zone, the level of adult mortality (high and low). A PSU is a geographical area defined by the 1988 Tanzanian Census that usually corresponds to a community or, in the case of a town, to a neighborhood. Once all the PSUs in Kagera have been classified into the eight strata, the PSUs from which households would be drawn have been selected. Six PSUs were selected randomly for each of the eight strata for a total of 48 final PSUs. For each of the PSU 16 households were drawn randomly. These 16 households form a *cluster*. In three of the 48 PSUs two clusters of households were selected. The final sample drawn was 816 households in 51 clusters drawn from 48 PSUs.

KHDS 2004 sampling strategy was to re-interview all individuals who were household members in any round of the KHDS 1991-1994. The household in which these individuals live would be administered the full household questionnaire. Attrition during the five waves was quite low especially considering the gap of ten years between the fourth and fifth wave. In fact, 93% of the baseline households has been re-contacted and re-interviewed in 2004 where a re-contact is defined as having interviewed at least one person from the household. Because people have moved out of their original household, the new sample in KHDS 2004 consists of over 2,700 households.

Much of the success in re-contacting respondents was due to the effort to track people who had moved out of the baseline villages. One-half of all households interviewed were tracking cases, meaning they did not reside in the baseline communities. Of those households tracked, only 38 percent were located nearby the baseline community. Overall, 32 percent of all households were located outside the baseline communities.

This dataset represents one of the few examples of long term longitudinal data in developing countries. This is a potential advantage of the data in what it permits looking at long term changes in households behavior and also permits to analyze the role of factors which, being quasi-fixed, are usually washed out in standard panel analysis due to lack of time variation. At the same time this characteristic of the data presents several challenges as the central concept of household becomes blurry in a ten year long period. In fact, tracking each individual in the original sample of households interviewed in the first round of the survey gives rise to a much higher number of households after ten years.

The survey collected a number of important pieces of information on the demographic characteristics of the household, of household’s consumption and of farming and nonfarming activities among other. It also complements the households' specific information with a community survey which collects information on the infrastructure and public services of each of the 51 communities covered by the survey and a price survey which collects data on local market prices of food and non-food products. This information permits us to obtain a wide range of variables of interest.

Derivation of the main variables

Two variables in particular are of special importance for our analysis: output quantities and producer prices. Obtaining correct measures of these variables from the survey presents several challenges.

Concerning the output measure, the survey collects information on the value sold and on the value respectively kept as seed, lost, stocked, given as gift or payment in kind or used for home-consumption. Addition of these aggregates will give the total value harvested V^T. Ideally the value harvested would be obtained as follow:

$$V^T = V^{sold} + V^{consumed} + V^{gift} + V^{lost} + \Delta V^{stock} + V^{processed}$$

However, some problems arise when dealing with aggregate estimates of output. First, there is no information on the change in stock but only on the total value of the crop kept as stock (V^{stock}). This should not represent a problem as food crops are perishable and cannot be stored for long periods hence it is likely that stocks are depleted at the end of each growing season. For coffee also storage is not safe as beans are very sensitive to storage conditions and only after processing coffee can be stored for a prolonged period of time. This ensures that coffee stocks also are depleted each season.

Second, part of the harvest might be used to create processed products. While we know the households that did not sell processed products, for the ones that did sell we do not know the quantity of crop used but only the final value of the product. There is not enough information in the dataset to extract the value of the crop used to produce the processed product and we decide to exclude processed crops from the total value harvested.

Finally, the section on home consumption of crops reports values of home-consumption for each crop but for coffee the aggregation of crops is slightly different from the one used for the other components (i.e. coffee is not reported as a stand-alone measure but it is aggregated with tea and cocoa). What can be inferred from the data is that only very few households produce tea while it is not possible to identify how many produce cocoa. Coffee however is not usually consumed in the Kagera region and to avoid introducing noise in the estimates we exclude this aggregate from the computation of the total value of coffee harvested.

Thus, our measure of the total value harvested is for food

$$V_{Food}^{T} = V^{sold} + V^{consumed} + V^{gift} + V^{lost} + V^{stock}$$

and for coffee

$$V_{Coffee}^{T} = V^{sold} + V^{gift} + V^{lost} + V^{stock}$$

The value harvested has to be deflated by an appropriate price to obtain the total quantity produced. As the producer price will also be one of the main covariates of interest the deflation might create an econometric problem in presence of measurement error. In fact, this procedure gives rise to the common problem of *"division bias"* and is likely to generate a spurious negative correlation between output and prices[2]. This represents a potential problem that needs to be addressed in the econometric estimation. Our strategy to attenuate this potential problem has two components:

first, as a measure of producer prices we use average prices instead of household specific prices to average out any measurement error. The justification for this choice is that household specific data for prices are usually subject to a high degree of measurement error given the peculiar characteristics of agricultural production which is subject to seasonality and lags that make prices difficult to recall in a single measure by the households.

Moreover, a further concern about using households' specific prices is that we are estimating the conversion factors using a price regression[3]. This is likely to add further measurement error to price data. Given these limitations, averaging households' prices at the community level is likely to reduce the measurement error if we are willing to assume that the error is randomly distributed over households with zero mean. This seems quite a reasonable assumption as there seems to be no compelling argument for the measurement error to take any different form.

As a second component, we seek to exploit different measures of prices that can be derived from the survey to reduce any spurious correlation between output and prices generate by the deflation. For food prices this is achieved exploiting the presence of a community price survey collecting local market prices for food. For coffee, where no market prices were collected, we exploit the possibility of averaging prices at distinct administrative levels. Thus, we deflate coffee and food output using the ward average,

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[2] See Benjamin (1992) and Deaton (1988). Also Kemp (1962) in the trade literature and Borjas (1980) in the labour economics literature.

[3] Details on the procedure adopted and results are reported in Appendix 1.

an intermediate administrative level smaller than the district but bigger than a community. As regressors we use community market prices for food and the average community prices for coffee.

Information on producer prices for crops has been directly collected in the survey for each household that sold part of the harvest. However, prices are expressed in several traditional units of measurement and need to be converted in a common standard unit. This is quite a common problem for agricultural surveys in developing countries where standardization is not complete. This issue, if often overlooked in empirical analysis, has been the subject of few studies which developed different techniques to deal with the problem[4]. A further problem arises for households that did not sell any of the harvest. For these households a price needs to be imputed. In Appendix 1 we develop a technique to address these two problems based on a regression which identifies conversion factors from price data expressed in different units and provides predicted prices for households not selling any of the produced output.

The food output index is derived from the aggregation of four food crops which represent both the main food crops produced in the region and the main staple food consumed: bananas, maize, beans and cassava. The food output index is derived as the total value of output of the four crops deflated by a food price index. The food price index is calculated as the simple average of the market prices of the four crops. We use the simple average instead of a weighted average to avoid introducing a source of spurious correlation between the output measure and the price index.

A further variable of interest is the agricultural wage. For the first four waves of the survey the salary paid for hired labour has been collected for the households that did

[4] See Capeau and Dercon (2004) and Lambert and Magnac (1998).

hire labour. In the fifth wave only the total amount spent on hired labour was collected which unfortunately prevents the use of household specific wages. However, the community questionnaire collected information on wages for agricultural workers in all of the community for the 5 waves of the survey. Wages are disaggregated by gender (male, female, and children) and only in 91-94 by type of activity (clearing, planting, harvesting, and other). In wave one to four the wage for a day of work (length of which is not specified) is recorded while in the fifth wave the hourly wage is recorded. To make them consistent we assume that a standard day of work is of eight hours and transform the hourly wage into the daily counterpart for wave five.

All the other variables of interest are easily obtained from the survey. The total value of assets is obtained by aggregating values of equipment, buildings, land, durables and livestock and the net value of financial assets reported by household members in the survey questionnaire. The total land area is obtained as the sum of all *shambas* owned or cultivated by the household and is expressed in acres. The education variable is the number of year of education of the household head. Rainfall is the total amount of rainfall as recorded in the closest weather station in the growing season. Distance from a motorable road is a community variable which expresses the community distance from a motorable road in kilometres. This information is collected only in the first and last wave and we extend the first wave distance to the other three waves of the first round of the survey. Thus, time variation in road distance is based on difference from the 91-94 value and the 2004 one.

1.5 Evolution of welfare and agriculture

The Kagera Health and Development survey being one of the few examples of long term panel with a first wave in 1991 and a fifth wave in 2004 can provide useful insights into the evolution of the income, the agricultural sectors and farming in the area.

Table 1.1 reports statistics on the evolution of income and the most important poverty and inequality indicators[5]. Average per-capita consumption has increased in real terms by 25.9% from 1991 to 2004 bringing a reduction in the percentage of households living below the basic needs poverty line of 5.5% percentage points. All welfare indictors show a significant improvement from 1991 to 2004. Inequality, measured by the Gini coefficient, increases instead by around three percentage points.

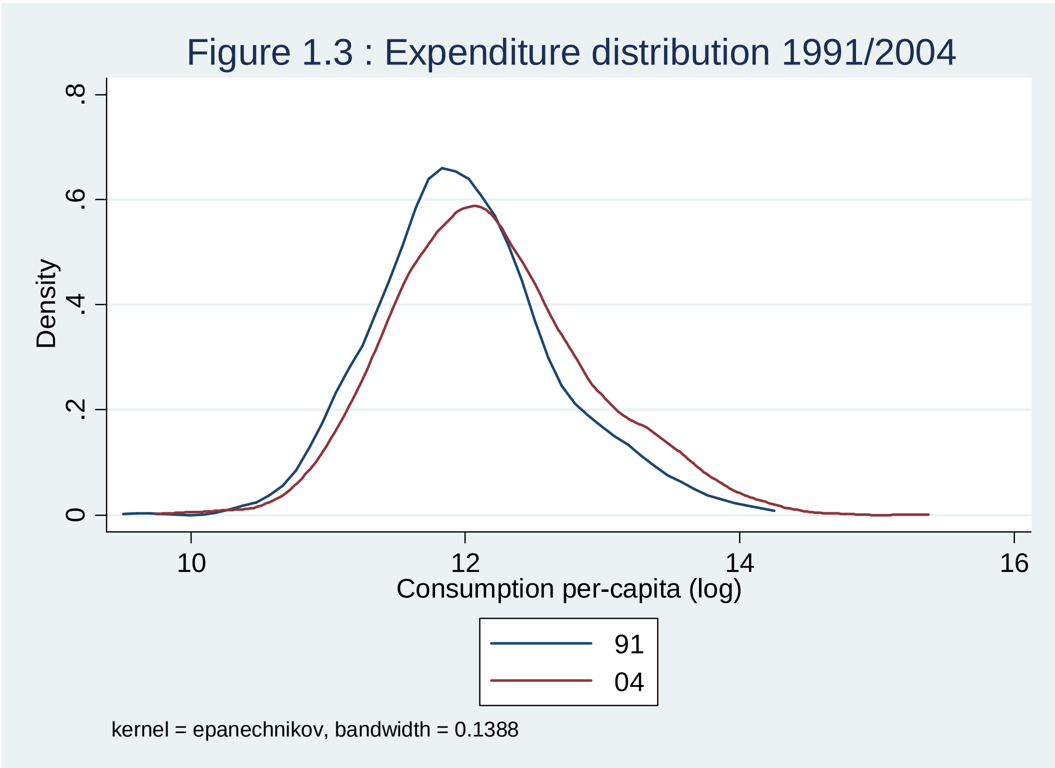
These figures are consistent with a region which shows some signs of economic development although not very pronounced given the length of the period considered. Figure 1.3 plots the income distribution for 1991 and 2004 showing that the increase in per-capita expenditure spreads along the entire income distribution but with a more pronounced increase at the top of the distribution and with some signs of increasing inequality.

[5] We proxy income with total expenditure as this has been shown to be a more reliable measure of living standards by better reflecting permanent income and by avoiding the problems of measuring income directly with the information available in household surveys (Chaudhury and Ravallion 1994; McKay 2000)

Table 1.1 : Evolution of welfare 1991/2004

	1991	**2004**	**Δ**
Mean per- capita expenditure (TZS)	207905.2	261863.3	25.9 (%)
Poverty Headcount	26.857	21.331	-5.5
Poverty gap	2.856	2.131	-0.7
Poverty severity	1.324	1.004	-0.3
Gini coefficient	.379	.417	3.2
Number of households	875	2630	

Note: Expenditures for both periods are in 2004 real prices. The basic needs poverty line is set at 109663 TZS units. The three poverty measures –poverty headcount, poverty gap and severity- are the first three members of the Foster-Greer-Thorbecke class of poverty measures.



While the above figures show signs of overall improvement in households' welfare indicators we are interested in understanding the role that the agricultural sector has on the overall economic performance in the area. Indeed, a first analysis of the data and of the production characteristics of the Kagera region highlights several important aspects. First, almost all households engage in some farming activities. Only in the fifth wave the number of households involved in farming is reduced mainly as a result of households who have moved to a different area. Second, the production system is mainly based on the duality between food and cash crops. Almost all households involved in farming activities produce food crops while a high percentage, around 65%, produce coffee. The agricultural system is characterized by smallholder producers with an average amount of land cultivated of four acres with a small decrease between 1991 and 2004.

Table 1.2 presents some indicators of the performance of the agricultural sector. While these figure need to be taken with caution, being simple descriptive statistics of a very complex phenomenon as the agricultural sector, they still can provide some broad picture that we will explore more deeply in the following chapters.

The first thing to notice is a general decline of the importance of agriculture for households in the area. The value of output per-capita has significantly decreased in the period by more than 30%, reducing the share of consumption financed by agricultural production from 66% in 1991 to 45% in 2004.

Table 1.2 : Evolution of the agricultural sector 1991/2004

	1991	**2004**
Agricultural output per-capita (TZS)	67427	44714
Yields per acre	102787.9	64324
Share of production in total expenditure	0.66	0.45
Input use (% households applying)		
Hired labour	25.80	32.70
Fertilizers	5.72	3.15
Organic fertilizers	44.77	23.31
Pesticides	12.55	6.68
Transport	10.61	5.80
Share of coffee production in total output	0.06	0.04
Share of food production in total output	0.70	0.71
Share of other crop production in total output	0.24	0.25
Herfindahl Index	0.31	0.32
Openness	0.60	0.67
Expenditure share of sales	0.08	0.04
Expenditure share of purchases	0.52	0.63
Normalized Trade Balance	-0.80	-0.89

Note: All the figures are simple averages over households. Agricultural output is the sum of the value of all the crops cultivated. Yields are calculated as agricultural output per acre of land cultivated. The share of production in total expenditure is agricultural output over total expenditure. The share of production in total output for coffee, food and other crops respectively is the value of each crop output over total agricultural output. The Herfindahl index is calculated as $\sum_i \left(\frac{x_i}{X}\right)^2$ where i indexes the ten crop aggregates considered and X is total agricultural output. Openness is calculated as $\frac{s+p}{X}$ where s and p are respectively total crop sales and purchases. The expenditure share of sales and purchases is the value of sales and purchases over total expenditure. The Normalized Trade Balance is calculated as $\frac{s-p}{s+p}$ and ranges between -1 and 1.

This is a significant shift away from agricultural production which signals that households have diversified their sources of income. The value of output per acre also decreases by 37% showing that productivity per acre has declined in the period. In terms of input use the figure show an increase in the percentage of households which hire labor in same stage of the agricultural season while there is a substantial reduction in the proportion of households applying other inputs such as fertilizers and pesticides. The trend of agricultural output, yields and input use are consistent with a decline of agricultural activity in the region and a diversification of households' income activities.

Figure 1.4 : Evolution of agriculture

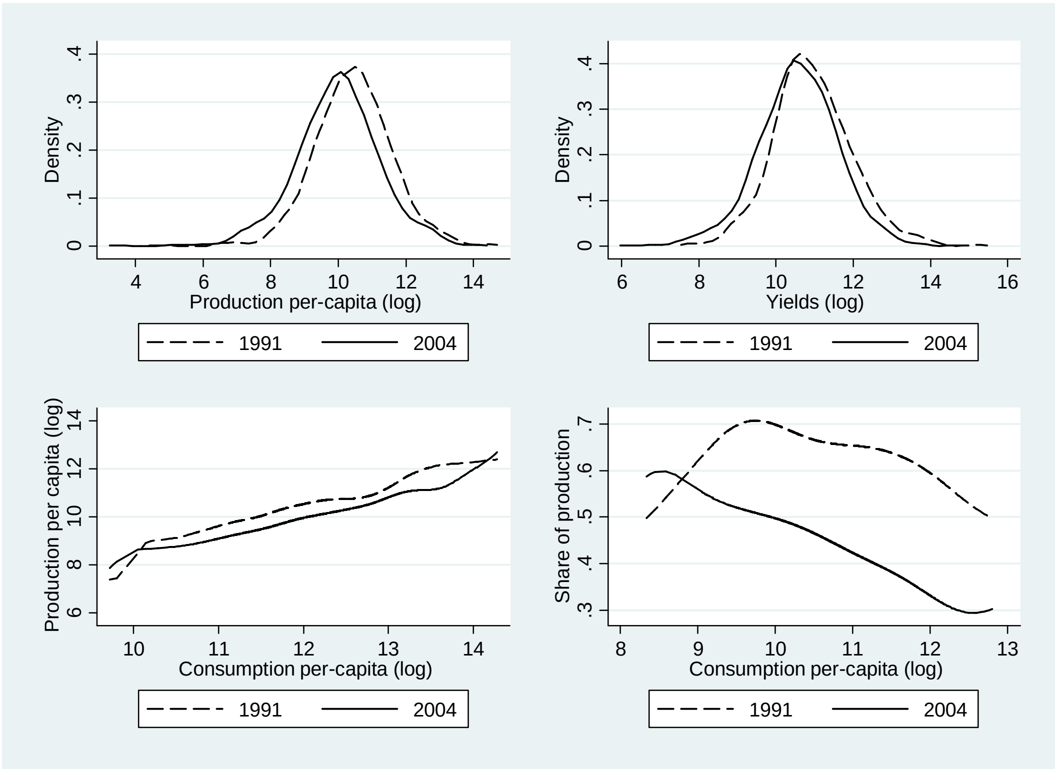


Figure 1.4 shows the distribution of agricultural output per-capita and yields in both periods and (bottom panels) plots the relationship between consumption per-capita and respectively agricultural output per-capita and the share of agricultural output in total consumption. There is a leftward shift in the distribution of yields and output per capita and a marked reduction in the share of consumption accounted by agricultural output.

This reflects a diversification strategy out of agriculture during the period and in general a decline of the importance of agricultural as an income generating activity.

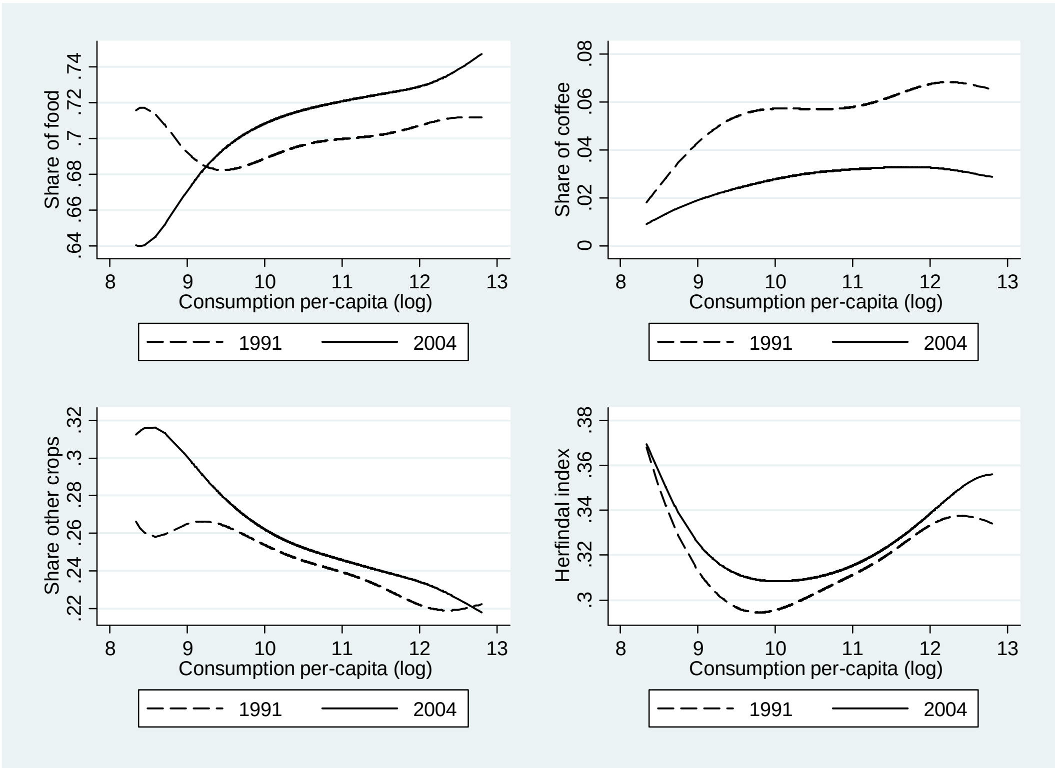
The fact that the share of agricultural production in total expenditures for higher income households is identifiably lower and also declines faster in between the two periods can be an indicator that higher income households are the ones that are able to diversify out of agriculture and into different income generating activities. The literature on income diversification strategies of rural households has identified different motives for diversification. Diversification can be a reaction to excessive risk, or high transaction costs or liquidity constraints. In these cases diversification is a matter of necessity and it is the poorest households that are most likely to diversify their incomes. On the other hand, income diversification can be also undertaken by richer households who have the necessary level of income and assets to make the transition into nonfarm activities where there are high entry costs.

In the first case, policies facilitating the movement of poor households out of high risk and low return agricultural activities into the non-farm wage employment, and self-employment along with easier access to urban jobs, seem to be the most appropriate.

In the second case, it may be more important from a policy point of view to stress public investments in agricultural activities such as roads, electricity and agricultural extension services in order to foster the growth of incomes in agriculture, especially among poorer households, so that they too can generate the necessary capital to move out of agriculture.

Figure 1.5 looks at the crop mix and shows the share of total agricultural production coming from coffee, food and other crops respectively as a function of consumption per-capita. The most obvious trend seems to be a reduction in the weight of coffee in the crop mix in favor of food and other corps. This could reflect the reduction in the coffee international prices experienced in the nineties.

Figure 1.5: Crop mix and specialization



The bottom-right panel of figure 1.5 shows the Herfindhal index of production specialization as a function of consumption per-capita. This index captures the degree of diversification in cropping strategies. It is bounded between 1/n (being n the number of crops cultivated) and 1. In this calculation we take into account ten crop aggregates so that a household cultivating all the ten crops with equal weight would have a value of the index of 0.1. The average index value is of 0.31 in 1991 and 0.32 in 2004 showing first that the crop mix is not very specialized (i.e. households tend to produce several different crops simultaneously). The second thing to notice is that there is no important movement from 1991 to 2004 in the within crops specialization pattern.

Figure 1.6 : Commercialization patterns

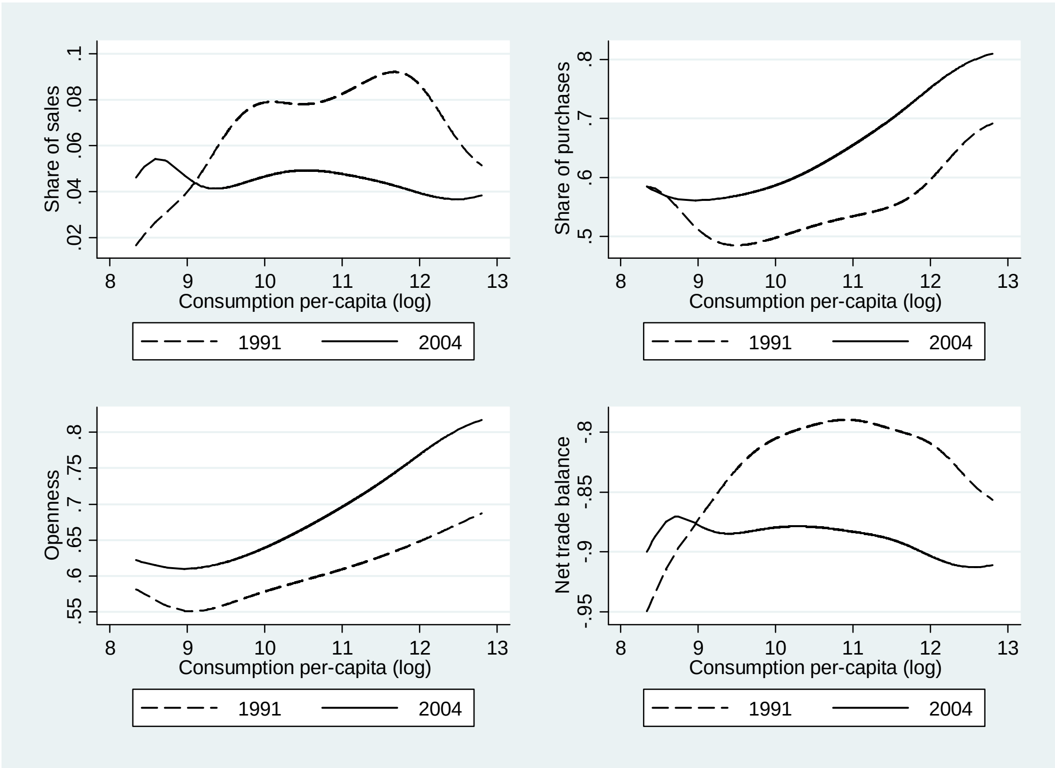


Figure 1.6 looks at the commercialization patterns and shows in the top two panels the share of agricultural sales on total expenditures and the share of total purchases on total expenditures. The share of sales of crops is quite low and decreasing in 2004 from 1991 across the whole of the income distribution except for the bottom part. The share of purchases accounts for around 50% of total consumption in 1991 and it increases along the income distribution. In 2004 market purchases accounted on average to around 60% of total expenditures with a significant increase from the previous period. As a result of these trends openness computed as the sum of market sales and purchases over total expenditures increases between 1991 and 2004 and is increasing in total consumption with households at the bottom of the distribution relying less on the market than higher

income households. The net trade balance, calculates as the ratio of the difference between households' sales and purchases over their sum, is instead decreasing in 2004 from 1991 reflecting the increase in purchases and the reduction in sales.

These statistics seem to show that households in the region rely on a traditional semi-subsistence agriculture characterized by a low level of specialization and commercialization. Moreover, there is no sign of a significant improvement in this respect in the 15 years period taken into account. The only significant trend coming out from the data is a reduction of the importance of farming as income generating activity, in particular for households at the top of the distribution. With these insights we move in the following chapters to an analysis of the constraints facing households in the area looking in particular at the role of transaction costs.

Appendix 1

ESTIMATING CONVERSION FACTORS FOR PRICES AND QUANTITIES

The measurement of the quantity produced of coffee and other crops in the Kagera survey presents several challenges. The crop section asks households the quantity sold during the past 12 months with a unit code and the price of the crop sold (with a unit code). Then, the values of crop kept for seed or given or lost or kept in stock are asked. This way of collecting the information creates several problems when we want to know the quantity produced in the last 12 months by the household and its sale price.

The main problem is that the units of measurement used for both the quantity sold and the price do not have standard conversion factors. This problem is common in rural surveys in developing countries where standardization is not widespread and local non-standard units of measurement are often quoted (Capeau and Dercon, 2005). The KHDS did not collect conversion factors for local units so an alternative method has to be employed. Moreover, many units used are physical volume units implying the density of each commodity will affect the conversion into standard units so that conversion factors will be commodity specific.

We follow the approach proposed by Capeau and Dercon (2005) to jointly estimate conversion factors and market prices for commodities in absence of market transactions. Starting from a simple accounting identity we have that p_{ijk} , the recorded selling price for household i in cluster j expressed in unit k , is equal to p_j the price in kg (or a different numeraire if needed) in cluster j multiplied by the amount of kilograms present in unit k , a_k .

$$p_{ijk} \equiv p_j a_k$$

In this identity two assumptions are implicitly used: first, we consider commodities as homogenous and no attention is posed to quality differences. Second, we assume that the price per kilogram does not depend on the unit in which it is sold.

Assuming a log-normally distributed multiplicative error term, the basic econometric specification is:

$$p_{ijk} = p_j a_k e^{u(i)}$$

taking logs this becomes

$$\ln(p_{ijk}) = \ln(p_j) + \ln(a_k) + u(i)$$

This equation can be estimated by OLS. The dependent variable is the logarithm of the price declared by the household in a specific unit. Assuming that the cluster price in a given unit chosen as numeraire varies systematically across space, time and rainfall we have:

$$\ln(p_j) = \alpha + \beta X_j + \delta R_j + \gamma t$$

where X is a vector of geographic coordinates of the clusters, R is a vector of cluster average rainfall for the 3, 6, 9 and 12 months preceding the interview and t is a vector of time variables. Substituting into the previous equation we get:

$$\ln(p_{ijk}) = \alpha + \beta X_j + \delta R_j + \gamma t + \ln(a_k) + u(i)$$

By specifying a set of dummies variables for the units of measurement the conversion factors a_k, become a set of dummies whose coefficient provides an estimation of the amount of kilograms (or whatever numeraire is chosen) for each unit.

We use the above econometric specification to obtain conversion factors for coffee and the main food crops as bananas, maize, cassava and beans. We pool all the observations for each crop of the five waves assuming in this way that the conversion factors do not vary over time. Out of the 8101 price/quantity pairs we set 187 to missing as prices are expressed in units which do not have enough observation to estimate the conversion factor with precision.

We use the above method also to identify and replace outliers. We run the above regression with a robust regression method which controls for influential observations[6]. Observations which fit poorly the data are identified as outliers and replaced with the predicted value. These observations are the ones with a weight in the robust regression of less than 0.1. With this approach we identify 299 out of the 7914 observations as outliers.

After replacing outliers we run the same regression again using standard OLS with robust standard errors to obtain the conversion factors. We also use this regression to obtain a price for households where no market transactions have been recorded, an approach which is superior to the simple imputation of the mean or median price. The results for each crop are reported in table 1.3 below. The numeraire for each crop is the unit with the highest number of observations. For bananas only one unit was recalled

[6] The robust regression method is implemented with the *rreg* Stata command. It is an iterative procedure which works by first performing a regression, calculating case weights based on absolute residuals, and then regressing again using these weights. Weights derive from the Huber weighting where cases with small residuals receive weights of 1 (no downweighting), but cases with larger residuals get gradually lower weights. Iterations stop when the maximum change in weights drops below a pre-specified tolerance.

(bunch) so there is no need to estimate any conversion factors. All the coefficients are well determined, highly significant and with the expected sign.

Table 1.4 shows the estimated convertion factors for each crop obtained from the regression dummies. We do not have any additional information in the survey to use as a comparison to assess the reliability of the estimated conversion factors. However, anecdotal evidence obtained during a field visit in the area shows that coffee bags (sacks) are considered equivalent to around fifty kilograms and our estimate is very close to that value. The only external source thet can be used to partially validate our estimates is the Survey of Household Welfare and Labour in Tanzania (SHWALITA) which covers around 4000 households in seven Tanzanian districts, two of them in the Kagera region. This survey collects convertion factors for several commodities/units. We can compare only the debe/kg convertion for beans which is estimated on average in the survey at 19 kilograms per debe. Our estimate is 15.9 kilograms per debe which is not very far from what found in the SHWALITA survey.

Table 1.5 shows descriptive statistics for the price series used in the econometric estimations in the following chapters. We can compare coffee prices to the average coffee price paid by coffee cooperatives in the area[7]. For the period 1990 to 1994 both the Kagera Cooperative Union and the Karagwe District Cooperative Union report prices in the range between 50 and 70 Tshs per Kilogram which is in line with the average coffee price reported in the survey (Table 1.5) for wave 1 to 4. For 2004 average prices reported by the cooperatives and by the Tanzania Coffee Board range

[7] Information on the cooperative prices was obtained by the cooperative offices during a field visit in the Karagwe and Bukoba district. We have historical prices from 1990 to 2010 for the Kagera Cooperative Union operating in all Kagera districts and the Karagwe District Cooperative Union operating mainly in the Karagwe district.

between 155 and 240 Tshs per Kilogram which is again close to what reported in the survey for wave 5.

Table 1.3 : Price regressions

VARIABLES	(1) Coffee	(2) Cassava	(3) Cooking bananas	(4) Sweet bananas	(5) Other bananas	(6) Beans	(7) Maize
Kg	**NUM.**	---				-2.770***	---
						(0.0466)	
Fungu	---	**NUM.**				---	-2.548***
							(0.107)
Sack	3.937***	2.848***				1.708***	1.630***
	(0.0180)	(0.100)				(0.0278)	(0.0354)
Debe	2.255***	1.760***				**NUM.**	**NUM.**
	(0.0267)	(0.0755)					
Day	0.000269***	0.000259***	0.000262***	0.000286***	0.000310***	0.000317***	0.000312***
	(4.54e-06)	(1.96e-05)	(9.97e-06)	(1.19e-05)	(7.96e-06)	(6.17e-06)	(8.93e-06)
nx_coord	-1.08e-07	1.50e-06	4.76e-06***	6.13e-06***	6.09e-06***	3.53e-07	1.07e-06***
	(2.66e-07)	(1.09e-06)	(5.61e-07)	(7.11e-07)	(5.85e-07)	(3.12e-07)	(4.09e-07)
ny_coord	3.06e-07	1.53e-06**	-1.96e-06***	-1.95e-06***	1.30e-07	-5.70e-07***	1.80e-07
	(2.77e-07)	(7.64e-07)	(4.28e-07)	(5.53e-07)	(3.98e-07)	(2.12e-07)	(2.44e-07)
rain3	-0.000877***	0.000246	0.000516	0.000579	0.000868***	0.000233	0.000262
	(0.000178)	(0.000699)	(0.000379)	(0.000404)	(0.000320)	(0.000273)	(0.000415)
rain6	-0.000966***	0.00188	0.000910	0.000950	-2.86e-05	-0.00109**	-3.05e-06
	(0.000269)	(0.00132)	(0.000686)	(0.000659)	(0.000539)	(0.000444)	(0.000745)
rain9	0.00115***	0.00117	-0.000563	-0.00272**	-0.000855	-3.40e-05	0.00192*
	(0.000395)	(0.00175)	(0.00107)	(0.00111)	(0.000863)	(0.000806)	(0.00108)
rain12	0.000109***	-0.000230**	-7.35e-05	0.000164**	4.46e-05	3.15e-05	-0.000267***
	(2.78e-05)	(0.000111)	(5.94e-05)	(7.19e-05)	(5.37e-05)	(4.54e-05)	(6.20e-05)
Constant	3.745***	3.726***	5.593***	4.111***	3.754***	6.683***	6.301***
	(0.0446)	(0.150)	(0.0702)	(0.109)	(0.0764)	(0.0377)	(0.0567)
Obs.	2,303	448	967	1,091	1,704	863	538
R-squared	0.956	0.799	0.500	0.366	0.522	0.940	0.914

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. All regressions are estimated by OLS. The dependent variable in all regressions is the log of the reported price.

(1) Kg is the numeraire
(2) Fungu is the numeraire
(3) (4) (5) no conversion factors are estimated as all prices are expressed in the same unit (Bunch)
(6) (7) Debe is the numeraire

Table 1.4 Estimated conversion factors

	Coffee	**Cassava**	**Beans**	**Maize**
KG	Num	---	Num	---
Sack	51.3	17.3	87.8	5.1
Fungu	----	Num	---	0.08
Debe	9.5	5.8	15.9	Num

Note: each column reports the conversion factors expressed in terms of the indicated numeraire. These are obtained from the exponential transformation of the coefficients estimated in table 1.3.

Table 1.5 Coffee and food prices summary statistics

	Coffee (TZS per Kg)	**Cassava** (TZS per Fungu)	**Beans** (TZS per Debe)	**Maize** (TZS per Debe)	**Bananas** (TZS per Bunch)
Wave 1	Mean= 64 Sd= 19 Vc= 0.29	72 (33) 0.45	810 (164) 0.2	544 (92) 0.17	203 (118) 0.58
Wave 2	Mean= 48 Sd= 11 Vc= 0.23	88 (30) 0.34	792 (117) 0.15	780 (95) 0.12	184 (119) 0.65
Wave 3	Mean= 45 Sd= 13 Vc= 0.29	112 (37) 0.33	872 (98) 0.11	704 (87) 0.12	254 (169) 0.66
Wave 4	Mean= 65 Sd= 15 Vc= 0.23	98 (39) 0.4	1012 (131) 0.13	723 (99) 0.14	278 (175) 0.63
Wave 5	Mean= 159 Sd= 48 Vc= 0,3	283 (97) 0.34	3125 (414) 0.13	2584 (418) 0.16	807 (499) 0.62

Note: the table reports the simple average across households, the standard deviation and the variation coefficient for the price series by wave. Wave 1 to 4 correspond to the 1991-1994 period while wave 5 is for 2003-2004.

Chapter 2

Agricultural supply response, transaction costs and separability: evidence from Tanzania

2.1 Introduction

In this chapter we analyze the production structure and the production decisions of rural households engaged in agriculture as their main activity, a common characteristic of rural areas in developing countries where agriculture represents the main source of income for most of the population. Having a clear understanding of how production decisions are taken and what are the main factors shaping them is a first important step towards an assessment of the impact of different policies on welfare and economic development.

The first aspect we analyze is the extent to which market imperfections influence households' production decisions. The literature on this subject has shown that different market failures can lead to peculiar and sometime perverse households' behavior. A general result shown is that in presence of market imperfections households are unable to separate consumption and production decisions. This in turn influences the way production decision are taken and consequently the way these have to be modeled. We test whether the separability hypothesis can safely be sustained for this sample of households or not.

The second aspect we will focus on is the supply response for cash and food crops. We analyze farmers' production decisions and in particular their supply response to price and non-price factors in a context which is potentially characterized by market imperfections. How responsive are farmers to price and non-price factors is a very important piece of information for policy analysis. We find that households in the region are responsive to prices for the main cash crop but not for food.

The availability of a long-term panel dataset allows us to investigate these issues with higher accuracy than previous studies. In fact, we can control for unobserved characteristics and at the same time identify the impact of some factors that are slowly changing and that are usually washed out in standard panel analysis. Moreover, we add to the empirical evidence on separability and supply response in rural Sub-Saharan Africa.

After a brief discussion of the theory of the role of market imperfection and separability in household models we present an empirical test for separability using a dataset on the Kagera region of Tanzania and then we estimate farmers supply response for food and coffee.

2.2 Conceptual background

When approaching the study of economic behavior in developing countries' rural areas we face the problem of how to characterize and model entities which incorporate the two traditional aspects of economic life: consumption and production.

Indeed, for a large part of the population of developing countries' rural areas these decisions are taken simultaneously under a single entity, the household. This can rarely be characterized as a pure commercial farm as it usually consumes part of its produce and employs family labour in the farm. But it cannot just be described as a pure subsistence farm either as it often sells part of the produce to the market and employs hired labour. It is thus generally a semi-subsistence unit where subsistence and commercial decisions are interrelated. Every attempt to model farming decisions in developing countries' rural areas should take these interactions into account. The recognition of the importance of these complexities gave rise to a specific form of economic modeling called farm household models.

One of the first recognition of the complex interactions shaping the economic behaviour of farm households came from the pioneer work of Chayanov (1926). Chayanov was concerned about peasant conditions in Russia in a context of almost absent labour markets. His main insight was on the recognition that the household which produces goods in part for consumption and in part for the market using mainly its own labour, forms a particular economic unit that has to be analysed as a whole to fully understand its economic behaviour.

Agricultural households models have then been formalized analytically and under a wider spectrum of conditions by several authors like Nakajima (1969), Sen (1966), Jorgenson and Lau (1969). The work of Singh, Squire and Strauss (1986) offers a systematic review of the theoretical and empirical issues associated with the analysis of households' production and consumption decisions.

The main characteristic of these models is that *"production and consumption decisions are linked because the deciding entity is both a producer, choosing the allocation of labour and other inputs to crop-production, and a consumer, choosing the allocation of* *income from farm profits and labour sale to the consumption of commodities and services."* (Taylor and Adelman, 2003)

The household's objective is assumed to be to maximize utility, consuming home-produced goods, purchased goods and leisure subject to a set of constraints. Constraints include cash income, time, endowment of assets, production technologies and prices of inputs, outputs and non-produced consumption goods. Prices are either fixed exogenously in the case of traded goods with perfect markets or determined as internal shadow prices imposing the condition that demand equal output in the case of non-traded goods with missing markets.

The standard problem for the household can be formalized as follow:

$$\begin{aligned}
&\max U(c_i; z^c) \\
&\text{s.t} \\
&g(q_i; z^p) = 0 \\
&\sum p_i c_i = \underbrace{\sum p_i q_i}_{\pi} + p_l T + E = y
\end{aligned}$$

Where the household maximizes utility defined over a vector of consumption goods c_i (which includes leisure). z^c are characteristics affecting preferences. Apart from labour identified with the sub-script *l* we use a single subscript *i* to identify outputs, inputs and consumption commodities but clearly not all of them are simultaneously inputs, outputs or consumption goods. We can think of a set

$$I = \{\text{food crop, cash crop, labor/leisure, other inputs, non-food consumption good, }\}$$

from which various subsets can be specified:

$P =$ farm outputs= $\{$food crop, cash crop$\}$
$C =$ consumption= $\{$food crop, labor/leisure, non-food goods$\}$

The maximization problem is subject to two constraints: first, the production function defined over a vector of netput q_i where inputs ($q_i < 0$, including labour) are combined to produce different outputs ($q_i > 0$) conditional on a productivity shifter z^p. The production function is assumed to be well-behaved being quasi-convex, increasing in output and decreasing in inputs.

The second constraint is a full income constraint imposing that total expenditures, including leisure, need to be equal to the full income given by profits plus the full value of time *T* plus exogenous income *E*. The labor market is perfectly functioning and family and hired labour employed in the farm are assumed to be homogenous as well as farm and off-farm labour. Land is considered as fixed. The household chooses the total amount of labour to supply in the farm or outside and the model poses no restriction on the combination of farm and off-farm labour as well as on the mix of family and hired labor. All other markets are perfectly functioning and thus prices are exogenous to the household.

The lagrangian for this problem is:

$$L = U(c_i; z^c) + \lambda[\sum p_i q_i - \sum p_i c_i + p_l T + E] + \phi g(q_i; z^p)$$

The first order conditions are:

$$\frac{\delta U}{\delta c_i} - \lambda p_i = 0 \qquad \phi \frac{\delta g}{\delta q_i} + \lambda p_i = 0 \qquad \phi \frac{\delta g}{\delta q_l} - \lambda p_l = 0$$
$$g(.) = 0$$
$$\sum p_i q_i - \sum p_i c_i + p_l T + E = 0$$

These can be rewritten as:

$$\frac{U_i}{U_j} = -\frac{g_i}{g_j} = \frac{p_i}{p_j} \qquad i \neq j$$

The FOCs give the output supply, factor and consumption goods demand functions:

(0.0) $$q_i = q_i(p_i; z^p) \qquad i \in P \quad j \in I$$

(0.0) $$c_i = c_i(p_j, y^*; z^c) \qquad i \in C \quad j \in I$$

Where y^* is the full income evaluated at the profit maximizing level of output.

The reduced form of the model is:

$$q_i = q_i(p_j; z^p) \qquad i \in P \quad j \in I$$
$$c_i = c_i(p_j; z^c, z^p, E, T) \qquad i \in C \quad j \in I$$

The model is thus recursive or separable in that production decisions are not affected by consumption-side variables. However, consumption depends on production decisions through profits. The model can thus be solved in a recursive way maximizing profit first and then maximizing utility for given profits.

The preceding illustrates the separation or recursive property of farm household models[8]. The property states that if all markets for which the household is both a producer and a consumer, including labor, are well functioning and the household faces all exogenously market-determined prices, then the consumption and production maximization problems can be solved in a recursive way: first maximize profits from the production activity and then maximize utility for given profits. Production decisions are not affected at all by preferences or other characteristics that influence consumption decisions while consumption decision are linked to production ones only through profits. This property simplifies significantly the theoretical and empirical treatment of households' decisions in that the production side can be modeled as a standard profit maximizing firm and the consumption side very close to a standard consumer problem.

The basic difference between a stylized household model as the one presented above and a standard consumer model is that in the latter the budget is fixed, whereas in the household model it is endogenous and depends on the production decisions that in turn determine profits. On the production side, if all markets are perfectly functioning in the standard neo-classical meaning, there are no differences from a standard producer model.

One of the most important applications of these models is the comparative static exercise that attempts to determine the sign and magnitude of exogenous shocks on variables of interest. The joint consideration of consumption and production decisions has the effect of changing some of the standard theoretical results. For example, in demand analysis a profit effect is now added to the standard substitution and income effects of a price change. This can reverse the standard outcome of demand analysis if

[8] In what follow we make use of the terms separability, separation property, recursiveness and recursive property interchangeably referring to the same property which makes possible the treatment of the two sides of the model, consumption and production, as two distinct problems.

the profit effect outweighs the standard Slutsky one. The effect on household consumption of a price increase becomes now ambiguous. On the production side also, the impact of price changes on marketed surplus for products that are also consumed becomes ambiguous as it depends on consumption decisions as well as production ones.

To obtain the elasticity of demand to the own price totally differentiate the demand function (0.0) with respect to the own price:

$$\begin{aligned}
\frac{\partial c_i}{\partial p_i} &= \frac{\partial c_i}{\partial p_i}\Big|_{\pi^*} + \frac{\partial c_i}{\partial \pi^*}\frac{\partial \pi^*}{\partial p_i} \\
&= \underbrace{\frac{\partial c_i}{\partial p_i}\Big|_U - c_i\frac{\partial c_i}{\partial y^*}}_{Slutsky\ eq.} + \underbrace{q_i\frac{\partial c_i}{\partial \pi^*}}_{Profit\ effect} = \frac{\partial c_i}{\partial p_i}\Big|_U + (q_i - c_i)\frac{\partial c_i}{\partial y^*} \\
\varepsilon_p &= \varepsilon_p^h + \left[\frac{p_i(q_i - c_i)}{y}\right]\eta_i \\
&= \varepsilon_p^h + s_i^m\eta_i
\end{aligned} \tag{0.0}$$

where ε_p^h is the Hicksian compensated own price elasticity of demand for good *i*, η_i is its income elasticity and s_i^m is the share of good *i* marketed surplus on income.

The demand elasticity depends now not only from the standard substitution and income effects but also from the profit effect reflecting one of the main characteristics of household models which make profit endogenous. The implication is that the profit effect can outweigh the standard substitution and income effects and the overall elasticity of demand to the own price is not determined a-piori in its sign. In particular, the sign depends on the income elasticity -if goods are normal or inferior- and on the sign of marketed surplus. For net-sellers consumption might respond in a positive way to changes in the own price even for normal goods. For the marketed surplus the comparative statics result can be shown as follow:

$$m_i = q_i - c_i$$

$$\frac{\partial m_i}{\partial p_i} = \frac{\partial q_i}{\partial p_i} - \frac{\partial c_i}{\partial p_i}$$

$$\frac{p_i}{m_i}\frac{\partial m_i}{\partial p_i} = \frac{q_i}{m_i}\frac{p_i}{q_i}\frac{\partial q_i}{\partial p_i} - \frac{c_i}{m_i}\frac{p_i}{c_i}\frac{\partial c_i}{\partial p_i}$$

$$\varepsilon_m = \frac{q_i}{m_i}\chi_i - \frac{c_i}{m_i}\varepsilon_p$$

The elasticity of marketed surplus (ε_m) is determined by the supply elasticity (χ_i) which, given assumptions about the convexity of the production function, has a positive sign, minus the elasticity of demand weighted respectively by the share of output and consumption on marketed surplus. In this case as well there is no a-priori conclusion for the sign of the elasticity. For net sellers and normal goods the elasticity might turn to be negative.

The above analysis is based on the assumption of complete markets which make the model recursive. However, in presence of missing or imperfect markets the recursive property is violated. If one market for a good where the household is both a producer and a consumer is missing or presents some kind of imperfections, then the household is not a price-taker anymore but is subject to a shadow price defined as the price that if observed would equate household’s demand and supply for that good. In this case, the shadow price will depend on both demand and supply factors and the separation between production and consumption decisions breaks down thus making both decisions simultaneous. Now demand side characteristics of the household influence production decisions[9]. This has important consequences on how households are impacted and react to price shocks. Moreover, this has implications on the appropriate modeling strategy of production as now it cannot be modeled separately from demand anymore. Household models that incorporate the interaction between demand and supply side become the most appropriate modeling tool in this case.

To show the implication of non-separability the above model can be modified to introduce a missing market. The problem facing the household is:

$$\max U(c_i; z^c)$$
s.t
$$g(q_i; z^p) = 0$$
$$\sum p_i c_i = \underbrace{\sum p_i q_i}_{\pi} + p_l T + E$$

(0.0) $\quad c_1 = q_1$

The additional constraint (0.0) implies that households are not participating in one of the markets (identified with the subscript 1) and thus have to internally equate supply and demand for that good. The lagrangean for this problem is:

$$L = U(c_i; z^c) + \lambda[\sum p_i q_i - \sum p_i c_i + p_l T + E] + \phi g(q_i; z^p) + \gamma(q_1 - c_1)$$

The first order conditions assuming interior solutions are:

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[9]It is clear that this applies only to goods where the household is both consumer and producer as Singh et al. point out clearly: *"If, however, the household faces only market prices or if it faces a virtual price for a commodity that is consumed but not produced (or vice versa), then the production choices will not depend on household preferences, but consumption choices will depend on production technology through full income. The model is then recursive."* (Singh, Squire and Strauss, 1986)

$$\frac{\delta U}{\delta c_i} - \lambda p_i = 0 \qquad \phi\frac{\delta g}{\delta q_i} + \lambda p_i = 0 \quad i \neq 1$$
$$\frac{\delta U}{\delta c_1} - \gamma = 0 \qquad \phi\frac{\delta g}{\delta q_1} + \gamma = 0$$
$$g(.) = 0$$
$$q_1 - c_1 = 0$$

These can be rewritten as:

$$\frac{U_i}{U_j} = -\frac{g_i}{g_j} = \frac{p_i}{p_j} \quad \forall i \neq j;\ i, j \neq 1$$

$$\frac{U_1}{U_j} = -\frac{g_1}{g_j} = \frac{\gamma}{\lambda}\frac{1}{p_j} = \frac{p_1^*}{p_j} \Rightarrow p_1^* = \frac{\gamma}{\lambda} \quad \forall j \neq 1$$

The last expression provides a definition of the shadow price for the missing market and shows how this reflects the household internal perception of scarcity for that good.

The FOCs give the output supply, factor and consumption goods demand functions:

(0.0) $$q_i = q_i(p_1^*, p_i; z^p)$$

(0.0) $$c_i = c_i(p_1^*, p_i, y^*; z^c)$$

where y^* is the full income at the optimum. The equilibrium condition for the missing market is:

(0.0) $c_1(p_1^*, p_i; y^*; z^c) = q_1(p_1^*, p_i; z^p)$

This implicitly defines the shadow price for the missing market as:

$$p_1^* = p_1^*(p_i, z^p, z^c, E, T)$$

The reduced form of the model is:

$$q_i = q_i(p_{j,}; z^p, z^c, E, T) \qquad i \in P \qquad j \in I$$
$$c_i = c_i(p_j; z^c, z^p, E, T) \qquad i \in C \qquad j \in I$$

This model is non-separable as now demand side variables affect production decisions so that the household's production problem has to be determined simultaneously with the consumption one. It is not possible anymore to analyse the farm side without considering consumption decisions at the same time. In empirical analysis this translates into the need to include demand determinants when estimating the supply function.

The assumptions about whether households are integrated into product and factor markets or not also affect the results of any comparative statics exercise. In fact, difficulties in determining the sign and magnitude of these effects increase when households face missing markets.

The effect in this case is well exemplified by the following example: the household produces cash crop and a staple crop for which market is missing. An increase in the cash crop price *"…will induce the household to increase its production of cash crops and raise household income, through cash crop profits. This creates a perceived scarcity of staples in the household, as higher income from cash crops increases the* *demand for normal goods, including staples. The shadow price of staple, therefore, increases as the market price for the cash crop goes up. The upward pressure on the staple price will intensify if increasing cash crop production requires shifting fixed household resources (e.g., land or human capital) out of staple production. The higher shadow price of staples induces the household to invest additional resources in staple production, possible reducing its cash crop supply response to the increase in price."* (Taylor and Adelman, 2003)

Thus, as the above example shows, missing markets might reduce the own-price supply response of cash crops. However, different specifications of the model concerning markets functioning and the competition in inputs between cash crop and non-tradable can change the result.

Using the above model it is possible to derive the comparative statics results for the non-separable case. The first step consists of deriving the elasticity of the shadow price with respect to market prices.

Totally differentiating equation (0.0) we obtain:

$$\frac{\partial q_1}{\partial p_j}dp_j + \frac{\partial q_1}{\partial p_1^*}dp_1^* = \frac{\partial c_1}{\partial p_j}dp_j + \frac{\partial c_1}{\partial p_1^*}dp_1^* + \frac{\partial c_1}{\partial y^*}\left[\frac{\partial \pi}{\partial p_j}dp_j + \frac{\partial \pi}{\partial p_1^*}dp_1^*\right]$$

This can be rewritten in elasticity form to obtain the elasticity of the shadow price to changes in a market price j as:

$$\varepsilon_{1j}^{p^*} = \frac{dp_1^*}{dp_j}\frac{p_j}{p_1^*} = -\frac{\chi_{1j} - \varepsilon_{1j} - \eta_1\left(\frac{p_j q_j}{y}\right)}{\chi_1 - \left(\varepsilon_1 + \eta_1\left(\frac{p_1 q_1}{y}\right)\right)} = -\frac{\chi_{1j} - (\varepsilon_{1j} + \eta_1 s_j^q)}{\chi_1 - \left(\varepsilon_1 + \eta_1 s_1^q\right)} \qquad (0.0)$$

Where χ_1 and χ_{1j} are respectively the elasticity of supply of good *1* with respect to the own price and the price of good *j*. ε_1 and ε_{1j} are the demand elasticity of good *1* with respect to the own price and the price of good *j*. η_1 is the consumption income elasticity of good *1*. s_1^q and s_j^q are the shares of production on total income.

A crucial step to see how a missing market can affect households' responsiveness to price changes is to determine the sign of expression (0.0). If the cross price elasticity of supply χ_{1i} is negative, the cross price elasticity of demand ε_{1j} is positive and the income elasticity η_1 is positive then the numerator is negative. The denominator instead is positive if $|\varepsilon_1| > \eta_1 s_1^q$.

If these conditions are satisfied then the whole expression is positive and an increase in the market price increases the shadow price in the missing market creating an internal scarcity effect. After obtaining the elasticity of the shadow price to changes in other market prices we can now look at the elasticity of demand and supply in the models with a missing market.

The demand elasticity in the case of a missing market is obtained by differentiation of (0.0):

$$\frac{\partial c_i}{\partial p_i} = \frac{\partial c_i}{\partial p_i} + \frac{\partial c_i}{\partial p_1^*}\frac{\partial p_1^*}{\partial p_i} \tag{0.0}$$

In elasticity form this becomes:

$$\varepsilon_p^t = \varepsilon_p + \varepsilon_{p*} \cdot \varepsilon_{1i}^{p*} \tag{0.0}$$

The first term in the right-hand side of (0.0) is the elasticity of consumption in the complete market model derived above (0.0) which gives the elasticity of demand keeping constant the shadow price. The additional term in (0.0) is the elasticity of demand with respect to the shadow price (ε_{p*}) times the elasticity of the shadow price to the market price of good *i* (ε_{1i}^{p*}). This term reflects the fact that now the shadow price is endogenous and depends on all other prices so a change in the price of good *i* has an additional indirect effect through the shadow price. The overall effect is that the ambiguity on the sign of the demand elasticity increases with respect to the complete market case examined above.

On the supply side the output supply elasticity is derived from differentiation of (0.0):

$$\frac{\partial q_i}{\partial p_i} = \frac{\partial q_i}{\partial p_i} + \frac{\partial q_i}{\partial p_1^*}\frac{\partial p_1^*}{\partial p_i}$$

this in elasticity form becomes:

(0.0) $$\chi_i^t = \chi_i + \chi_{ip*} \cdot \varepsilon_{1i}^*$$

Here to the standard supply elasticity χ_i the second term is added which represents the elasticity of supply to the shadow price χ_{ip*} time the elasticity of the shadow price to the market price ε_{1i}^*.

Expression (0.0) has an important interpretation. For example let's examine the supply response of the cash crop to its own price when the food market is missing. If the cash crop supply elasticity with respect to the shadow price of food is negative (the two are competing crops) and the elasticity of the shadow price with respect to the cash crop price is positive (under the above assumptions) then the second term on the right hand side of (0.0) is negative and the cash crop supply response is reduced with respect to the situation where the food market is fully functioning.

This is the result reached in de Janvry et al.'s (1991) famous study. Missing markets, they argue, reduce households' supply response in particular for cash crops, thus offering an interpretation of the common view about farmers' sluggishness.

However it is important to highlight that this result is subject to a number of assumptions or expectations about the degree of competition among crops and the cross price elasticity of supply, about the cross price elasticity of demand and the income elasticity.

The above considerations imply that market imperfections are of crucial importance when analyzing the production behavior of rural households. Therefore, a crucial issue when modelling households' response to shocks and policy interventions concerns the assumptions made on how efficiently markets work in the specific environment where the households operate and thus the concept of separable as opposed to non-separable household models.

Market imperfections are defined as some form of factors which makes the market deviate from the standard neoclassical perfect market assumption where the market is fully competitive, products are homogeneous, there are no costs in the exchange process and information is complete and symmetric across all agents. Market imperfections can be of various natures from the extreme case of a complete missing market to intermediate ones where the market selectively fails for some imperfections.

In the context of rural markets the literature has given attention to several different causes of market imperfections. Heterogeneity in different kinds of labour and/or commodities; different preferences between off-farm and on-farm employment; different efficiencies in family and hired labor; differing qualities between home-produced and market supplied commodities; constraints on the maximum quantity that can be exchanged on the market are all examples of deviations from the standard neoclassical assumptions which might generate market failures.

An important cause of deviation from the perfect market framework is the presence of transaction costs. *"Transaction costs are defined as all costs of entering into a contract, exchange or agreement: searching for trading partners, screening potential candidates, obtaining and verifying information, bargaining, bribing officials, transferring the product (including transport, storage and packaging costs), and monitoring, controlling and enforcing the transaction."* (Heltberg and Tarp, 2002). Commuting time for off-farm employment, monitoring costs for hired labour, high transport costs to the main markets are among the main examples.

The effect of transaction costs is to create a band between the sale and the purchase prices. The poorer the infrastructure, the less competitive the marketing system, the less information is available and the more risky the transactions, the greater the size of the band. If the shadow price of a product produced or used by the household falls into the band trade will not occur and self-sufficiency becomes for the household more advantageous than market exchange.

In synthesis, deviations from the standard neoclassical assumption, and in the specific case the presence of high transaction costs, can force households not to take part to market exchange of certain products. If that happens the household will have an internal equilibrium where demand and supply are equated and separability will be violated.

2.3 Empirical tests for separability: a review of the literature

The theoretical result that separability might be a too restrictive assumption in cases where market failures are important and pervasive has led to a stream of studies that try to verify empirically if the separable behavior of households can be considered a good approximation of reality or not. Tests for separability in household models have been conducted in several different ways in the literature. The results provided by these tests are mixed.

Lopez (1984, 1986) represents one of the first attempts to test the separation property. He considers two cases of non-separability caused by (a) different preferences between on-farm and off-farm work and by (b) the existence of commuting time to off-farm work. Both models reach similar conclusions and are non-recursive. He uses non-nested hypothesis techniques to test the hypothesis that utility and profit-maximization decisions are independent. Using Canadian data he rejects the hypothesis of separability.

A different way of econometrically testing the separability hypothesis using the reduced form of the household model comes from recognizing that when separability breaks down production and consumption components influence each other and household characteristics that should influence only the consumption component influence also the production one. That is, it is possible to test for the significance of variables that are considered to influence only preferences into the output supply and factor demand equations. If these variables are significant determinants of production decisions than separability will be rejected.

Benjamin (1992) uses this approach and examines three cases of imperfections on the labor market that lead to non-separability.

The first cause of non-separability he considered is the "surplus labor" model where constraints on off-farm employment opportunities affect on-farm employment decisions. The constraint is represented by a maximum amount of hours that a household may work off-farm.

The second case considered includes some form of rationing on the labor demand side. Where the previous case may describe the slack season, this one may describe the peak season where wages may not rise sufficiently to clear the market, resulting in labor shortages. The farmer may have to depend on his family to meet farm labor demand.

The third case analyzed is where there are differing returns to on and off-farm employment. In his theoretical analysis he shows how demographic variables influence on-farm labor allocation under non-separable behavior.

Benjamin derives an empirical test for the separation hypothesis on the labor market in Java. The dependent variable is observed total farm employment modeled as:

$$\log L = \alpha + \beta \log w^{*} + \gamma \log A$$

Where L is total farm employment measured as total person-days of labor used on each farm; w^* is the shadow wage and A is a vector of production-side determinants as land harvested and input prices. The shadow wage w^* is modeled as a function of the market wage w and of a set of demographic characteristics a of the household:

$$w^{*} = m(a) \cdot w$$

The functional form chosen for $m(a)$ is such that $m(a) = 1$ if there are no demographic effects:

$$m(a) = 1 + \lambda(a)$$

With $\lambda(a)$ small under the null we have that $\log m(a) \simeq \lambda(a)$. This leads to the following relationship to estimate:

$$\log L = \alpha + \beta \log w + \gamma \log A + \varphi a$$

Under the null of separability the demographic variables should not affect labor decisions and the coefficient φ should be non-significant. An F test is used to determine the joint significance of the demographic variables. He cannot reject separability as the demographic determinants are not significant.

Bowlus and Sicular (2003) use the same approach used by Benjamin to test the separability hypothesis in a rural region of northern China. They use panel data to control for unobservable characteristics. They reject the hypothesis of separability and find that households' size and composition do affect farm labor supply. They are interested in assessing the hypothesis that the main cause for non-separability in China is the presence of surplus labor. In order to verify this they split the sample according to different land endowments at the village level and to different off-farm employment opportunities. Their conclusions call for the need for a more complete explanation of the cause of non-separability as caused by lack of mobility of factors between different villages.

Pitt and Rosenzweig (1986) in their study on the impact of health on households production decisions using a sample of Indonesian households also run a test for separability similar to the one developed by Benjamin. They test whether illness of households members influence profits or not. Under perfect markets for labor and separability (and in particular under perfect substitutability of family and hired labor) it should not. They cannot reject the hypothesis of separability.

Grimard (2000) applies the same test presented by Benjamin to a sample of rural households in Ivory Coast and is able to reject separability between production and consumption.

Another approach to the separability test uses the structural form of the model to estimate a complete set of demand and supply equations and derive estimation for the endogenous price of non-tradable for each household. These estimated prices give a measure of the relative scarcity of a factor/good for the household and if compared with market prices give a different way of testing for separability. Differences in the two prices imply non-separability.

Jacoby (1993) adopts this approach estimating labor supply equations and comparing the marginal product of labor with the market wage. He rejects separability using data on Peruvian households.

Skoufias (1994) uses an approach very similar to the one used by Jacoby. He estimates the marginal productivity of family labor estimating a Cobb-Douglas production function with a panel of Indian households and then uses these estimates to derive a labor supply function. To test the hypothesis of separability he regresses the estimated shadow wage (the marginal productivity of labor) on the actual market wages in the following way:

$$\ln \hat{W}_i^* = \alpha + \beta \ln W_i + \varepsilon_i$$

The null hypothesis that labor markets operates efficiently and separability holds implies that $\alpha = 0$ and $\beta = 1$. This hypothesis is strongly rejected.

One of the main weaknesses of all these studies has been identified in the failure to recognize heterogeneity across households (de Janvry and Sadoulet 2004) which in part could explain some counterintuitive results. As extensively pointed out in the literature (de Janvry, et al 1991), market failures and non-separable behavior are essentially households specific. Markets fail for some households while they do not for others and separability holds for some and not for others households. Indeed, an important characteristic of the separability test is its capacity to take into account households' heterogeneity or not. In the literature this translates into the difference between tests that do not consider households' heterogeneity and local or idiosyncratic tests which instead do.

Idiosyncratic tests have been conducted under different approaches. Carter and Olinto (2003) use a disequilibrium model to estimate the probability of being constrained on a specific market. This approach uses the structural form of the model and involves the estimation of demand and supply functions and assigning each household a probability of being constrained in that market. They apply this approach to test non-separability derived from constraints on the credit market.

A different approach uses observed non-participation in a particular market to infer market failure and non-separability. This involves dividing the sample into groups according to regimes of participation. Then, they verify ex-post that market participating households behave according to separability while non-participating ones behaves according to non-separability correcting for selection bias in a two steps Heckman procedure.

Sadoulet, de Janvry and Benjamin (1998) develop a household model where differential asset endowments and idiosyncratic transaction costs affect participation to the labour market. Different labour skills, land and capital endowments and wide idiosyncratic wage bands generated by large transaction costs have the consequences that farm households are differentially integrated into labour market, with some selling labour, others hiring labour and others choosing for labour self-sufficiency.

They first use an ordered probit to predict membership in the three different labour regimes to then test for recursiveness. The model predicts separability to hold for labour sellers and buyers, while non-separability applies for self-sufficient households. Recursiveness implies that labour intensity and labour productivity do not vary with the asset position of the households. Results support the hypothesis that recursiveness applies for buyers and sellers while it does not for self-sufficient households where asset measures do affect labour decisions.

Carter and Yao (2002) adopt an approach that is very similar to the one used by Sadoulet and al. (1998). The cause of non-separability is identified in the functioning of the land market in China. They use panel data to control for fixed effects and instead of estimating an ordered probit followed by an OLS regression they jointly estimate both the regressions for the rental regime and for labour allocation using a Full Information Maximum Likelihood method. They show how global tests are inappropriate in cases where markets are not completely absent but imperfect. Comparing the pooled model vs. the local one they can see the differences in the coefficients and are able to capture differential effects for different rental regimes.

These two studies share one characteristic: they use observed market behaviour to infer separability. The drawback of this approach is that participation is not a sufficient condition for separability. As pointed out by Vakis et al (2004, p.4), *"..tests that account for heterogeneity on the basis of observed market participation may hide non-separable behaviour due to constraints on that market"*. This means that even if a household does participate in a market it can still be constrained (for example by a maximum amount of off-farm labour that can be sold) and this constraint generates non-separability even in presence of market participation.

The focus of the study by Vakis et al. (2004) is to explain labour allocation decisions and unobserved heterogeneity of small farmers that participate in the market as net sellers. The model is a standard household model where the household maximizes utility derived from income and leisure. Time can be allocated between on-farm work, off-farm work with a wage w and leisure. An unknown upper limit is present on the amount of labour that can be sold on the market. There is no hired work as the focus is on net sellers only and there is no land market for simplicity. In absence of other constraints, for a household that participates in the labour market, separability depends on whether the maximum off-farm labour constraint is binding or not. Thus, even for households that are observed to sell labour, non-separability may exist. The reduced form of the on-farm labour allocation depends only on production side characteristics if the household is not constrained and on both production and consumption characteristics if the off-farm labour constraint is binding.

The empirical estimation uses data on Peruvian households. Findings show that the separability hypothesis is rejected for labour net-sellers households identified as constrained while it is not for others pertaining to the unconstrained regime. The result shows the existence of farmers who although participating in the labour markets make their decisions according to a non-separable model.

Among studies that take into account households' heterogeneity, a different strategy to test for separability has been used too. Indeed, some studies make use of the structural form of the model to estimate a production function and from this an estimated factor marginal productivity and a standard error for each household. The estimated idiosyncratic shadow price with its confidence interval is compared with the effective market price for each household. Separability for a single household is rejected if the two prices differ. This approach is followed by Lambert and Magnac (1998) for Ivory Coast and by Bhattacharyya and Kumbhakar (1997) for the Indian region of Bengal. They both found substantial differences in the shadow and market prices indicating that separability does not hold.

2.4 Separability and supply response

In this section we carry over the empirical estimation of the supply response for food and coffee for the KHDS sample after having tested for separability.

Agricultural supply response has had an important role in the agricultural economics literature on the ground that policy's results will crucially depends on how farmers respond to different incentives.

Empirically the estimation of the supply response has followed three main methodologies. The first set of studies falls under the Nerlovian approach and uses aggregate time series data at the sectoral level to estimate supply response both at the aggregate or crop level. The main advantage of this type of analysis lies in the possibility to incorporate a dynamic specification to the model using past prices as proxies for expected prices which are an important part of the analysis given the lagged structure of agricultural production. However, important drawbacks of this approach are the scarce attention given to non-price factors and to heterogeneity among farmers which derive from using aggregate time series data. Examples of studies using this approach are Danielson (2002) and McKay et al. (1998) for Tanzania.

The second set of studies uses data at the farm/household level to estimate profit functions or cost functions to derive the associated output supply and input demand functions. This approach assumes profit maximization and perfectly functioning markets and is usually estimated as a system where the theoretical constraints of symmetry, homogeneity, monotonicity and convexity which make it compatible with profit maximization can be tested a posteriori or imposed ex-ante. As a consequence of the joint assumptions of profit maximization and perfect markets models using this supply approach are separable in nature and do not permit one to explore and test the relations between the production and the consumption behavior of farmers. A further drawback of the profit function approach is that a specific form for the profit function has to be imposed and this is sometimes quite an arbitrary choice. Examples of this approach are among others Suleiman et al. (2004) for Ethiopia and Hattink et al. (1998) for Ghana.

The third set of studies uses farm household models to estimate supply functions and input demands. Household models are better able to fully characterize the interaction between the production and consumption side of small-holders and can handle missing and imperfect markets better and are thus more suitable for the analysis of non-price factor, market participation and market imperfections. Examples of studies using household models for the analysis of supply response are Goetz (1992), Heltberg and Tarp (2002), Alene et al. (2008), Key et al. (2000), Strauss (1984).

Given that the focus of this study is in the possible interactions between the consumption and the production sides of households we use a household model to estimate supply elasticity for food and coffee. We estimate the reduced form of the coffee and food supply functions. The sample includes all households producing coffee or food for which the complete set of information is available[10].

The important advantage of the dataset in hand is that it is a panel which allows us to control for time invariant unobservable household specific characteristics which could otherwise confound the estimates. Moreover, being a long term panel it also permits us to exploit some long term variation in characteristics which are usually slowly changing such as road infrastructure, and to analyze the evolution of household behavior between the two rounds of the survey.

We use a balanced version of the panel looking only at the households which have been interviewed in all the five waves of the survey for a total of 733 households. To link households in 2004 with the original household we follow in order the head of the household, the spouse of the head, the oldest son or daughter. The sample is composed of 733 households interviewed during four waves on a six month interval between 1991 and 1993 and then re-interviewed during a fifth wave in 2004. Descriptive statistics of the sample are presented in tables 2.1 and 2.2 below.

Following equation (0.0) of the household model the equation to estimate is the following:

$$Q_{it} = \beta P_{it} + \delta Z_{it}{}^{p} + \eta_i + \mu_t + \varepsilon_{it}$$

[10] The dependent variable is clearly censored at zero for both food and coffee a fact which, if not taken into account, could bias our estimations. However, for food the actual number of censored observations is very low (5%) and so should not be a concern. For coffee the number of censored observations is higher (35%) causing some concern and suggesting the use of a tobit estimator. However, the fixed effects tobit estimator is not a consistent estimator, only a random effects tobit is an available option which would preclude controlling for time invariant unobserved heterogeneity. As a robusteness check we run the random effects tobit for coffee obtaining results very similar to the standard random effects estimator implying that the censoring does not represent a concern. We thus opt for maintaining the fixed effects estimator as our preferred specification.

The dependent variables are respectively total output harvested of coffee and food. The covariates are: a set of prices; households' demographic characteristics that directly affect supply as age, size and education; endowment variables; transaction costs and weather related variables. We use household fixed effects estimator to control for households specific and time invariant factors like entrepreneurial skills and land quality that are likely to affect the dependent variable while being correlated with other covariates. We also control for time effects using year dummies.

The set of prices used as explanatory variables includes coffee and food prices and agricultural wages. Ideally, we would like to introduce into the regression also the prices of variable inputs other than labour like fertilizers, pesticides and transport. Unfortunately, we know if the households used these inputs but we do not have information on their prices. Thus, the kerosene price is used as a proxy for prices of inputs like synthetic fertilizers for which no prices have been collected in the survey.

All these prices are expressed in real terms by deflation with the Laspeyre price index at the regional level calculated from the consumer price survey collected in conjunction with the main survey[11]. As explained before (Chapter 1), we use the average community producer prices for the price of coffee while for the food and input price we use market prices collected in the price survey.

[11] The KHDS survey collects price questionnaires for each cluster in the region and for each wave of the survey. The laspeyres index uses as base the 1991 average price in the region per item *i* denoted as B_i. Then the price index for cluster *c* is calculated as $L_c = \sum_i W_i \frac{p_{ic}}{B_i}$ where P_{ic} is the price of item *i* in cluster *c* and W_i is the expenditure weight of good *i*. Weights are calculated using 1991/1994 expenditure weights. See Beegle, De Weerdt and Dercon (2006) for further details.

Z^p is a vector of variables that reflects factors influencing production decisions. This should include indicators of skills and ability of the household, land and capital endowment, land fertility and weather conditions.

We control for managerial skills and ability including the educational status, the age and gender of the head. The long term structure of the panel permits the identification of these factors as the head can change due to the death of the original head. Differences in farming ability that are time invariant and household specific are controlled for by the use of panel fixed effects estimation.

We control for the land and capital endowment of farmers. Endowment of capital is measured by the asset value of the household. Land endowment is measured as total amount of land cultivated in acres.

Fixed effects estimation controls for the unobserved fertility and other characteristics of land. Weather conditions are controlled by the total amount of rainfall in the community in the last season.

To measure variable transaction costs we use four variables: community distance from a motorable road, household ownership of a means of transport, length of time the road is impassable in certain periods of the year as a proxy for the quality of the infrastructure and finally a dummy for the presence of a market in the community.

The last variable included as covariate is the exogenous part of income. This includes non-labour income, gifts and remittances received and transfers from organizations. The variables are described in table 2.3.

Table 2.1 : Descriptive statistics KHDS

	WAVE 1		WAVE 2		WAVE 3		WAVE 4		WAVE 5		TOTAL	
	N°	*%*	*N°*	*%*	*N°*	*%*	*N°*	*%*	*N°*	*%*	*N°*	*%*
Household engage in farming												
Yes	723	98.6	730	99.6	730	99.6	710	96.9	674	92	3567	97.3
No	10	1.4	3	0.4	3	0.4	23	3.1	59	8	98	2.7
Total	733	100	733	100	733	100	733	100	733	100	3665	100
Household produces coffee												
No	240	32.7	230	31.4	222	30.3	247	33.7	332	45.3	1271	34.7
Yes	493	67.3	503	68.6	511	69.7	486	66.3	401	54.7	2394	65.3
% of hhd engaged in farming		68.2		68.9		70		68.4		59.5		67.1
Total	733	100	733	100	733	100	733	100	733	100	3665	100
Household sells coffee												
No	288	39.3	611	83.4	348	47.5	442	60.3	401	54.7	2090	57
Yes	445	60.7	122	16.6	385	52.5	291	39.7	332	45.3	1575	43
% of producers		90.3		24.2		75.3		59.9		82.8		65.8
Total	733	100	733	100	733	100	733	100	733	100	3665	100
Household hires labor												
No	537	74.4	498	68.2	457	62.6	478	67.5	406	68.2	2376	68.2
Yes	185	25.6	232	31.8	273	37.4	230	32.5	189	31.8	1109	31.8
Total	722	100	730	100	730	100	708	100	595	100	3485	100
Household applies fertilizer												
No	680	94.2	696	95.3	708	97	695	98.2	576	96.8	3355	96.3
Yes	42	5.8	34	4.7	22	3	13	1.8	19	3.2	130	3.7
Total	722	100	730	100	730	100	708	100	595	100	3485	100
Household applies pesticide												
No	630	87.3	660	90.4	671	91.9	670	94.6	557	93.6	3188	91.5
Yes	92	12.7	70	9.6	59	8.1	38	5.4	38	6.4	297	8.5
Total	722	100	730	100	730	100	708	100	595	100	3485	100
Household had transport expenses												
No	645	89.5	696	95.3	648	88.8	688	97.2	567	95.3	3244	93.1
Yes	76	10.5	34	4.7	82	11.2	20	2.8	28	4.7	240	6.9
Total	721	100	730	100	730	100	708	100	595	100	3484	100
Household head is female												
No	536	73.1	530	72.3	522	71.2	513	72.2	510	69.7	2611	71.7
Yes	197	26.9	203	27.7	211	28.8	198	27.8	222	30.3	1031	28.3
Total	733	100	733	100	733	100	711	100	732	100	3642	100

Table 2.2 : Descriptive statistics KHDS (cont.)

Wave	Land area (Acres)		Quantity produced coffee (KG)		Wage (TZS)		Transfer (TZS)		Assets (000 TZS)		Age Head (Years)		Coffee Price (TZS)	
	Mean	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*
1991	4.3	(2.9)	274.2	(1088.4)	157	(74.7)	44536	(237778.2)	1204.6	(1529.3)	48.6	(16.8)	64.1	(8.3)
1992	5.2	(5.0)	183.25	(542.4)	172.7	(80.2)	16712.8	(48634.7)	1256.5	(1612.2)	49.3	(16.9)	48.5	(6.1)
1993.1	4.6	(2.9)	222.8	(973.4)	181.8	(71.2)	32608.5	(115187.3)	1287.2	(1584.8)	49.5	(17)	45.1	(5.9)
1993.2	4.9	(2.4)	104.0	(232.3)	233.4	(147.7)	84696.5	(826526.6)	1335.6	(2106.1)	49.8	(16.9)	65.7	(6.3)
2004	3.9	(2.8)	159.9	(343.2)	768.3	(363.4)	39188.6	(212040.8)	1057.4	(1412.3)	53.7	(16.9)	157.6	(20.1)
Total	4.6	(3.6)	189.6	(728.3)	302.7	(298.4)	43290.9	(396409.6)	1227.6	(1664.9)	50.2	(17)	76.1	(42.9)

Wave	Quantity sold coffee (KG)		Quantity produced food		Quantity sold food		Food price index		Road distance (KM)		Education Head (Years)		HHD Size	
	Mean	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*	*Mean*	*Sd*
1991	170.6	(993.6)	371.0	(501.1)	20.4	(73.9)	54.2	(19.1)	0.11	(0.6)	4.1	(3.4)	6.1	(3.0)
1992	31.0	(161.6)	156.2	(149.8)	8.3	(21.1)	59.2	(13.1)			4.1	(3.3)	5.9	(2.9)
1993.1	159.6	(874.6)	149.2	(150.9)	9.2	(28.1)	67.9	(10.3)			4.2	(3.3)	5.9	(3.0)
1993.2	60.4	(167.9)	169.5	(245.4)	15.8	(162.8)	74.2	(15.1)			4.2	(3.4)	5.9	(3.0)
2004	101.3	(266.6)	228.5	(271.2)	16.2	(74.6)	210.2	(39.9)	0.42	(1.7)	4.6	(3.8)	5.2	(2.9)
Total	104.7	(619.3)	214.4	(305.1)	13.9	(87.7)	93.1	(62.9)	0.17	(0.9)	4.2	(3.4)	5.8	(3.0)

Table 2.3 : Variables description

Variable	Unit	Description
Log coffee P	Real TZS/Kg	Log real coffee price
Log food P	Real TZS/Kg	Log real food price Average of bananas, cassava, maize, beans prices.
Log kerosene P	Real TZS/bottle	Log real kerosene price
Log wage	Real TZS/day	Log real agricultural wage per day of work
Transfers	Mln Real TZS	Transfer income as sum of remittances, transfer from organizations, pensions and other non-labour income.
Age head	Years	Age of household head
Female	Dummy	1=female head 0=male head
Log area	Acres	Log of household total area of land cultivated
Rainfall	Mm/month	Total rainfall season
Log capital	Mln TZS	Log of total value of household stock of physical and financial asset
HHD size	Person	Number of household members
Road distance	Km	Community distance from motorable road
Education head	Years	Total numbers of years of education acquired
Transport ownership	Dummy	0=no private vehicle 1=own private vehicle (car or motorbike or bicycle)
Road impassable	Months	Number of months road is impassable
Market	Dummy	0=no market in community 1=market in community

In order to check if the fixed effects is the appropriate estimator to use we compute a Hausman test to compare random and fixed effects estimators and the result strongly rejects the null that the unobserved households' characteristics are uncorrelated with the regressors. Thus, the within estimator is to be preferred. In all the estimations we control for the seasonality of production using a set of dummies reflecting if the household was interviewed during the long rainy season, the short rainy season or the dry season in the case of food and during the marketing season as opposed to the harvesting season for coffee. The timing in which the household has been interviewed might in fact influence the response due to the seasonality of production. Dummies for each of the five waves of the survey are also introduced in all the estimations to control for unobserved time effects common to all households. Standard errors are corrected for within household serial correlation and are robust to heterosckedasticity.

Before discussing the results for the estimation of supply response we test for the validity of the separability assumption in our sample. The existence of market imperfections can be tested empirically using the standard result that if these constraints are binding consumption and production decisions are taken simultaneously. Preferences and demographic characteristics will then influence input and output decisions.

One way of testing separability, proposed by Benjamin (1992), is through the econometric estimation of the reduced forms of the output supply and factor demand equations to test the significance of the demographic characteristics affecting consumption decisions z_c.

We test this hypothesis including in the coffee and food supply equations variables reflecting the composition of the household which are supposed to affect preferences and thus consumption decision but do not belong directly to the supply equation. The equation to estimate is:

$$Q_{it} = \beta P_{it} + \delta Z_{it}{}^{p} + \lambda Z_{it}^{c} + \eta_i + \mu_t + \varepsilon_{it}$$

Z^c is the set of consumption related variables on whose joint significance or not relies the test for separability. Benjamin (1992) proposes a set of variables catching the demographic composition of the households. These are: household size, proportion of adults (aged between 15 and 55), proportion of elderly (older than 55) , all differentiated by gender, and proportion of children (younger than 7). Results of the estimation and the F test for the joint significance of these variables are reported in the table 2.4 below.

Household size is highly significant in both the coffee and food supply equations while the variables reflecting the household composition show some significance only in the coffee equation. In both the food and coffee production equations we find that the demographic variables are jointly significant. This implies that households' production decisions are influenced by the demographic composition of the household and that separability for this sample is rejected.

A potential problem associated with this test is the possible endogeneity of household composition. As Benjamin (1992) points out this is more a statistical problem than a theoretical one. The concern is that households' composition is affected by unobservable factors that might also affect production leading to bias in the coefficients. Here however, as opposed to Benjamin's study, the model is estimated controlling for households fixed effects thus reducing significantly the likelihood that unobserved heterogeneity affects the estimates.

Table 2.4 : Separability test

VARIABLES	(1) Coffee	(2) Food
Log coffee P	0.768***	0.432***
	(2.79e-05)	(0.000136)
Log food P	0.0260	0.0210
	(0.860)	(0.778)
Log kerosene P	-0.138	-0.233***
	(0.260)	(0.000314)
Log wage	-0.0825	0.112***
	(0.183)	(0.000634)
Transfers	-0.0658*	-0.00128
	(0.0710)	(0.983)
Age head	0.0314*	0.0216***
	(0.0700)	(0.00937)
Age square	-0.000246	-0.000174**
	(0.114)	(0.0221)
Female	-0.167	0.0131
	(0.224)	(0.858)
Log area	0.117*	0.0925**
	(0.0523)	(0.0110)
Rainfall	0.000146*	-6.91e-05
	(0.0919)	(0.119)
Log capital	0.171***	0.0842***
	(0.00126)	(0.00134)
Road distance	-0.123**	0.00869
	(0.0411)	(0.652)
Education head	0.0315	-0.00206
	(0.294)	(0.899)
Education square	-0.000530	0.00114
	(0.794)	(0.301)
Transport ownership	0.135	0.0432
	(0.149)	(0.396)
Road impassable	0.0301	-0.0165
	(0.380)	(0.295)
Market	-0.0838	-0.0603*
	(0.187)	(0.0809)
HHD size	0.0288*	0.0745***
	(0.0619)	(0)
Proportion male adults	-0.237	-0.197
	(0.392)	(0.189)
Proportion female adults	-0.427*	-0.0664
	(0.0841)	(0.653)
Proportion male elder	-0.0572	-0.220
	(0.882)	(0.307)
Proportion female elder	-0.586*	-0.312
	(0.0589)	(0.124)
Proportion children	-0.574**	-0.111
	(0.0165)	(0.398)
F test Z^c variables	**1.95**	**12.03**
P-value	**(0.07)**	**(0.00)**
Observations	2,285	3,471
Number of hhd	607	732
F	11.15	39.76
r2_w	0.152	0.302
r2_b	0.217	0.375
r2_o	0.208	0.336

Note: Robust pvalues in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The five variables in bold are the Z^c variables in the model to which the F test of joint significance is referred to.

Coffee

The first set of results looks at coffee production. The baseline fixed effects estimation is presented in the first column of table 2.5. From the results of the estimations some general indications on the adequacy of the model to describe the production behaviour of coffee farmers in the Kagera region can be drawn.

A first important indication comes from the own price elasticity of coffee. Elasticity of coffee production to the own price is estimated to be 0.78, positive and significant at the one per cent level. This would imply an inelastic response to coffee price but of a reasonable magnitude by developing countries standards. Theoretical expectations point to a positive elasticity of supply and previous studies tend to confirm the presence of positive but small supply elasticity in developing countries in Sub-Saharan Africa[12].

None of the other prices seems to have a statistically significant impact on coffee production which is contrary to prior expectations. The food price coefficient, even if not significantly different from zero, has a positive sign which points towards a complementarity between coffee and food production.

The demographic variables all have the expected signs but only the age of the household head and the family size have a statistically significant impact on coffee production. In particular age has a positive impact on the quantity of coffee produced which is in line with the expectation that experience is an important factor influencing agricultural production. The estimated coefficient is of 0.03 implying an additional year of the head increases coffee production by 3% ceteris paribus. Age shows diminishing returns with a maximum around the age of 65.

12 See Rao (1989) for a survey and some results on crop-specific supply response in several developing countries. Also Hattink et al. (1998) for cocoa and maize in Ghana and Danielson (2002) for Tanzania.

Also interesting is the result of the gender dummy. Households with female head are no different on average than male headed households with respect to total coffee production.

Education has no significant impact of coffee production which is at odds with a-priori expectations that higher educated households should be better able to understand and correctly apply agricultural techniques.

Looking at the endowment variables the results show that the coefficients for the total amount of land cultivated and for capital endowment are significant and positive. The concern for these variables is about their potential endogeneity as it is also possible that households which are more productive and better linked to markets are also able to use more land and capital. In this respect the results have to be taken with caution. However, controlling for fixed household characteristics limits this problem as it controls for households managerial skills and time invariant ability. This problem can in fact mainly be seen as an omitted variable problem where omitting household inherent *"productivity"* can bias the estimates of other variables correlated with the omitted factor. Panel fixed effects estimation can limit this problem as long as the omitted factor is fixed or quasi-fixed. Comparing the coefficient on capital endowment between the OLS (second column of Table 2.5) and the fixed effect we can see that this is almost halved. We recognize that controlling for fixed effects although important could not be sufficient to rule out the potential endogeneity of these variables. However, given the difficulties in finding convincing instruments to run a instrumental variable regression we maintain the assumption that these variable are exogenous after controlling for households and communities fixed effects.

Rainfall has a positive impact on coffee production as expected. Transfers have a negative impact on coffee production.

The last set of variable measures transaction costs. The results show that households living in communities further away from a motorable road tend to produce less coffee. The coefficient has the expected sign and implies that an increase in the distance from a motorable road by one kilometre reduces coffee production on average by 12%. These results show the importance of transaction costs in households' production decisions. High transaction costs limit significantly production of cash crops like coffee and by limiting access to markets make marketing them much more difficult. There is concern in the literature about the potential endogeneity of roads deriving from the fact that the decisions to build roads can barely be considered as random but instead are taken considering the associated returns of a new infrastructure. If that is the case, then roads are likely to be built in areas where the productive potentials are higher generating a reverse causality problem which would bias the estimates. Here however we are controlling for fixed unobservable characteristics of farmers and communities through fixed effects estimation. This should eliminate the potential correlation between the error term and the access to roads in controlling for the productive potential of different communities.

The second indicator of transaction costs, the number of months during which the roads are impassable, is an indicator of the quality as opposed to the quantity of road infrastructure in the community. This variable has no significant impact on coffee production. This is not completely surprising as coffee is mainly marketed during the dry season where road accessibility is less a concern. The market and the transport ownership dummies are not significant in the preferred fixed effects specification.

A first set of conclusions can be drawn from the basic results for coffee production. First, farmers are responsive to coffee prices with an estimated elasticity of 0.78. Second, as expected farmers with higher endowment of land and capital tend to produce higher quantities of coffee. Third, non-price factors are important in determining farmers' production decisions. Access to road has a positive effect on coffee production in the region.

In the other 4 columns of table 2.5 we report results for OLS, random effects, community fixed effects and first difference estimators of the same specification as a robustness check. Results for the main variable of interest, the own price elasticity, are very similar for all the five estimators and we can see that although fixed effects remains the preferred model it is conservative in terms of statistical significance in particular for variables for which we don't have strong time variation. It is important that the same model estimated by first differencing gives very similar results to the baseline specification. The within and the first difference estimators differ in their assumption concerning the exogeneity of the explanatory variables with the first difference estimator assuming weak exogeneity in place of the strict exogeneity needed for consistency of the within estimator. Big differences between the two usually indicate problems with the strict exogeneity assumption[13].

[13] See Wooldridge (2010).

Table 2.5 : Coffee supply

VARIABLES	(1) Household Fixed effects	(2) OLS	(3) Random Effects	(4) Cluster Fixed effects	(5) First Difference
Log coffee P	0.784***	0.650***	0.773***	0.898***	0.700***
	(2.01e-05)	(0.000213)	(1.57e-07)	(2.12e-06)	(0.00265)
Log food P	0.0357	0.186	0.101	-0.0303	0.105
	(0.809)	(0.176)	(0.434)	(0.832)	(0.557)
Log kerosene P	-0.130	-0.305**	-0.205*	-0.181	-0.210
	(0.282)	(0.0191)	(0.0675)	(0.153)	(0.159)
Log wage	-0.0782	-0.0107	-0.0430	-0.0991	-0.0753
	(0.202)	(0.862)	(0.429)	(0.105)	(0.278)
Transfers	-0.0658*	0.00670	-0.0372	0.0315	-0.103***
	(0.0659)	(0.937)	(0.452)	(0.690)	(0.00424)
Age head	0.0356**	0.0172*	0.0279**	0.0271***	0.0279
	(0.0393)	(0.0994)	(0.0124)	(0.00648)	(0.194)
Age square	-0.000273*	-0.000101	-0.000196*	-0.000181**	-0.000169
	(0.0787)	(0.293)	(0.0516)	(0.0495)	(0.399)
Female	-0.193	-0.0442	-0.101	-0.136*	-0.231
	(0.141)	(0.616)	(0.225)	(0.0819)	(0.191)
Log area	0.110*	0.167**	0.133**	0.193***	0.0576
	(0.0667)	(0.0209)	(0.0219)	(0.00471)	(0.408)
Rainfall	0.000156*	0.000177**	0.000209***	0.000177**	0.000231**
	(0.0733)	(0.0185)	(0.000939)	(0.0417)	(0.0284)
Log capital	0.183***	0.315***	0.246***	0.319***	0.180***
	(0.000521)	(6.58e-08)	(3.04e-07)	(1.14e-08)	(0.00490)
HHD size	0.0256*	0.0600***	0.0478***	0.0348***	0.0137
	(0.0653)	(1.14e-05)	(1.91e-05)	(0.00305)	(0.472)
Road distance	-0.121*	-0.0862**	-0.0937***	-0.0632	-0.129
	(0.0510)	(0.0195)	(0.00634)	(0.299)	(0.158)
Education head	0.0389	0.0614**	0.0635***	0.0506*	0.0792**
	(0.196)	(0.0209)	(0.00791)	(0.0550)	(0.0347)
Education square	-0.00104	-0.00553***	-0.00461**	-0.00420*	-0.00295
	(0.611)	(0.00777)	(0.0152)	(0.0631)	(0.241)
Transport ownership	0.128	0.376***	0.295***	0.261***	0.154
	(0.175)	(1.36e-06)	(3.75e-05)	(0.000281)	(0.172)
Road impassable	0.0324	-0.00796	0.00132	0.0498	-0.0352
	(0.335)	(0.683)	(0.945)	(0.126)	(0.369)
Market	-0.0880	0.0438	-0.0190	-0.0775	-0.118
	(0.170)	(0.518)	(0.742)	(0.241)	(0.106)
Constant		1.124			
		(0.280)			
Observations	2,285	2,285	2,285	2,285	1,502
R2	0.672	0.247		0.362	0.114
F	12.91	19.88		14.29	7.371
Number of hhd	607	607	607	607	607
Rho	0.544		0.428		
chi2			478.9		
R2_w	0.148		0.140		
R2_b	0.219		0.284		
R2_o	0.208		0.241		
Hausman test		Chi2(23)	45.2		
		p-value	0.003		

Robust pvalues in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Additional variables included in the estimations but not reported are dummies for each of the five waves of the survey and seasonal dummies for the coffee growing and marketing season. For the fixed effects estimation we report both the R-squared for the LSDV model (R2) and the three different R-squared from the within estimator (R2_w, R2_b and R2_o).

Food

We repeat the same estimation exercise using the same baseline specification for food production. Food is an aggregate of the four main food crops produced in the region: beans, maize, bananas and cassava. Results for the baseline fixed effects estimation are reported in the first column of table 2.6.

The result shows a positive, although very low and not statistically significant own price elasticity of food. Quite surprising is the positive and relatively high elasticity of food production to the coffee price. This implies that food and coffee are complements and do not compete for fixed factors as land and capital as also found for the food price in the coffee equation. This is quite plausible as coffee in Kagera represents an important source of income for most of the households and a remunerative coffee season allow farmers to invest in manure, seeds and other inputs to produce food.

Kerosene price has the expected negative sign and contrary to coffee it is significant for food.

Among the demographic characteristics the age of the head is positively related to food production with an estimated effect of an additional year of the head of 2.3% on the quantity of food produced and a turning point at around 58 years.

Being a female headed household has a no statistically significant on the total output produced. Education has no influence on food production while the number of components of the households has a positive impact on the quantity of food produced.

Land endowment is positively associated with food production with an estimated land elasticity of 0.09. Capital endowment also has a positive impact on production with elasticity of 0.08.

Rainfall has no significant impact on food production which is not what was expected as irrigation is not widespread in Tanzania and in Kagera in particular and agriculture is rainfed and should be dependent on the amount of rain received in a given year. This might be due to how we measure the rain and requires further attention. It might be that rain in a specific period of the year is important for the harvest to be successful or that the variability matters instead of the average amount.

Transfers have no significant impact on food production as opposed to the previous result for coffee.

Concerning the transaction costs variables only the dummy for the presence of a market in the community is marginally significant for food production and has a negative sign which is at odds with previous expectations. This lack of explanatory power of the transaction costs variables might reflect the fact that transaction costs have a differential impact on households according to whether they are net-buyers or net-sellers and here we are not taking into account this heterogeneity in the households' market position which might confound the estimates for transaction cost variables. A more sophisticated model that takes into account heterogeneity in household market participation could be more appropriate to analyse food markets in this context. We will introduce this more complex model in the next chapter.

The other columns in table 2.6 reports the OLS, random effects, community fixed effects and first difference estimations for the food supply equation as a robustness check. While most of the coefficients have similar values in all the different estimators, the own price elasticity of food becomes negative in the OLS and random effects estimators. While these estimators are inconsistent given the results of the Hausman test which rejects the lack of correlation between the individual effects and the other covariates the change in sign in the food price coefficient might still signal some problem we might need to address. In particular, we might underestimate the underlying supply response by failing to take into account heterogeneity in market participation for food and the fact that some households are self-sufficient for food and thus not responsive to market prices. In the next chapter we will take into account this heterogeneity and estimate a full model of market participation and supply response for food.

Table 2.6 : Food supply

VARIABLES	(1) Household Fixed Effects	(2) OLS	(3) Random Effects	(4) Cluster Fixed effects	(5) First Difference
Log coffee P	0.430***	0.667***	0.572***	0.480***	0.318**
	(0.000142)	(0)	(6.07e-11)	(5.10e-05)	(0.0174)
Log food P	0.0206	-0.290***	-0.164**	-0.0271	0.117
	(0.782)	(0.000200)	(0.0210)	(0.719)	(0.204)
Log kerosene P	-0.230***	-0.393***	-0.318***	-0.270***	-0.280***
	(0.000382)	(2.18e-09)	(1.69e-07)	(4.34e-05)	(2.45e-05)
Log wage	0.110***	0.278***	0.204***	0.109***	0.112***
	(0.000690)	(0)	(0)	(0.000943)	(0.00182)
Transfers	-0.00263	0.0840	0.0472	0.104	0.0674
	(0.964)	(0.304)	(0.510)	(0.202)	(0.266)
Age head	0.0231***	0.00321	0.00976*	0.00579	0.0151
	(0.00560)	(0.588)	(0.0886)	(0.223)	(0.149)
Age square	-0.000196***	-5.07e-06	-6.71e-05	-3.49e-05	-0.000132
	(0.00987)	(0.929)	(0.212)	(0.439)	(0.176)
Female	0.0245	0.181***	0.135***	0.0706*	-0.0311
	(0.718)	(0.000139)	(0.00319)	(0.0540)	(0.710)
Log area	0.0912**	0.233***	0.185***	0.211***	0.0841*
	(0.0118)	(4.71e-08)	(8.76e-07)	(1.11e-08)	(0.0515)
Rainfall	-6.84e-05	-5.16e-05	-5.38e-05	-5.99e-05	-8.29e-05
	(0.125)	(0.186)	(0.128)	(0.196)	(0.126)
Log capital	0.0860***	0.0936***	0.0958***	0.106***	0.0737**
	(0.00101)	(0.000303)	(4.33e-05)	(3.56e-05)	(0.0216)
HHD size	0.0811***	0.0853***	0.0846***	0.0847***	0.0884***
	(0)	(0)	(0)	(0)	(0)
Road distance	0.00960	0.0118	0.00167	-0.00903	0.00606
	(0.622)	(0.423)	(0.900)	(0.660)	(0.814)
Education head	-0.00154	0.0548***	0.0415***	0.0221**	-0.0107
	(0.924)	(5.37e-06)	(0.000171)	(0.0252)	(0.552)
Education square	0.00110	-0.00234***	-0.00132*	-0.000615	0.00163
	(0.323)	(0.00564)	(0.0744)	(0.394)	(0.193)
Transport ownership	0.0432	0.135***	0.108***	0.104***	0.0277
	(0.396)	(0.000389)	(0.00279)	(0.000916)	(0.642)
Road impassable	-0.0154	0.0326***	0.0267***	-0.00431	-0.00374
	(0.333)	(0.000442)	(0.00358)	(0.795)	(0.849)
Market	-0.0600*	-0.208***	-0.152***	-0.0768**	-0.000359
	(0.0825)	(2.45e-10)	(7.86e-07)	(0.0257)	(0.993)
Constant		3.182***		3.715***	
		(2.43e-10)		(4.38e-09)	
Observations	3,471	3,471	3,471	3,471	2,706
R2	0.648	0.382		0.500	0.233
F	47.39	64.69		37.53	35.86
Number of hhd	732	732	732	732	730
Rho	0.428		0.237		
R2_w	0.300		0.288		
R2_b	0.375		0.480		
R2_o	0.335		0.378		
Hausman test		Chi2(24)	201.5		
		p-val	0.000		

Robust pvalues in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Additional variables included in the estimations but not reported are dummies for each of the five waves of the survey and seasonal dummies for the long rain, short rain and dry seasons. For the fixed effects estimation we report both the R-squared for the LSDV model (R2) and the three different R-squared from the within estimator (R2_w, R2_b and R2_o).

Seemingly unrelated regression estimation

The coffee and food supply equations can also be estimated as a system of equations taking advantage of the likely correlation in the error term to increase the efficiency of the estimates. We estimate the system on the subsample of households that produce coffee and food contemporaneously thus the sample is slightly reduced to 2,259 observations. Both equations control for households fixed effects. To account for heteroscedasticity and possible within group correlation of the errors we bootstrap the standard errors. Table 2.7 reports results for this estimation.

Results are similar to the ones obtained from separate estimations. The cross-price elasticity is positive showing again some degree of complementarity. The own price elasticity of coffee is slightly reduced to 0.7 while the food price elasticity increases to 0.14 and is significantly different from zero. Road distance negatively affects coffee production with a point estimate implying an additional kilometer reduces supply by 8%.

Table 2.7 : SUR with fixed effects

VARIABLES	(1) Food	(2) Coffee
Log coffee P	0.568***	0.703***
	(1.99e-07)	(5.07e-06)
Log food P	0.148**	0.0289
	(0.0490)	(0.805)
Log kerosene P	-0.112*	-0.0858
	(0.0882)	(0.403)
Log wage	0.0569*	-0.0730
	(0.0838)	(0.165)
Transfers	0.0269	-0.0564
	(0.786)	(0.461)
Age head	0.0269***	0.0247*
	(0.00111)	(0.0530)
Age square	-0.000221***	-0.000173
	(0.00399)	(0.149)
Female	0.107*	-0.173
	(0.0965)	(0.105)
Log area	0.0553	0.136***
	(0.130)	(0.00576)
Rainfall	-9.69e-05**	0.000132*
	(0.0294)	(0.0543)
Log capital	0.0794***	0.104***
	(0.00222)	(0.00425)
HHD size	0.0649***	0.0199
	(0)	(0.111)
Road distance	0.0105	-0.0896**
	(0.669)	(0.0274)
Education head	0.0137	0.0402
	(0.400)	(0.102)
Education square	0.000568	-0.00143
	(0.638)	(0.424)
Transport ownership	0.00557	0.122*
	(0.906)	(0.0923)
Road impassable	-0.0108	0.0193
	(0.485)	(0.468)
Market	-0.0595*	-0.0828
	(0.0988)	(0.111)
Observations	2,259	2,259
R-squared	0.348	0.132

Bootstrapped P- values in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Evolution of supply response

An interesting feature of the data is the long term longitudinal dimension which permits analyzing how households' behavior has changed from the first round of the survey in 91/93 to the second one in 2004.

In table 2.8 we show the results of the estimation of the supply functions for coffee and food interacting respectively coffee and food price with the 2004 year dummy. The results show that households are more responsive to prices in 2004 but only for food the interaction term is statistically significant.

This result, although not conclusive, seems to give some credit to an increase in price responsiveness over the time frame considered. Given the extensive reforms that have been introduced in Tanzania in that very same period it would be interesting to explore if there are links between the increased price responsiveness and the reforms in the agricultural sector.

The problem we face in establishing any link is that during the nineties Tanzania went through an extensive structural adjustment programme which involved changes in almost all economic sectors and it is thus very difficult to disentangle the effect of specific reforms from the overall adjustment. Also, changes in how supply responds to prices can be due to technological changes which happen independently from any policy action.

Table 2.8 : Evolution of supply response: FE with interaction term

VARIABLES	(1) Coffee	(2) Food
Log food P	0.0170	-0.0322
	(0.908)	(0.683)
Log food P*year04		0.374*
		(0.0535)
Log coffee P	0.682***	0.401***
	(0.000426)	(0.000446)
Log coffee P*year04	0.498	
	(0.121)	
Log kerosene P	-0.101	-0.209***
	(0.408)	(0.00150)
Log wage	-0.0801	0.106***
	(0.192)	(0.00105)
Transfers	-0.0695*	-0.00118
	(0.0536)	(0.984)
Age head	0.0343**	0.0227***
	(0.0451)	(0.00615)
Age square	-0.000263*	-0.000193**
	(0.0880)	(0.0110)
Female	-0.200	0.0201
	(0.129)	(0.765)
Log area	0.109*	0.0912**
	(0.0688)	(0.0118)
Rainfall	0.000167*	-7.23e-05
	(0.0566)	(0.106)
Log capital	0.185***	0.0853***
	(0.000464)	(0.00104)
HHD size	0.0269*	0.0810***
	(0.0518)	(0)
Road distance	-0.122**	0.0124
	(0.0487)	(0.528)
Education head	0.0370	-0.00184
	(0.218)	(0.910)
Education square	-0.000903	0.00115
	(0.660)	(0.299)
Transport ownership	0.125	0.0414
	(0.180)	(0.416)
Road impassable	0.0384	-0.0162
	(0.257)	(0.305)
Market	-0.0884	-0.0570*
	(0.168)	(0.0983)
Observations	2,285	3,471
R-squared	0.149	0.302
Number of hhd	607	732
F	12.44	45.59
r2_w	0.149	0.302
r2_b	0.220	0.374
r2_o	0.210	0.336

Robust pval in parentheses
*** p<0.01, ** p<0.05, *

Testing the difference in supply response

In this section we test empirically the proposition that households facing full functioning markets are more responsive to price changes for cash crops. In particular, we analyzed in the theoretical section the own price elasticity of cash crops for households which have a perfectly functioning market for food crops and compared this to the one of households lacking access to the food market. The theoretical result shows that under certain expectations about key measures as the income elasticity of consumption and the cross elasticity of supply, the latter should be lower. However, we pointed out that different results on these measures, however unexpected they can be, can also reverse this result. In their study, de Janvry, Fafchamps and Sadoulet (1991) use a simulation technique to test this proposition and find that households with missing markets are actually less responsive to changes in the cash crop price.

We test this result on our sample of Tanzanian households comparing the supply response of coffee for households that take part in the market for bananas, the main staple food produced and consumed in the region, and households that instead are self-sufficient.

In doing this comparison we need to take into account the potential selection bias introduced by restricting the sample to participant in the bananas market and self-sufficient. Given that we are using a panel dataset and the Heckman procedure is not readily extensible to this case, we adopt instead the methodology proposed by Wooldridge (1995) to test for selectivity in panel datasets. The methodology consists in estimating the first stage probit equation by pooled probit and then using the inverse mills ratio in the quantity equation. A standard *t*-test for the significance of the inverse mills ratio is a valid test for selectivity even if this procedure is not valid to correct for selectivity.

To reinforce the identification of the model we use three variables as proxy for fixed transaction costs that affect the participation in the food market but not the volume decision, these are the population density of the community were the household resides, a dummy for the ethnic group of the head of the household (taking value of one if the head pertains to the main ethnic group) and a dummy for the presence in the household of a radio or a TV or a telephone. These variables should capture the degree of information and network possibilities the household has and thus the degree of fixed transaction costs as discussed also in Heltberg and Tarp (2002).

Results of the test are presented in table 2.9. The first column shows results for the pooled probit where the dependent variable takes value of one if the household is self-sufficient in the banana market and zero otherwise. The second column estimates the coffee supply function for banana self-sufficient households as a standard fixed effects adding the inverse mills ratio from the first step as a covariate. This is not statistically significant which implies that, once controlling for the fixed effects, there is no selectivity issue and the equation can be estimated as a normal fixed effects on the sub-sample.

Table 2.10 reports estimation of coffee supply for the entire sample of households producing coffee and bananas in the first column and then for the sub-sample of banana self-sufficient households in the second column and for the other household who participate to the banana market in the third column. The results show no substantive difference in price responsiveness between the two groups which is in contrast with the common belief that households who face missing food markets are less responsive on the cash crop market.

There are two main reasons why these estimates can be biased. First, the instruments used to identify the inverse mills ratio when testing for selectivity might be inappropriate leading to a false rejection of the hypothesis of the presence selection bias. Of the instruments used only population density is statistically significant and there are reasons to think that this variable might not be orthogonal to the supply decision.

The second reason relates to the fact that multiple market imperfections are possible in particular on the labour and credit market and this can interact with imperfections on the food market confounding the estimates. Accounting for multiple market imperfections is infeasible with small datasets like the one we are using.

Table 2.9 : Wooldridge test for selectivity

VARIABLES	(Probit) Self-sufficient bananas	(Fixed Effects) Coffee production
Log coffee P	-0.629***	1.083
	(0.000503)	(0.151)
Log food P	-0.0417	0.232
	(0.782)	(0.522)
Log kerosene P	-0.00650	0.0178
	(0.960)	(0.952)
Log wage	0.141**	-0.437**
	(0.0280)	(0.0498)
Transfers	-0.151	0.226
	(0.269)	(0.251)
Age head	-0.00545	0.0148
	(0.574)	(0.732)
Age square	9.51e-05	0.000272
	(0.300)	(0.486)
Female	-0.0527	0.117
	(0.489)	(0.735)
Log area	-0.0701	0.123
	(0.304)	(0.483)
Rainfall	0.000184***	0.000364
	(0.00320)	(0.219)
Log capital	0.0741	0.0128
	(0.141)	(0.944)
HHD size	0.0176	0.0209
	(0.103)	(0.624)
Road distance	-0.0285	-0.291***
	(0.528)	(0.00659)
Education head	0.0199	0.00801
	(0.380)	(0.930)
Education square	-0.00387**	0.00410
	(0.0399)	(0.625)
Transport ownership	0.0477	0.297
	(0.481)	(0.184)
Road impassable	0.0579***	-0.0371
	(0.000300)	(0.685)
Market	-0.0407	0.0340
	(0.551)	(0.832)
Density	-0.000179**	
	(0.0103)	
Main ethnic group	-0.0951	
	(0.170)	
Tv radio phone ownership	0.0209	
	(0.758)	
	(0.0109)	
Inverse Mills Ratio		**-0.587**
		(0.682)
Constant	1.428	
	(0.132)	
Observations	2,251	679
r2_p	0.0453	
Number of hhd		363
F		6.118
r2_w		0.213
r2_b		0.104
r2_o		0.0982

Robust pvalues in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.10 : Separate FE estimations

VARIABLES	(3) Overall	(4) Autarkic	(5) no-autarky
Log coffee P	0.821***	0.859*	0.850***
	(1.13e-05)	(0.0679)	(0.000366)
Log food P	0.0682	0.197	-0.117
	(0.645)	(0.573)	(0.540)
Log kerosene P	-0.120	0.00747	-0.117
	(0.335)	(0.979)	(0.457)
Log wage	-0.0822	-0.381**	0.0314
	(0.182)	(0.0155)	(0.684)
Transfers	-0.0376	0.159	-0.0464
	(0.327)	(0.235)	(0.345)
Age head	0.0319*	0.0113	0.0361*
	(0.0688)	(0.787)	(0.0830)
Age square	-0.000227	0.000319	-0.000310*
	(0.150)	(0.391)	(0.0970)
Female	-0.187	0.105	-0.287*
	(0.169)	(0.763)	(0.0820)
Log area	0.118*	0.0918	0.0683
	(0.0522)	(0.555)	(0.340)
Rainfall	0.000169*	0.000458**	0.000148
	(0.0581)	(0.0233)	(0.194)
Log capital	0.164***	0.0481	0.153***
	(0.00170)	(0.751)	(0.00888)
HHD size	0.0279**	0.0275	0.0405**
	(0.0471)	(0.494)	(0.0191)
Road distance	-0.127**	-0.302***	-0.0438
	(0.0431)	(0.00432)	(0.527)
Education head	0.0372	0.0148	0.0629*
	(0.220)	(0.865)	(0.0748)
Education square	-0.000953	0.00265	-0.00436**
	(0.645)	(0.714)	(0.0483)
Transport ownership	0.120	0.314	0.282**
	(0.212)	(0.151)	(0.0136)
Road impassable	0.00827	-0.0164	-0.00640
	(0.823)	(0.824)	(0.885)
Market	-0.0860	0.00682	-0.177**
	(0.188)	(0.963)	(0.0355)
Observations	2,251	679	1,572
Number of hhd	604	363	556
F	12.32	6.514	9.938
r2_w	0.147	0.212	0.174
r2_b	0.222	0.0999	0.226
r2_o	0.210	0.0942	0.204

Robust pval in parentheses
*** p<0.01, ** p<0.05, *

2.5 CONCLUSIONS

In this paper we estimated the supply response for cash and food crops for a sample of farmers in the Kagera region of Tanzania using a long term panel dataset of households in the region. The use of this data permits to control for households unobserved time invariant characteristics and at the same time to analyze the impact of some variables of interest which are quasi-fixed in the short term.

We find a positive own price supply elasticity for coffee while food supply is found to be unresponsive to prices. We investigate the impact of transaction costs on production and find that households more distant from a road produce less coffee. One kilometer of additional distance reduces supply by 12%.

We find limited evidence that farmers are becoming more responsive to prices but further research is needed to understand better the drivers of this evolution. We also find no evidence that households facing market imperfections on the food market are less responsive to prices for the cash crop. An overall test for separability rejects the separability assumption.

Chapter 3

Supply response, market participation and transaction costs in food markets: evidence from a Tanzanian panel

3.1 Introduction

This chapter analyses the role barriers to trade in the form of high transaction costs have on market participation and supply response in rural food markets in developing countries.

Exploiting the availability of a long term panel dataset we develop an error components switching regression model that takes into account individual unobserved heterogeneity. The switching regression model endogenizes the three possible households' choices of being a food buyer, seller or self-sufficient and shows that measures of transaction costs are both economically and statistically significant in explaining an increase in food domestic production for buyers and a reduction for sellers. This implies a reduction in the role of market exchange and a lower degree of specialization that would otherwise arise in absence of transaction costs. The results also show the importance of households' heterogeneous market participation for the estimation of supply response.

High transaction costs have been considered an important feature characterizing the functioning of rural markets in developing countries. A general definition of transaction costs identifies them as all those costs that agents have to incur in order to conclude a market transaction beyond the price of the good or service which are the immediate object of the transaction.

The literature on the argument (Goetz 1992, Heltberg and Tarp 2002, Key et al. 2000) has usually distinguished between two different types of transaction costs: proportional transaction costs (*PTC*) and fixed transaction costs (*FTC*). The former vary in function of the quantity traded and the latter instead are a lump sum representing the one off cost of entering a market irrespective of the quantity traded.

PTCs include the costs of transferring the good traded such as its transport and the time spent in between to reach the market. *FTCs* include the costs of: a) searching for a market or a trading partner; b) negotiating and bargaining; c) screening, enforcing and supervising contracts.

The main challenge we face when analyzing the impact of transaction costs is that they are usually not observed and measured directly in most surveys. What we often observe are some factors which are thought to affect them. For example, *FTCs* such as searching, screening and so on are very difficult to quantify directly but we can instead observe other variables which indicate agents' degree of information and network relationship available which are expected to determine their *FTCs*.

The effect that transaction costs have on farmers is twofold: on the one side they directly affect the effective price received by sellers and paid by buyers and thus the quantities exchanged. On the other side, transaction costs also generates heterogeneity in the way households relate to markets and can potentially explain why some farmers decide to take part to the market exchange while others remain self-sufficient. In particular fixed transaction costs can be seen as barrier to trade which need to be overcame if the farmer has to take part to the market.

The implication for the estimation of agricultural supply response is that both the heterogeneity in market participation and the role of non-price factors have to be taken into account to obtain correct estimates of supply response. In particular, accounting for the heterogeneity in market participation implies the estimation of separate supply functions for each market regime as they are likely to behave differently and to respond to different incentives.

In the following sections after a review of the literature on supply response and market participation we review the theoretical framework which incorporates transaction costs, heterogeneity in market participation and supply response. Then we account for the problem we have to face when using a panel data for this analysis and our strategy to address it. We then report the results of the empirical analysis and finally draw some conclusions.

3.2 Literature review

Several studies have addressed under a wide spectrum of angles and methodologies the role that transport costs, infrastructure, isolation and transaction costs play in shaping economic decisions and the process of economic development. In recent years a number of studies have dedicated an increasing amount of attention to the role of rural infrastructure in developing countries identifying channels reasons through which rural infrastructure and transaction costs can influence agricultural production, income and poverty in developing countries' rural areas.

Transportation and transaction costs can affect directly agricultural productivity and output. Productivity can be affected through input adoption as the price of imported inputs rises the higher are transportation costs but also through increased price volatility or differing specialization patterns and crop mix. Stifel and Minten (2008) present evidence that transportation costs reduce rice yields and input use in Madagascar. Dorosh et al. (2010) also show a significant effect of road infrastructure on agricultural output and input adoption using a more aggregated cross-sectional spatial approach for Sub-Saharan Africa.

One factor explaining the inverse relationship between productivity and transportation costs runs through the effect they have on the level of specialization and choice of the crop mix. The evidence on the link between transaction costs and specialization is mixed. Qin and Zhang (2011) directly link the Herfindal specialization index to road access in a Chinese rural province and find a higher degree of specialization among better connected households. Stifel et al (2003) found for a sample of households in Madagascar a lower level of concentration of agricultural production in more isolated areas and a shift towards staple food production at the expenses of more valuable crops. On the other hand, Gibson and Rozelle (2003) find that increased isolation reduces the number of income generation activities pursued by households and thus increases specialization of income sources. Omamo (1998) uses simulation techniques to show that households facing higher transaction costs tend to alter the crop mix and increase the share of food crops at the expenses of cash crops.

A somewhat different but interrelated aspect implied by high transaction costs concerns the impact they have on the degree of commercialization and on farmers' market participation decisions. The literature on market participation and transaction costs has shown that high transaction costs can drive households out of the market as an optimal strategy to avoid high fixed and proportional transaction costs (De Janvry et al. 1991).

The main implication of this finding is that transaction costs will generate heterogeneity in how households relate to the market as some will optimally choose not to take part to market transactions. This in turn might imply heterogeneous behavior that needs to be taken into account in empirical applications and requires an appropriate econometric strategy.

Goetz (1992) in his pioneer study of Senegalese grain market analyses the marketing behavior of buyers and sellers respectively. He models the discrete market participation decision of buyers and sellers and then estimates separate market surplus equations accounting for selectivity into the corresponding regime. The evidence is not totally conclusive but it does show that information is a significant driver of market participation decisions. The drawback of this study is that it looks only at how fixed transaction costs influence households' decision to enter the market while not allowing for the role of transaction costs in influencing the quantity transacted.

With a similar approach, Heltberg and Tarp (2002) in their study of supply response in Mozambique model selling farmers' marketing behavior. They found evidence that ownership of a means of transport and proximity to a railway increases both the likelihood of entering the market as a seller and the quantity sold. The break-down of the marginal effect into the entry/exit and quantity components shows that the first effect is substantially larger. Implying that promotion of market access can solicit a greater volume of additional supply from peasants entering the market for the first time than for existing participants. The study suffers from two shortcomings. First, they use cross-sectional data and are not able to identify any price effect which limits their ability to compare the effectiveness of price versus non-price factors in increasing market participation and sales. Second, the proxy used for fixed transaction costs as population density and information dummy are not statistically significant casting some doubts on the identification of the model.

Key, Sadoulet and de Janvry (2000) follow a different approach in their study of Mexican farmers' participation in the maize market. They estimate a structural model of market participation and supply decisions taking into account the distinct role of proportional and fixed transaction costs. They jointly estimate the supply functions and the production thresholds using a censoring model with unobserved censoring thresholds. Here the focus is not on marketing behavior but on production behavior given the heterogeneity in market participation. They found that both proportional and fixed transaction costs do matter for market entry and output decisions.

Bellemare and Barrett (2006) look at the pastoralists' participation in livestock markets in Ethiopia and Kenya and estimate the determinants of marketing surplus for the different regimes of net-buyers, net-sellers and self-sufficient. Ouma et al. (2010) analyze smallholders' participation in banana markets in Central Africa adopting an approach very similar to the one presented by Goetz (1992) showing that farmers located one hour further from the nearest urban market reduce the transacted quantities by 17% for sellers and 12% for buyers. Alene et al. (2008) present a study of maize supply and fertilizer demand in Kenya and find that farmers located far from the market reduce transacted quantities by 62%.

Some of the above studies look at the market surplus as opposed to supply. Their aim in that case is to analyze marketing behavior estimating the determinants of the quantities bought or/and sold while controlling for the endogenous selection into the respective market participation regime. Other studies look instead at the production side only and estimate the determinants of quantity produced controlling for regime selection.

Other studies have focused more on the role of transaction costs in the labour and land market. Carter and Yao (2002) estimates regime specific equations for the households' labor intensity taking into account their participation regime in the land rental market. The transaction cost in their study is a measure of legal limitations which encumber transactions in the land market in China. They use an ordered probit as selection equation and estimate both selection and outcome equations using simulated maximum likelihood. They use a panel dataset of Chinese households and make use of a correction to control for households' fixed effects. Sadoulet, de Janvry and Benjamin (1998) model households labor intensity distinguishing across regimes of participation in the labor market for a sample of Mexican households. They apply a two-step procedure à la Heckman where however the first step selection equation is an ordered probit.

The above studies while all pertaining to the same stream of literature on market participation and transaction costs differ in some important aspects. The econometric strategy varies. Some studies make use of the ordered structure of the regime choice while others do not. As we will show in the theoretical model in the next section an ordered structure for the market participation decision is in principle preferable as it exploits the ordered structure of the relationship, but it also complicates the estimation.

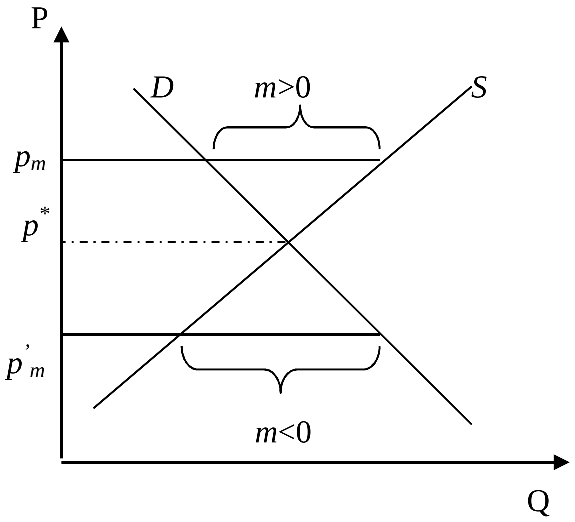
The type of data used is generally cross-sections, only few studies make use of longitudinal data in this literature and when they do, apart from Carter and Yao (2002), they treat them as cross-sections even if the econometric literature has established the potentially serious biases this procedure involves when individual unobserved heterogeneity is present. The availability of longitudinal data potentially also opens up the possibility to explore the dynamic pattern of market participation. The main aim of this paper is to address these shortcomings and use the longitudinal data at hand to incorporate unobserved heterogeneity into the analysis.

3.3 Theoretical framework

Before introducing a more formal treatment of the implication of transaction costs for market participation and the estimation of the supply function it will be useful to look at the intuition behind just comparing the scenarios in presence and absence of transaction costs.

Consider a farm household which both produces and consumes food. The household will be characterized by a demand and a supply function (*figure 3.1*). In absence of transaction costs the household is a net-seller if the market price (p_m) is higher than the shadow price (p^*) defined as the price that would equate demand and supply of the household. In a similar way the household would be a net-buyer if the shadow price is higher than the market price (p'_m). The passage from being a net-buyer to being a net seller is a continuous one and only in the limited case when the shadow price equals exactly the market price non-participation in the market would be a utility maximizing choice.

Figure 3.1 Net-sellers and net-buyers



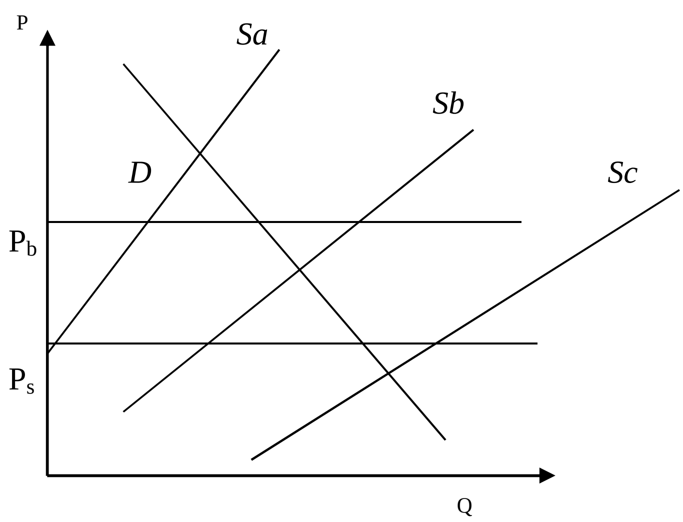
Thus, in absence of transaction costs households face a single price for buying and selling and all will take part in the market either as buyers or sellers. The set of autarchic households should tend towards emptiness.

The introduction of proportional transaction costs, as said, would increase the effective price paid by buyers while reducing the effective price received by sellers and thus generates a price band between the two prices. As in the case where there are no transaction costs, the choice of the regime of market participation is based on comparing the utility obtained in the different regimes for a particular commodity. The difference is that the presence of a price band is likely to generate a set of households for which utility is maximized by being self-sufficient and not taking part to the market exchange.

A third regime, autarky or self-sufficiency, is now possible and market participation becomes a discrete choice for effect of the price band generated by transaction costs.

The utility obtained in different regimes and thus the decision on whether to take part in the market depends on a comparison between the shadow price of those goods with the buying and selling market prices. If the shadow price is higher than the buying price then the household will maximize its utility level by being a net-buyer. If the household shadow price is below the market selling price then the household will be better off as a net-seller. Finally, if the shadow price falls within the band non-participation is the utility maximizing strategy for the household. *Figure 3.2* represents three different hypothetical households differing only in term of the supply (*Sa*, *Sb* and *Sc*). The different point where supply crosses demand determines household's market position.

Figure 3.2 Households' market position



The role of transaction costs can be analyzed in a formal model which endogenises market participation decisions. The model presented below follows closely the one proposed by Key et al (2000), one of the most complete expositions of the role of transaction costs in rural food markets. Consider a utility maximizing household which consumes a set of goods c_i and produces q_i agricultural products. To simplify notation let's define m_i as the marketed surplus for good i and express the cash constraint in terms of marketed surplus taking into account transaction costs. Market prices are corrected for proportional transaction costs which add to the market price in case of goods purchased ($m_i < 0$) and reduce the effective sale price ($m_i > 0$). Transaction costs (τ) are differentiated between proportional (τ_{pi}) and fixed (τ_{fi}) transaction costs and between buyers (τ^b) and sellers (τ^s). They are not directly observed but some factors affecting them (f_t) are observed. z^c and z^p are respectively households' consumption and production shifters. The household's problem is to choose quantities of consumption goods in order to maximize utility subject to a set of constraints:

$$
\begin{aligned}
&\max_{c} U(c_i; z^c) \\
&\text{s.t} \\
&g(q_i; z^p) = 0 \\
&q_i - m_i - c_i = 0 \\
&\sum_{i=1}^{N} \left[(p^m - \tau^s_{pi}(f^s_t))\delta^s_i + (p^m + \tau^b_{pi}(f^b_t))\delta^b_i \right] m_i - \tau^s_{fi}(f^s_t)\delta^s_i - \tau^b_{fi}(f^b_t)\delta^b_i + E = 0
\end{aligned}
$$

The first constraint is a standard well-behaved production function. The second is a resource constraint imposing that quantities consumed are equal to quantities produced deducted (added) sales (purchases). The third constraint is a cash constraint imposing that expenditures need to be equal to revenues from the sale of farm products plus the exogenous income E taking into account proportional and fixed transaction costs (δ^j_i

takes value of one if the household is class j and zero otherwise). The lagrangian for this problem is:

$$
\begin{aligned}
L &= U(c_i; z^c) \\
&+\lambda[\sum_{i=1}^{N}\left[(p^m - \tau_{pi}^s(f_t^s))\delta_i^s + (p^m + \tau_{pi}^b(f_t^b))\delta_i^b\right] m_i - \tau_{fi}^s(f_t^s)\delta_i^s - \tau_{fi}^b(f_t^b)\delta_i^b + E] \\
&+\phi g(q_i; z^p) + \eta(q_i - m_i - c_i)
\end{aligned}
$$

Given the presence of fixed transaction costs which generates discontinuities in the Lagrangean function Key et al. (2000) show how the solution can be decomposed into two steps, first finding the optimal solution conditional on the market participation regime and then choosing the market participation regime which maximizes utility.

The first order conditions for consumption goods, outputs and traded goods assuming interior solutions are respectively:

$$
\begin{aligned}
&\frac{\delta U}{\delta c_i} - \eta = 0 \\
&\phi \frac{\delta g}{\delta q_i} + \eta = 0 \\
&\lambda\left[(p^m - \tau_{pi}^s(f_t^s))\delta_i^s + (p^m + \tau_{pi}^b(f_t^b))\delta_i^b\right] - \eta = 0
\end{aligned}
$$

We can define the decision price as:

$$
p_i = \begin{cases} p_i^m - \tau_{pi}^s & \text{if } m_i > 0, \text{ seller} \\ p_i^m + \tau_{pi}^b & \text{if } m_i < 0, \text{ buyer} \\ \mathrm{p_i^*} = \dfrac{\eta}{\lambda} & \text{if } m_i = 0, \text{ self-sufficient} \end{cases}
$$

The problem is now to choose the utility maximizing regime by comparing utilities under different regimes. Using the above defined decision price we can define the maximum utility attained in each regime using the same indirect utility function $V(p_i, y, z^c)$. Define $y_0(p_i)$ as the household income before incurring any fixed transaction costs:

$$y_0(p_i) = \sum_{i=1}^{N} p_i q_i + E$$

Then the utility levels for different regimes can be written as:

$$V^s = V(p^m - \tau_p^s, y_0(p^m - \tau_p^s) - \tau_f^s, z^c) \quad \text{if seller}$$
$$V^b = V(p^m + \tau_p^b, y_0(p^m + \tau_p^b) - \tau_f^b, z^c) \quad \text{if buyer}$$
$$V^a = V(p^*, y_0(p^*), z^c) \quad \text{if autarkic}$$

These expressions show that in absence of fixed transaction costs the household would be indifferent between selling and being self-sufficient if $p^* = p^m - \tau_p^s$. From the FOC it can be shown that utility is increasing in the decision price for sellers and decreasing in the decision price for buyers. Thus, if $p^m - \tau_p^s > p^*$ a household facing no fixed transaction costs would be better off selling. In a similar way, the household will be indifferent between buying and being self-sufficient if $p^* = p^m + \tau_p^b$ and it would be better-off buying on the market if $p^m + \tau_p^b < p^*$.

Figure 3.3 Indirect utility function

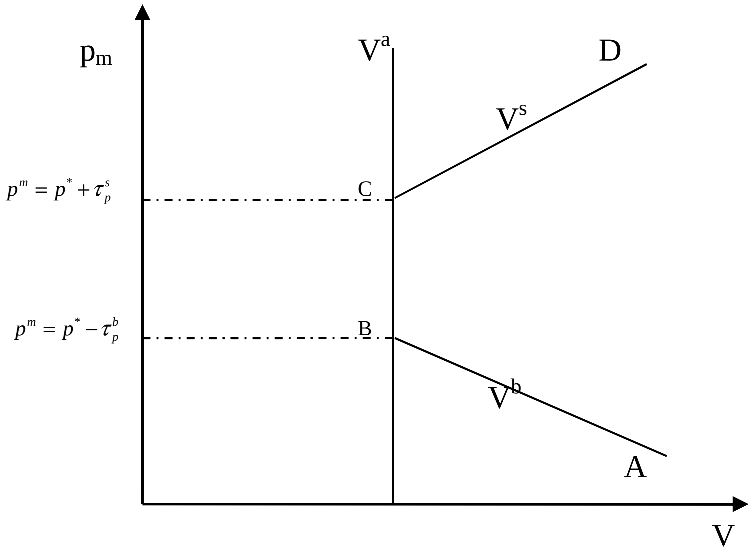
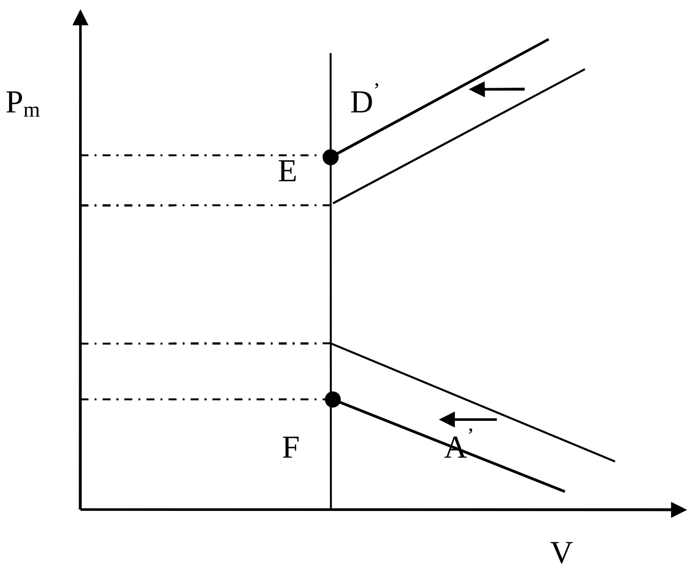


Figure 3.3 shows the indirect utility function *V* as a function of the market price. The vertical line shows the utility attainable by autarkic households which is independent of the market price. At point C the household will be indifferent between selling and being autarkic and for prices above C it will be a seller with utility increasing with price. At point B the household will be indifferent between buying and being autarkic and for prices below B it will be better-off buying with utility decreasing with the price. If the market price is between B and C the household will be better-off staying in autarky. The optimal market participation strategy is ABCD.

The implication of the introduction of fixed transaction costs as well as the proportional ones can be shown looking at the fact that fixed transaction costs lower household income and thus utility for each level of price. This will shift the utility curves to the left as shown in *figure 3.4*. Fixed transaction costs will thus discourage households from entering the market until the price is sufficiently high (low) to cover fixed transaction costs for sellers (buyers), points E and F in *figure 3.4*.

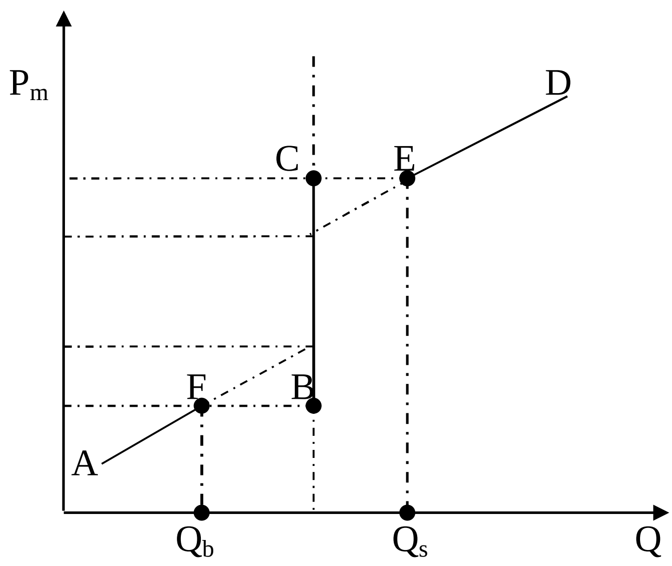
Figure 3.4 Fixed transaction costs



However, fixed transaction costs do not enter household's supply curve because only the marginal return to production affects production decisions. The first implication of this finding is that once entering the market either as a buyer or seller there will be a discrete jump in the quantity produced as the decision price will change discretely. The supply function derived has three distinct regimes for different price levels and is shown in *figure 3.5*. The vertical part of the supply function corresponds to the autarkic regime which is unresponsive to prices. The lower segment AF is the buying region and finally the upper segment ED corresponds to the selling region. The discrete change in the quantities produced when entering the market either as buyer or seller can also be seen in *figure 3.5* at the points Q_s and Q_b. These two quantities are the quantity thresholds below which it is not optimal for the household to enter the market.

The second important implication of this distinct role of fixed transaction costs is that it gives a way of econometrically identifying the parameters of both the market participation and volume decisions.

Figure 3.5 Supply function



The above analysis has several implications for the estimation of supply response.

First, we need to take into account the unresponsiveness of autarchic households. Unless this is accounted for it is likely that pooled estimates of the true underlying supply response will be downward biased.

Pooled estimates of the supply response would in principle provide an unbiased estimate of the unconditional supply response. They present an appropriately weighted average of the positive supply responses of households taking part to the market and the null supply response of self-sufficient households. However, pooled estimates cannot provide an unbiased estimate of the underlying supply elasticity conditional to the market participation regime which is an important piece of information if we want to evaluate the impact of different policies on different subsamples. Moreover, pooled estimates cannot take into account the fact that households could potentially switch regime following a price change changing in this way the weights of the simple elasticities.

Second, changes in prices and other non-price factors which affect market participation decisions should be accounted for in the estimation of the overall supply response. Third, transaction costs have a different impact on buyers and sellers and estimation of regime specific supply functions can help identify and test the effective importance of transaction costs on production behavior. For a seller an increase in transaction costs is expected to have a negative effect on production. For a buyer instead an increase in transaction costs is expected to have a positive impact on production.

In the following sections, after discussing the econometric challenges we face when using longitudinal data in this context, we will try to estimate empirically this model and analyze in a coherent framework market participation and supply decisions.

3.4 Discrete choice models for longitudinal panel data

The analysis of how transaction costs affect the market participation decision and how this decision in turn affects supply response implies the need for models able to consider simultaneously the discrete choice on market participation and the continuous one regarding output. The literature on discrete choice models and selection models is very extensive and several different techniques have been developed[14]. The extension of these techniques to longitudinal panel data is however not completely straightforward and developments in this area for panel data have been slower. This section analyses the econometric problems related to applying discrete choice modeling to panel data.

The easiest way to show the problems that discrete choice models present in a panel data context is to analyze the basic probit model which serves as the basis for other more complex extensions as ordered and selection models.

The distinction between random and fixed effects normally made in a linear context also applies to discrete choice models. The key difference is that a fixed effect estimator does not pose any restriction to the correlation structure of the individual heterogeneity and the set of explanatory variables while the random effect model assumes that there is no correlation between the individual heterogeneity and the other covariates. This

[14] See Greene (2008) for a review.

assumption, needed for consistency of the random effect model, is an important drawback in most applications.

There are no particular problems in extending the random effect specification to discrete choice models like the probit model. However, the same is unfortunately not true for the fixed effect specification which has been shown in different studies to be an inconsistent estimator of the underlying parameters. The main aspect to notice here is that, as opposed to linear panel models, here it is not possible to find a suitable transformation (like the within transformation) that removes the individual effects. The only alternative is to include the full set of dummies and estimate what Greene (2001) calls a *brute force* estimator. This option is feasible computationally (although quite intensive) but suffers from the incidental parameter problem. This problem arises because a sufficient statistic able to sweep out the fixed effects is not available and slope parameters have to be estimated as a function of the fixed effects. Estimates of the fixed effects are inconsistent in small *t* panels (they do not converge asymptotically to the true parameter if *n* increases but *t* doesn't) and this means that also the slope parameters would be inconsistent.

In the absence of a fixed effect estimator the model can be estimated as a random effects model. The additional assumption needed for consistency of the random effects is that the individual specific effects are normally distributed with zero mean and constant variance:

$$u_i \sim N\ [0, \sigma_u^2]$$

The difficulties in estimating discrete choice models for panel data also carry over to models of sample selection which are further complicated by the fact that the common two-step Hackman procedure[15] often used in cross-sectional analysis to control for selectivity is not readily available for panel data. The sample selection bias may arise because the subsample of households not participating in the food market is non-randomly selected.

A general model with selection can be formalized as follow:

$$y_i^* = \beta x_i + \varepsilon_i$$
$$d_i^* = \gamma z_i + v_i$$
$$d_i = 1 \text{ if } d_i^* > 0; \;\; d_i = 0 \text{ otherwise}$$
$$\text{y}_i = y_i^* * d_i$$

*d** represents the selection equation while *y* is the outcome variable of primary interest.

The main problem in this setting is that it is likely in most applications that unobservables affecting the selection decision are correlated with the unobservable in the outcome equation:

$$E(\varepsilon_i, v_i) \neq 0$$

If that is the case the errors in the selection and outcome equations are likely to be correlated. OLS over the sub-sample where $d_i = 1$ would give biased and inconsistent estimates for the correlation of x and ε introduced through the correlation of v and ε.

A common solution to the general selection problem is Heckman's two-step estimation. Consider a situation where in the model above specified ε and *v* have a bivariate normal distribution with covariance $\sigma_{\varepsilon v}$.

$$\varepsilon, v \sim BVN(0, 0; \sigma_\varepsilon^2, \sigma_v^2; \sigma_{\varepsilon v})$$

[15] Heckman (1979).

We are interested in the determinants of *y* for a selected sample of households where *d** exceeds zero and thus $d_i = 1$. Defining ϕ and Φ as respectively the normal density and cumulative distributions we have:

$$\begin{aligned} E[y_i \mid d_i = 1] &= E[y_i \mid d_i^* > 0] \\ &= E[y_i \mid v_i > -\gamma z_i] \\ &= \beta x_i + E[\varepsilon_i \mid v_i > -\gamma z_i] \\ &= \beta x_i + \frac{\sigma_{\varepsilon v}}{\sigma_v^2} E[v_i \mid v_i > -\gamma z_i] \\ &= \beta x_i + \frac{\sigma_{\varepsilon v}}{\sigma_v^2} \sigma_v \frac{\phi(-\gamma z / \sigma_v)}{1 - \Phi(-\gamma z / \sigma_v)} \\ &= \beta x_i + \rho \sigma_\varepsilon \frac{\phi(\gamma z / \sigma_v)}{\Phi(\gamma z / \sigma_v)} \end{aligned}$$

The model then becomes:

$$[y_i \mid d_i = 1] = E[y_i \mid d_i = 1] + u_i = \beta x_i + \beta_\lambda \lambda(\gamma z_i) + u_i$$

OLS estimation on the selected sample without correction leads to biased estimates because of the omission of the relevant term λ, the inverse Mills ratio.

An important issue concerning the Heckman procedure is the identification strategy. In principle the model can be identified through non-linearities in the probit model. However, this strategy can result in a weak identification with inflated second step standard errors and unreliable estimates of the coefficients (Vella 1998). To avoid these problems additional variables included in the selection equation but excluded from the outcome equation should be found in order to help identification.

The extension of the selection model to a panel data setting is not straightforward. Rewriting the above selection model to take into account the longitudinal nature of the data we obtain:

$$y_{it}^{*} = \beta x_{it} + \mu_i + \varepsilon_{it}$$
$$d_{it}^{*} = \gamma z_{it} + \alpha_i + v_{it}$$
$$d_{it} = 1 \text{ if } d_{it}^{*} > 0; \;\; d_{it} = 0 \text{ otherwise}$$
$$\mathrm{y}_{it} = y_{it}^{*} * d_{it}$$

In this case the two error components, individual heterogeneity (μ_i) and idiosyncratic error (ε_{it}), are assumed to be correlated with the same component in the other equation generating a problem of selection.

Looking at the fixed effect estimator we can derive the conditions for its consistency following Wooldridge (2010) and Vella (1998). Applying the within transformation to the data we obtain the fixed effect estimator of β as follow:

$$\hat{\beta} = \left(N^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} d_{it} \ddot{x}_{it}^{'} \ddot{x}_{it} \right)^{-1} \left(N^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} d_{it} \ddot{x}_{it}^{'} \ddot{y}_{it} \right)$$
$$= \beta + \left(N^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} d_{it} \ddot{x}_{it}^{'} \ddot{x}_{it} \right)^{-1} \left(N^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} d_{it} \ddot{x}_{it}^{'} \varepsilon_{it} \right)$$

Where

$$\ddot{x}_{it} = x_{it} - T_i^{-1} \sum_{t=1}^{T} d_{it} x_{it} \qquad \ddot{y}_{it} = y_{it} - T_i^{-1} \sum_{t=1}^{T} d_{it} y_{it} \qquad T_i = \sum_{t=1}^{T} d_{it}$$

Consistency of the fixed effect model thus requires $E(d_{it} \ddot{x}_{it}^{'} \varepsilon_{it}) = 0$. This in turn requires

$$E(\varepsilon_{it} \mid x_{it}, d_{it}, \mu_i) = 0$$

which imposes no restrictions on the relationship between d_i and (x_i, μ_i). The only restriction is that the idiosyncratic error is independent of the selection indicator which in turn requires no correlation between ε and v.

Thus, consistency of the fixed effect estimator would be guaranteed if the selection operates only through the individual specific effect α_i. The same result does not apply for the random effect estimator which instead is inconsistent also if the selection operates through the individual effect. In principle, in situations in which we are confident that the selection operates only through the individual effect we could estimate a fixed effect model neglecting the selection issue. However, these conditions are not always met and it is important to at least test for selection in any case.

However, extending the Heckman procedure to panel data presents several complications that are not easy to address. The first of these is the inconsistency of the fixed effects probit estimator for small *t*-dimension panels discussed above which brings us far away from the use of fixed effects estimators.

A first idea would be to run a pooled probit for the selection equation, obtain the inverse Mills ratio and estimate the outcome equation by fixed effects including the selection correction. This method however does not produce consistent estimators either (Wooldridge 2010).

A second option, adopted by Ridder (1990) and Nijman and Verbeek (1992) would be to estimate the first step by random effects probit, obtain correction terms and then estimate the second step by OLS with the correction terms added. This procedure closely resembles the Heckman procedure but the correction terms have a different and more complex form than the inverse Mills ratio.

Other models to correct for selectivity in panel data have been developed. In particular, we will focus in our empirical application on a model proposed by Zabel (1992) which departs from two-step procedures and proposes a Full Information Maximum Likelihood (FIML) estimation. This significantly increases the computational burden of the estimation but provides a coherent framework for the joint estimation of selection and outcome equations.

In the next section we adapt Zabel's model to the ordered nature of our problem to analyze supply decision controlling for the market participation regime.

3.5 Supply response and market participation: A panel selectivity model with an ordered probit selection rule

We adopt a Full Information Maximum Likelihood approach instead of the two step procedure. The model was first proposed by Zabel (1992) in the context of a binary probit selection rule and as an alternative to other two step procedure developed before. As shown above, in our case an ordered selection rule would be more appropriate. The main drawback of Zabel's approach was its computational intensity but as noted in Greene (2006) the development of simulation methods have to some extent made it easier to estimate such models. Carter and Yao (2002) present one application of the same family with an ordered probit selection rule.

We sort individuals (or households) into J+1 classes according to an ordered probit selection rule:

$$d^*_{it} = \gamma' Z_{it} + r_i + u_{it}$$

$$d_{it} = \begin{cases} 0 \text{ if } -\infty < \mathrm{d}^*_{it} \le \mu_0 \\ 1 \text{ if } \mu_0 \le \mathrm{d}^*_{it} \le \mu_1 \\ 2 \text{ if } \mu_1 \le \mathrm{d}^*_{it} \le \mu_2 \\ \ldots\ldots. \\ J \text{ if } \mu_{j-1} < \mathrm{d}^*_{it} < +\infty \end{cases}$$

where d^*_{it} is a latent unobserved variable assumed to be dependent on a vector of explanatory variables Z, a vector of unknown parameters γ, an individual specific heterogeneity component r_i assumed to be random and an idiosyncratic random term u_{it}. What we actually observe is the discrete variable d_{it} which takes values from 0 to J to distinguish the J+1 classes.

For each of the J+1 classes we observe an outcome variable:

$$Y_{itj} = \beta'_J X_{itJ} + v_{iJ} + \varepsilon_{itJ} \quad \text{with } d_{it} = 0,1,..,J$$

Y_{itj} is the outcome variable, at time *t* for household *i* belonging to class *j* and is a linear function of a vector of explanatory variables X_{itj}, an individual specific time invariant random effect v_{ij} and an idiosyncratic error term ε_{itj}.

Both the outcome and selection equations allow for the presence of individual random effects. There are J+1 random effects in the outcome equations and an additional one in the ordered probit equation for a total of J+2 random effects. The assumptions needed for the random components and the idiosyncratic error are:

$$v_{ij} \sim N(0, \sigma^2_{vj})$$
$$\varepsilon_{itj} \sim N(0, \sigma^2_{\varepsilon j})$$

for the outcome equations and

$$r_i \sim N(0, \sigma_r^2)$$
$$u_{it} \sim N(0,1)$$

for the ordered probit selection equation. The variance of u is normalized to unity for identification purposes.

To simplify the estimation we assume the individual-specific error terms are uncorrelated with each other, an assumption which could in principle be relaxed. Each of the idiosyncratic error terms in the outcome equations ε_{itj} and the one in the selection equation u_{it} have instead correlation coefficient ρ_j. Thus, ε_{itj} and u_{it} follow a bivariate normal distribution:

$$(\varepsilon_{itj}, u_{it}) \sim N_2(0,0;\sigma_{\varepsilon j}^2, 1; \rho_j \sigma_{\varepsilon j}^2)$$

The likelihood for individual i has the following form:

$$L_i = \prod_t f(y_{itj}) \times \Pr(d_{it} = j \mid y_{itj})$$
$$= \iint \prod_t \frac{1}{\sigma_{\varepsilon j}} \phi(t_{itj}) \left[\Phi\left(\frac{\gamma Z_{it} + r_i + \rho_j t_{itj} - \mu_{j-1}}{\sqrt{1-\rho_j^2}} \right) - \Phi\left(\frac{\gamma Z_{it} + r_i + \rho_j t_{itj} - \mu_j}{\sqrt{1-\rho_j^2}} \right) \right] \phi(v_{ij}) \phi(r_i) \, dv_{ij} dr_i$$

Where $t_{itj} = \dfrac{y_{itj} - \beta_j^{'} X_{itj} - v_{ij}}{\sigma_{\varepsilon j}}$, ϕ is the standard normal density function and Φ is the standard normal cumulative function. The derivation uses the fact that given the joint distribution of $(\varepsilon_{itj}, u_{it}) \sim N_2(0,0;\sigma_{\varepsilon j}^2, 1; \rho_j \sigma_{\varepsilon j}^2)$ the conditional distribution of u given ε_j is:

$$(u_{it} \mid \varepsilon_{itj}) \sim N(\frac{\rho_j \varepsilon_j}{\sigma_{\varepsilon j}};1-\rho_j^2) = N(\rho_j t_{itj};1-\rho_j^2)$$

Then the log-likelihood is $\ln L = \sum_i \ln L_i$.

The likelihood requires a double integration for any observation and is computationally intensive. However, recent developments in simulation methods provide a way to evaluate the above likelihood function. Simulation techniques are methods to numerically approximate otherwise intractable integrals. There are various forms of simulation used for different kind of problems[16]. In our case it is enough to notice that the above integrals are expectations over the random individual effects:

$$E_r\left[E_v\left[\phi(.)[\Phi_1(.)-\Phi_2(.)]/\sigma\right]\right]$$

and these expectations can be approximated with the average of a sufficient number of draws from the standard normal distribution generating r_i and v_{ij}.

Letting *g=1,…,G* count the draws of the simulation model, the above likelihood function can then be approximated with the following simulated likelihood function:

$$L_i^s = \frac{1}{G}\sum_{g=1}^{G}\prod_t \frac{1}{\sigma_{\varepsilon j}}\phi\left(t_{itj,g}\right)\left[\Phi\left(\frac{\gamma Z_{it}+r_{i,g}+\rho_j t_{itj,g}-\mu_{j-1}}{\sqrt{1-\rho_j^2}}\right)-\Phi\left(\frac{\gamma Z_{it}+r_{i,g}+\rho_j t_{itj,g}-\mu_j}{\sqrt{1-\rho_j^2}}\right)\right]$$

[16] Examples of recent applications of simulation techniques are, among others, Hyslop (1999) on married women labour participation choices, Cappellari and Jenkis (2004) on movements in and out of poverty, Morris (2003) on educational choices, Razo-Garcia (2010) on exchange rate ragimes and financial account openness.

where $t_{itj,g} = \frac{y_{itj} - \beta_j^{'} X_{itj} - v_{ij,g}}{\sigma_{\varepsilon j}}$. $r_{i,g}$ and $v_{ij,g}$ are random draws from the respective normal distributions and G is the total number of draws taken from the distributions of v and u. The variance of v and u is unknown and needs to be estimated within the model.

To generate the random draws we follow Train (2009)[17] and use draws derived from Halton sequences which improve accuracy with a reduced number of draws with respect to pseudo-random number generators. This is due to the fact that draws derived from Halton sequences increase the coverage of the domain of integration and induce a negative correlation between the draws thus reducing the variance of the simulation.

The Halton method works by first defining a sequence by using a particular prime number, P. The elements of the sequence are then obtained by an iterative process comprising a series of successive rounds. In the first round, the unit interval is split into P equal-width segments, and elements with values equal to the P–1 segment cut-points are defined. In the second round, each segment created in the first round is further split into P new segments. P-1 new elements are picked for each segment. In the next round, each segment is split P ways again and the cycling continue for as long as one needs sequence elements. As the number of rounds increases, the unit interval gets more and more filled in by sequence elements.

The simulated likelihood is then maximized numerically with respect to the parameters $\beta_j, \gamma, \sigma_{\varepsilon j}, \sigma_{vj}, \sigma_r, \rho_j, \mu_1..\mu_{j-1}$. This method is called Maximum Simulated Likelihood (MSL)[18].

[17] See Cappellari and Jenkins (2006) for a brief review of the different methods available to generate random draws for MSL and their relative advantages. Also, they develop the Stata routine *mdraws* used for this application to generate Halton sequences.

[18] See Train (2009) and Gourieroux and Monfort (1993).

In our case the classes of market participation are three, in order: buyers, autarchic and sellers.

(0.0)
$$d_{it}^{*} = \gamma' Z_{it} + r_i + u_{it}$$
$$d_{it} = \begin{cases} 0 \text{ if } -\infty < d_{it}^{*} \leq \mu_0 \text{ if buyer} \\ 1 \text{ if } \mu_0 \leq d_{it}^{*} \leq \mu_1 \text{ if autarchic} \\ 2 \text{ if } \mu_1 < d_{it}^{*} < +\infty \text{ if seller} \end{cases}$$

For each regime of market participation we observe food supply:

(0.0)
$$\begin{cases} Y_{it}^{B} = \beta_B' X_{itB} + v_{iB} + \varepsilon_{itB} \quad \text{if } d_{it} = 0 \\ Y_{it}^{A} = \beta_A' X_{itA} + v_{iA} + \varepsilon_{itA} \quad \text{if } d_{it} = 1 \\ Y_{it}^{S} = \beta_S' X_{itS} + v_{iS} + \varepsilon_{itS} \quad \text{if } d_{it} = 2 \end{cases}$$

The likelihood of a household being respectively a buyer, autarchic and seller at time t is then given by the above formulas and the full log-likelihood is obtained taking the within-group product over time of the single observation likelihoods, integrating these products over the random effects, taking logs and summing over groups we obtain the full log-likelihood:

$$\ln L = \sum_i \ln \iint \prod_t \left\{L_{it}^{B}\right\}^{b} \left\{L_{it}^{A}\right\}^{a} \left\{L_{it}^{S}\right\}^{s} \phi(v_{iA}) \phi(r_i)\, dv_{iA} dr_i$$

Where the exponents *b*, *a* and *s* take value of 1 if the household *i* at time t is respectively a buyer, autarchic or seller and zero otherwise.

The simulated likelihood is derived as follow:

$$\ln {}^{s}L = \sum_i \ln \frac{1}{G} \sum_g \prod_t \left\{{}^{s}L_{it}^{B}\right\}^{b} \left\{{}^{s}L_{it}^{A}\right\}^{a} \left\{{}^{s}L_{it}^{S}\right\}^{s}$$

where the super-script *s* denotes simulated values. In our estimation we use 50 random draws to approximate the likelihood function. Gourieroux and Monfort (1993) show that with this method a moderate number of replications is enough to obtain a good approximation of the likelihood function.

We develop a Stata routine to implement the above model using Maximum Simulated Likelihood technique. Appendix 3 reports the Stata code.

3.6 Empirical Analysis

The KHDS dataset offers several interesting insights into the evolution of agriculture in the region and the different behaviour of households pertaining to different food market regimes. Table 3.1 shows some descriptive statistics on households' production structure for 1991 and 2004 decomposed by regime of market participation in the food market.

The share of agricultural production in total expenditures, as already noted in chapter one, drops quite dramatically during the period across all categories. Food net-buyers are the group where agriculture accounts for the lower share of expenditures. Staple food maintains a high and stable share of total production across all the three categories.

Yields have actually decreased during the period. While this might be due to the life-cycle evolution of our sample or to contingent weather-related factors it is an indication of a stagnant agricultural sector. Notably yields are on average lower for food net-buyers in both years. An indirect confirmation of the stagnation of agriculture comes from input use figures. The proportion of households applying fertilizers and pesticides, if low in both periods, has actually dropped even more. Again, net-buyers show a lower inputs adoption.

Table 3.1 : Descriptive statistics

	1991							
	Net-buyers		Autarky		Net-seller		Overall	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
Yield (000')	90.0	141.7	93.5	135.6	120.3	275.9	102.9	207.5
Consumption pc (000'tsh)	189.1	125.3	150.1	94.3	195.9	139.8	187.2	129.0
	Production shares							
Food	0.71	0.19	0.67	0.2	0.7	0.17	0.7	0.18
Coffee	0.04	0.07	0.09	0.14	0.07	0.1	0.06	0.09
Vegetables	0.03	0.06	0.02	0.04	0.03	0.04	0.03	0.05
Other cash crops	0	0.03	0.01	0.06	0	0.03	0	0.03
Fruits	0.07	0.1	0.07	0.08	0.06	0.08	0.07	0.09
Other food	0.09	0.12	0.08	0.09	0.06	0.1	0.08	0.11
Other crops	0.06	0.09	0.07	0.09	0.07	0.08	0.07	0.09
	Expenditure shares							
Agricultural production	0.54	0.34	0.73	0.53	0.77	0.59	0.66	0.49
Sales	0.05	0.09	0.09	0.15	0.14	0.13	0.09	0.12
Purchases	0.57	0.2	0.43	0.18	0.49	0.17	0.52	0.19
	Inputs							
Land size (acre)	3.64	2.76	4.48	2.95	4.95	2.97	4.29	2.94
Hired labor (% hiring)	19	40	14	35	37	48	26	44
Fertilizer (% applying)	5	21	4	21	7	26	6	23
Pesticide (% applying)	8	27	9	28	19	39	13	33
Manure (% applying)	45	50	42	50	45	50	45	50
N	329		91		295		715	

	2004							
	Net-buyer		Autarky		Net seller		Overall	
	Mean	Sd	Mean	Sd	Mean	sd	Mean	Sd
Yield (000')	54.0	76.5	69.4	118.8	83.9	103.6	69.3	96.4
Consumption pc (000'tsh)	181.9	131.6	188.5	129.7	215.5	187.9	197.7	159.4
	Production shares							
Food	0.72	0.17	0.73	0.18	0.72	0.16	0.72	0.17
Coffee	0.03	0.06	0.03	0.07	0.05	0.08	0.04	0.07
Vegetables	0.02	0.06	0.02	0.05	0.02	0.04	0.02	0.05
Other cash crops	0	0.03	0	0	0	0.04	0	0.03
Fruits	0.05	0.06	0.03	0.04	0.05	0.07	0.05	0.06
Other food	0.13	0.12	0.13	0.14	0.1	0.11	0.11	0.12
Other crops	0.05	0.07	0.06	0.1	0.06	0.08	0.06	0.08
	Expenditure shares							
Agricultural production	0.4	0.2	0.49	0.24	0.61	0.41	0.51	0.33
Sales	0.05	0.08	0.04	0.09	0.15	0.14	0.09	0.12
Purchases	0.65	0.18	0.55	0.19	0.57	0.16	0.6	0.18
	Inputs							
Land size (acre)	3.38	2.63	3.81	3	4.56	2.92	3.96	2.86
Hired labor (% hiring)	20	40	24	43	41	49	31	46
Fertilizer (% applying)	2	15	3	17	3	17	3	16
Pesticide (% applying)	6	24	7	26	7	25	7	25
Manure (% applying)	14	35	13	33	27	45	20	40
N	262		87		274		623	

We estimate the switching regression model for the food market participation and output decisions (eq. 3.1 and 3.2).

Households can position themselves into three classes with an ordered structure: buyers (B), autarchic (A) and sellers (S). We define autarkic or self-sufficient households as the ones that do not buy or sell any quantity of food in a given year.

We have a problem in classifying households' market position as a high percentage of households buy and sell food in the same year[19]. This is mainly an artifact of the aggregation of four food crops into a single food aggregate. In fact, several households have different marketing relationships for different crops. We decide to use an aggregate food measure because in this way we can maximize the number of observations and avoid at the same time repeating this very complex and time consuming estimation for each crop. Further development of the model could allow in the future speeding up the routine and running the estimation for several crops.

To address the problem of the households buying and selling food in the same season we decide to use the net market position to classify households as food net-buyers, net-sellers or self-sufficient[20].

Households are defined as net-buyers (net-sellers) if the value of food bought in the year is higher (lower) than the value sold. Self-sufficient huseholds are households who sell and buy the same amount of food on the market in term of value[21].

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[19] Out of the 3,487 observations that compose the sample 1,089 (31%) are of households that buy and sell food in a given season. The remaining sample is composed of 2,398 observations of which 944 (39%) are buyers, 524 autarkic (21%) and 930 (38%) sellers.

[20] Using this classification we have 1552 (44%) Net-buyers, 533 (15%) Self-sufficient and 1402 (40%) Net-sellers observations.

[21] We recognize the difficulties involved in this classification caused by different recall periods between production and consumption data and seasonality in the household market relationship across the year.

An alternative option would be to exclude from the estimation households that buy and sell as the model of market participation based on transaction costs cannot properly explain this behavior. In this way we can use a different classification where households are defined as buyers (sellers) if they exclusively buy (sell) food in a given year. Autarkic households are those who neither buy nor sell any food. We use this alternative classification as a robustness check in section 3.7 below.

Explanatory variables in the food functions are, according to the theoretical model, supposed to capture both households' supply and demand factors (Z), which determine the relative position of the supply and demand curves, exogenous income (E), prices (P) and proxies for proportional transaction costs (T^p). In the market participation equation the explanatory variables are all the variables included in the supply equations plus fixed transaction costs (T^f).

We run the model as a random effects model with district (ϑ_d) and time (μ_t) fixed effects in both supply and participation relationship. The equations to estimate are:

$$d_{it} = f(\ln P_{it}, Z_{it}, E_{it}, T_{it}^{p}, T_{it}^{f}, \vartheta_d, \mu_t)$$

$$\ln Q_{jit} = f(\ln P_{it}, Z_{it}, E_{it}, T_{it}^{p}, \vartheta_d, \mu_t) \qquad j=\{B, A, S\}$$

The dependent variables are the market participation regime indicator and the logarithm of food output for the participation and supply equations respectively. The set of prices used as explanatory variables includes coffee and food prices, agricultural wages and kerosene price. All these prices are expressed in real terms by deflation with the

However, given the way data has been collected in the survey a different way of classifying households would be impossible nor any sensitivity analysis strategy is available. We thus rely, as common in the literature, on the above classification as the best possible approximation of the complex relationship households have with the market.

Laspeyre price index at the regional level calculated from the consumer price survey collected in conjunction with the main survey[22]. We use the cluster average of producer prices for coffee while for food and kerosene we use market prices collected in the price survey.

We control for the educational status, the age and gender of the head and for land and capital endowment of farmers. Endowment of capital is measured by the logarithm of the value of the household’s assets. Land endowment is measured as logarithm of the total amount of land cultivated in acres.

We use five district dummies corresponding to the six administrative sub-regions of Kagera (the omitted category is the Biharamulo district) to control for the unobserved fertility and other characteristics of land. We control for weather conditions using the total amount of rainfall in the community in the last season.

The variables used to capture transaction costs are distance to a motorable road, a dichotomous variable indicating whether the road is impassable in certain periods of the year or not, ownership of a means of transport (bicycle, motorbike, and car), presence of a market in the community, population density, a dummy for ethnic minority and an information dummy for ownership of a radio, telephone or TV. The last three should capture the availability of information and network possibilities and thus affect fixed transaction costs rather than proportional ones. These variables have been proposed as measures of fixed transaction costs from different authors in studies of supply response and transaction costs (Heltberg and Tarp 2002 use population density and ownership of information means as measures of fixed transaction costs; Goetz 1992 uses also the ethnicity dummy for networking opportunities). They act as identifiers in the selection

[22] See Beegle, De Weerdt and Dercon (2006).

model as they affect only participation decisions and not output ones. Population density data at the district level is available only for 2002 and to use it we need to make the assumption that district density is relatively stable across time[23].

The previous literature on the argument has struggled to find a convincing distinction between variables affecting proportional and fixed transaction costs respectively. This study is no exception. We recognize the possibility that for instance impassability of the road could affect fixed transaction costs as well as the proportional ones. However, given the difficulty of observing and measuring transaction costs the classification of variables as affecting one or the other hinges on a judgement about what type of transaction costs are more likely to be affected by that variable.

The model would not be biased if some of the variables affecting proportional transaction costs also influence fixed transaction costs. Estimation would only be biased if variables affecting fixed transaction costs also have an impact on variable transaction costs. This assumption is unfortunately not testable and given the complexity of the model it is not possible to run any sensitivity analysis. We thus maintain the assumption that ethnicity, population density and ownership of radio/tv, after controlling for the road network, the availability of means of transport and the presence of markets, determine only the availability of information and the networking opportunities and thus influence only fixed transaction costs.

[23] Population density data at the ward (administrative district) level was obtained from the International Livestock Research Institute and National Census Bureau (geo-information section) of Tanzania. Source of data used for their development is the Tanzania census maps of population and housing census 2002 available from the Tanzania National Bureau of Statistics (NBS).

Table 3.2 : Summary statistics of main variables

	Net-buyers		**Self-sufficient**		**Net-sellers**	
	Avg	Sd	Avg	Sd	Avg	Sd
Food output (kg)	164.5	165.8	189.9	187.5	242.4	377.8
Coffee price (91’ TZS)	46.1	16.7	47.1	18.9	49.7	19.3
Food price (91’ TZS)	54.7	12.7	53.8	11.6	54.7	12.5
Kerosene price (91’ TZS)	89.7	30.3	94.1	33.4	98.5	31.7
Wage (91’ TZS)	158.9	82.3	174.1	82	166.4	77.8
Age head	49.4	17.1	54.5	16.9	50	16.7
Female head	0.29	0.46	0.3	0.46	0.27	0.44
Totarea (Acres)	3.87	2.98	4.77	3.94	5.37	3.9
Rainfall (100mm)	10.3	4.7	10.3	4.2	9.9	4.9
Assets (mln TZS)	0.94	1.11	1.25	1.46	1.59	2.15
HH Size	6.01	3.13	5.78	2.86	5.75	2.93
Market	0.69	0.46	0.67	0.47	0.7	0.46
Road distance (Km)	0.19	0.99	0.15	0.85	0.16	0.9
Road impassable	0.42	0.49	0.5	0.5	0.42	0.49
Education (years)	4.19	3.5	3.68	3.36	4.32	3.25
Transport ownership	0.28	0.45	0.31	0.46	0.36	0.48
Density (000’ per Km^2)	0.68	1.7	0.19	0.37	0.20	0.39
Main ethnic group	0.6	0.49	0.66	0.47	0.65	0.48
Info	0.31	0.46	0.3	0.46	0.33	0.47
N	1552		533		1402	

Table 3.2 presents summary statistics of the explanatory variables for each regime of market participation.

We constrain the coefficients of the buying and selling equations to be the same. We let only the key coefficients on transaction costs to differ among buyers and sellers. This is not justified apriori on the theoretical ground but facilitates significantly the estimation in reducing the number of coefficients being estimated and increasing precision of the estimates.

Table 3.3 gives the results of the estimation. Results of the market participation equation (column 4 in Table 3.3) show that the main factors affecting the decision are cultivated land and assets value which both increase the probability of being a seller. Family size instead increases the probability of being buyer. Quite surprisingly neither the price variables nor the proportional transaction costs are statistically significant.

Population density and the dummy for the ethnic group, the proxy used for fixed transaction costs, are instead highly significant. Higher population density increases the probability of being a buyer for a given land endowment while belonging to the main ethnic group increases the likelihood of being a seller. The third variable reflecting fixed transaction costs is instead not statistically significant. Table 3.4 presents the average partial effects for the ordered probit selection equation computed as the partial effect averaged across the entire sample.

Table 3.3 : Results

VARIABLES	(1) Net-buyers	(2) Net-seller	(3) Autarkic	(4) Oprobit
Coffee price (log)	0.162***		0.263**	0.127
	(0.045)		(0.103)	(0.085)
Food price (log)	0.309***			-0.088
	(0.058)			(0.121)
Kerosene price (log)	0.001		0.080	0.104
	(0.052)		(0.111)	(0.103)
Wage (log)	0.219***		0.262***	0.006
	(0.029)		(0.072)	(0.056)
Age head	0.014***		0.0134	0.018**
	(0.005)		(0.010)	(0.009)
Age squared	-0.000**		-0.000	-0.000**
	(0.000)		(0.000)	(0.000)
Female	0.044		0.067	0.089
	(0.037)		(0.082)	(0.069)
Land area (log)	0.177***		0.062	0.265***
	(0.030)		(0.073)	(0.053)
Rainfall (00' mm)	-0.005		-0.002	-0.009
	(0.003)		(0.009)	(0.006)
Assets (log)	0.053***		0.116**	0.167***
	(0.020)		(0.050)	(0.037)
Size	0.086***		0.091***	-0.076***
	(0.006)		(0.014)	(0.010)
Education (year)	0.024**		0.044**	0.024
	(0.010)		(0.022)	(0.019)
Education square	-0.001		-0.001	-0.001
	(0.001)		(0.002)	(0.001)
Market	-0.125**	0.007		0.010
	(0.050)	(0.042)		(0.059)
Road distance (km)	0.013	-0.019		-0.038
	(0.023)	(0.020)		(0.028)
Road impassable	0.020	-0.077*		-0.098
	(0.048)	(0.039)		(0.061)
Transpown	0.021	0.135***		0.042
	(0.051)	(0.040)		(0.063)
Density (000'/km^2)				-0.285***
				(0.042)
Methnic				0.322***
				(0.101)
Info				-0.029
				(0.061)

Note: Sample 3,487 observations. Log-likelihood=-6830. Dependent variable in column one to three is log of food output. In column four the dependent variable is the ordered probit index (buyer=0, self-sufficient=1, seller=2). Covariates not reported in the table but included in the estimation are five district dummies for the six districts in the region, two seasonal dummies for the three growing/harvesting seasons, time dummies and an urban community dummy. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3.4 : Average Partial Effects Ordered Probit

	Net-Buyers	Autarkic	Net-Sellers
Coffee price (log)	-0.043	0.0002	0.043
	(0.029)	(0.014)	(0.035)
Food price (log)	0.029	-0.0001	-0.029
	(0.041)	(0.015)	(0.039)
Kerosene price (log)	-0.035	0.0001	0.035
	(0.035)	(0.012)	(0.040)
Wage (log)	-0.002	0.0000	0.002
	(0.019)	(0.003)	(0.019)
Land size (log)	-0.089***	0.0003	0.089***
	(0.019)	(0.031)	(0.038)
Rainfall (100mm)	0.003	-0.000	-0.003
	(0.002)	(0.001)	(0.002)
Assets (log)	-0.056***	0.0002	0.056**
	(0.013)	(0.020)	(0.024)
Size	0.026***	-0.0001	-0.025***
	(0.004)	(0.009)	(0.009)
Age	-0.006**	0.0000	0.006
	(0.003)	(0.002)	(0.004)
Education	-0.007	0.0000	0.007
	(0.006)	(0.003)	(0.006)
Female	-0.034	-0.0001	0.034
	(0.026)	(0.008)	(0.028)
Rural	-0.183***	0.0140	0.169*
	(0.061)	(0.060)	(0.089)
Market	-0.004	0.0000	0.004
	(0.023)	(0.001)	(0.023)
Road distance (km)	0.013	-0.0001	-0.013
	(0.009)	(0.005)	(0.011)
Road Impassable	0.039	-0.0020	-0.036
	(0.024)	(0.012)	(0.027)
Transport own	-0.016	0.0001	0.016
	(0.024)	(0.004)	(0.025)
Density (000'/km2)	0.096***	-0.0004***	-0.096***
	(0.016)	(0.0000)	(0.037)
Main ethnic group	-0.125***	0.0030	0.122***
	(0.039)	(0.034)	(0.049)
Info	0.011	-0.0001	-0.011
	(0.024)	(0.003)	(0.024)

Table 3.5 : Decomposition of unconditional marginal effects

	Quantity	Selection	Total
Coffee price (log)	0.179***	0.082	0.261***
	(0.051)	(0.071)	(0.068)
Food price (log)	0.256**	-0.057	0.199
	(0.103)	(0.07)	(0.139)
Kerosene price (log)	0.015	0.067	0.082
	(0.053)	(0.081)	(0.079)
Wage (log)	0.226***	0.004	0.230***
	(0.031)	(0.037)	(0.041)
Land size (log)	0.157***	0.171***	0.328***
	(0.048)	(0.073)	(0.110)
Assets (log)	0.064***	0.108***	0.172***
	(0.026)	(0.044)	(0.037)
Size	0.087***	-0.049***	0.038*
	(0.006)	(0.019)	(0.021)
Road distance (km)	-0.002	-0.025	-0.027
	(0.015)	(0.020)	(0.026)
Age	0.013***	0.011	0.025***
	(0.004)	(0.008)	(0.009)
Education	0.026***	0.014	0.039***
	(0.010)	(0.012)	(0.013)
Female	0.074	0.069	0.143**
	(0.054)	(0.059)	(0.074)
Market	-0.122**	0.008	-0.114*
	(0.053)	(0.047)	(0.062)
Road Impassable	-0.010	-0.077	-0.087
	(0.058)	(0.063)	(0.092)
Transport own	0.074	0.032	0.107
	(0.073)	(0.051)	(0.090)
Info		-0.021	-0.021
		(0.045)	(0.045)
Main eithnic group		0.230**	0.230**
		(0.118)	(0.118)
Density		-0.2**	-0.2**
		(0.1)	(0.1)

Note: The first column shows the unconditional marginal effect of a marginal change in the covariate on the log food output coming from adjustment in the quantity weighted by the probability of being in regime j. The second column shows the unconditional marginal effect of a marginal change in the covariate on log food output coming from regime switching and weighted by the expected output if in regime j. The third column is the sum of the quantity and selection marginal effects. Standard errors in parentheses are computed using the delta method. *** p<0.01, ** p<0.05, * p<0.1.

The first three columns of table 3.3 show the results for the food supply equations respectively for the buying and selling regimes and for the autarky regime. The buying and selling equations differ only for the proportional transaction costs variables which according to the theoretical model have a differential impact in the two regimes.

Two main results are of interest. The first concerns the own price elasticity which although small at 0.3 is highly significant.

The second result concerns the role of proportional transaction costs. As highlighted above we expect transaction costs to have an opposite impact on buyers and sellers. High transaction costs should give buyers an incentive to produce more in order to reduce their reliance on expensive market goods. On the contrary, sellers facing high transaction costs have an incentive to reduce production as the price they receive for their produce will be lower. The model reproduces this theoretical result quite well. The transaction cost variables in the buying and selling equations have the expected opposite signs with the exclusion of the transport ownership. For buyers only the presence of a market in the community has a significant impact on food production. For sellers transport ownership and impassable road are significant. The magnitudes of the coefficients are quite significant in economic terms. The presence of a regular market reduces buyers' food production by around 13%. Ownership of a means of transport increases sellers' output by 14% while living in areas where the road becomes impassable in certain periods of the year reduces sellers' output by around 8%.

These results add some evidence to the relevance transaction costs have on rural households' behavior. In particular, transaction costs increase net-buyers reliance on "home" food production while reducing net-sellers' capacity to supply the market. High transaction costs provide thus an incentive towards the adoption of a self-sufficiency strategy and thus reduce specialization and the productivity gains associated with it. This distinct effect of transaction costs cannot be analyzed without taking into account the heterogeneous relation households have with the market.

A further prediction of the model is that higher transaction costs would increase the probability of households being in the self-sufficiency region. This is the “discrete” effect on households’ market participation as opposed to the “continuous” one on output decisions highlighted before. This prediction is not supported by the data that show proportional transaction costs variables not being an important determinant of market participation choices. The ordered probit marginal effects in table 3.4 show that the model does not identify any effect on the probability of being self-sufficient apart from population density. This poor performance might be due to the small number of purely self-sufficient households in our sample or to the too restrictive ordered probit specification and it is certainly an aspect that deserves further research.

Also the price variables are not statistically different from zero in the participation equation (table 3.3 column 4). This result is against prior expectations that higher food prices should increase the probability of becoming a net-seller.

An interesting feature of this switching model is that we can compute different marginal effects of interest according to the research question. In particular as shown by Huang et al. (1991) and McDonald and Moffitt (1980), we can compute the unconditional marginal effect for the full sample for the total supply regardless of the regime for which it is observed as:

$$\sum_{j=0}^{J} M_j = \frac{\delta E(y_j \mid d=j)}{\delta x} \times \Pr(d=j) + \frac{\delta \Pr(d=j)}{\delta x} \times E(y_j \mid d=j)$$
$$= \beta_j \left[\Phi\left(\gamma Z + r - \mu_{j-1}\right) - \Phi\left(\gamma Z + r - \mu_j\right) \right] +$$
$$+ \gamma \left[\phi\left(\gamma Z + r - \mu_{j-1}\right) - \phi\left(\gamma Z + r - \mu_j\right) \right] \left[X_j \beta_j + v_j + (\gamma Z + r) \rho_j \right]$$

Where, as above, the subscript j identifies the regime of market participation. The above expression provides the marginal effect of variable *x* on the total quantity supplied. The first term represents the quantity response weighted by the probability of being in regime *j* and the second term the marginal change in the probability of being in regime *j* weighted by the expected value of the quantity if in regime *j*. The total effect can thus be decomposed into a quantity response component and a regime switching component. All components are computed for each household and then the marginal effect averaged across the entire sample. Table 3.5 shows the unconditional marginal effects computed in this way.

The total unconditional own price elasticity of food is 0.2 taking into account the unresponsiveness of self-sufficient households and the effect of regime switching. Comparing this result with the pooled one obtained neglecting the heterogeneity in market participation[24] it becomes clear that not taking into account the price unresponsiveness of self-sufficient households introduces a downward bias in the estimation of the price elasticity.

The main effects on output come from land and asset endowments, wages and coffee price which operate through both the selection and the quantity side.

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[24] Appendix 1 contains the results of this pooled random effect estimation. The own price elasticity has negative sign and is not statistically different from zero.

3.7 Robustness checks

We perform three different estimations to see if the above baseline results are robust to different specifications. The first concern is about the role of other market imperfections that could bias our estimates of the price elasticity and the transaction costs coefficients. The second concern is that using the households' net market position to distinguish among net-buyers, net-sellers and self-sufficient could also impact on the estimates. Finally a third issue relates to the different recall period used in the three intermediate waves of the survey.

The first factor that could influence our results relates to the possible influence of missing markets for insurance and credit and a failure to control adequately for land characteristics. We thus introduce some variables to control for covariate risk factors, access to credit and land quality. To control for covariate risk factors we use the five years before the survey rainfall variation coefficient, the previous year rainfall deviation from the fifteen-year median rainfall and a drought prone dummy for communities that experienced a drought in the ten years before the survey. To control for credit availability we use a dummy for the presence of a bank, money-lender or credit cooperative in the community. Finally we attempt to better control for land characteristics using the average food yield in the community expressed as kilograms per acre and a variable indicating the roughness of the terrain defined as the difference between the highest and lowest altitude. Table 3.6 shows the results for the estimation including these additional variables. The main results derived in the baseline estimation are all unchanged by the inclusion of these additional controls. The credit availability variable has negative impact on food supply for net-buyers and autarkic households while it has a positive although not significant one for net-sellers. This implies that at least for net-buyers and autarkic households credit availability favors a strategy of diversification out of food production. Food yields have, as expected, a positive sign in all equations. The covariate risk factors show some puzzling results. The rainfall variation coefficient has positive sign in the supply equations for net-buyers and net-sellers while it is negative for autarkic households. This implies that the ex-ante response to higher risk is increased food production for net-buyers and net-sellers while the opposite seems to be for autarkic households. The second risk variable, rainfall deviation from the fifteen-year median tries to catch the ex-post response to covariate risk. The sign is negative for net-buyers and net-sellers while positive but not significant for autarkic. The negative sign implies that households respond by increasing food production after a negative weather shock. These results are consistent with an overall strategy that sees higher food production as a response to higher risk. However, this is not so for autarkic households which is puzzling as we do not expected important behavioural differences in this respect.

The second robustness check consists in excluding from the estimation households that buy and sell food at the same time to see if results are biased by the use of the net market position to characterize households. Table 3.7 presents the results. There are no major changes from the baseline estimation if not that transaction costs' coefficients are slightly higher and more precisely estimated as one would have expected.

Finally the third estimation checks if the use we have made of the longitudinal survey affects the estimation. If fact, the second, third and fourth wave of the survey have a six month recall period instead of a full year. We control for this recall difference in the baseline estimation with time and seasonal dummies but there could still be a bias in particular if we misclassify households' market position. An alternative way to use these data that has been proposed (Rios et al. 2008) is to merge the second and third wave to form a comparable full year wave while dropping the fourth wave. We perform the baseline estimation using these three full-year waves only. Table 3.8 presents the results of the estimation. The main results are robust to this alternative use of the data and they actually suggest that the baseline transaction costs coefficients could be underestimated.

Table 3.6 : Controlling for risk, credit access and land quality

VARIABLES	(1) Net-buyers	(2) Net-sellers	(3) Autarkic	(4) Oprobit
Coffee price (log)	0.112**		0.166*	0.099
	(0.045)		(0.101)	(0.086)
Food price (log)	0.273***			-0.049
	(0.059)			(0.124)
Kerosene price (log)	0.032		0.228**	0.056
	(0.053)		(0.114)	(0.109)
Wage (log)	0.163***		0.183**	0.003
	(0.029)		(0.074)	(0.058)
Age head	0.014***		0.016*	0.0166*
	(0.005)		(0.009)	(0.009)
Age squared	-0.000**		-0.000	-0.000*
	(0.000)		(0.000)	(0.000)
Female	0.044		0.108	0.093
	(0.036)		(0.082)	(0.069)
Land area (log)	0.183***		0.095	0.288***
	(0.030)		(0.071)	(0.053)
Rainfall (00' mm)	0.016**		0.005	-0.045***
	(0.008)		(0.016)	(0.014)
Assets (log)	0.059***		0.098**	0.165***
	(0.020)		(0.048)	(0.037)
Size	0.084***		0.087***	-0.077***
	(0.006)		(0.014)	(0.010)
Education (year)	0.021**		0.041*	0.025
	(0.010)		(0.022)	(0.019)
Education square	-0.001		-0.001	-0.001
	(0.001)		(0.002)	(0.001)
Rainfall CV	0.035	0.314***	-0.603**	0.442**
	(0.171)	(0.111)	(0.244)	(0.181)
Market	-0.087*	-0.003		0.002
	(0.049)	(0.042)		(0.059)
Road distance (km)	0.010	-0.011		-0.048*
	(0.022)	(0.020)		(0.028)
Road impassable	0.035	-0.072*		-0.083
	(0.048)	(0.041)		(0.063)
Transpown	0.026	0.136***		0.033
	(0.049)	(0.039)		(0.063)
Rainfall deviation (100mm)	-0.274***	-0.212***	0.039	0.387***
	(0.091)	(0.080)	(0.172)	(0.134)
Drought	-0.009	0.022	-0.033	-0.088*
	(0.045)	(0.037)	(0.069)	(0.053)
Credit	-0.114***	0.015	-0.120*	-0.086*
	(0.044)	(0.037)	(0.066)	(0.051)
Terrain roughness	-0.002	0.006	-0.009	-0.004
	(0.006)	(0.006)	(0.008)	(0.009)
Food yields (kg/acre)	0.019***	0.007***	0.027***	0.005*
	(0.003)	(0.002)	(0.005)	(0.003)
Density (000'/km^2)				-0.264***
				(0.042)
Methnic				0.360***
				(0.102)
Info				-0.026
				(0.062)
Observations	3,487			
Ll	-6734			

Note: Dependent variable in column one to three is log of food output. In column four the dependent variable is the ordered probit index (Net-buyer=0, Self-sufficient=1, Net-seller=2). Covariates not reported in the table but included in the estimation are five district dummies for the six districts in the region, two seasonal dummies for the three growing/harvesting seasons, time dummies and an urban community dummy.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3.7 : Excluding buying and selling households

<table>
<tr><td></td><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td></tr>
<tr><td>VARIABLES</td><td>Buyers</td><td>Sellers</td><td>Autarkic</td><td>Oprobit</td></tr>
<tr><td>Coffee price (log)</td><td colspan="2">0.198***</td><td>0.239**</td><td>0.141</td></tr>
<tr><td></td><td colspan="2">(0.062)</td><td>(0.107)</td><td>(0.109)</td></tr>
<tr><td>Food price (log)</td><td colspan="2">0.315***</td><td></td><td>-0.113</td></tr>
<tr><td></td><td colspan="2">(0.075)</td><td></td><td>(0.150)</td></tr>
<tr><td>Kerosene price (log)</td><td colspan="2">-0.073</td><td>0.064</td><td>0.139</td></tr>
<tr><td></td><td colspan="2">(0.069)</td><td>(0.115)</td><td>(0.129)</td></tr>
<tr><td>Wage (log)</td><td colspan="2">0.222***</td><td>0.300***</td><td>-0.020</td></tr>
<tr><td></td><td colspan="2">(0.038)</td><td>(0.075)</td><td>(0.069)</td></tr>
<tr><td>Age head</td><td colspan="2">0.016***</td><td>0.019**</td><td>0.016</td></tr>
<tr><td></td><td colspan="2">(0.006)</td><td>(0.010)</td><td>(0.011)</td></tr>
<tr><td>Age squared</td><td colspan="2">-0.000*</td><td>-0.000*</td><td>-0.000</td></tr>
<tr><td></td><td colspan="2">(0.000)</td><td>(0.000)</td><td>(0.000)</td></tr>
<tr><td>Female</td><td colspan="2">0.050</td><td>0.074</td><td>0.114</td></tr>
<tr><td></td><td colspan="2">(0.048)</td><td>(0.086)</td><td>(0.090)</td></tr>
<tr><td>Land area (log)</td><td colspan="2">0.175***</td><td>0.033</td><td>0.360***</td></tr>
<tr><td></td><td colspan="2">(0.039)</td><td>(0.074)</td><td>(0.066)</td></tr>
<tr><td>Rainfall (00' mm)</td><td colspan="2">-0.000*</td><td>0.000</td><td>-0.000</td></tr>
<tr><td></td><td colspan="2">(0.000)</td><td>(0.000)</td><td>(0.000)</td></tr>
<tr><td>Assets (log)</td><td colspan="2">0.054**</td><td>0.110**</td><td>0.144***</td></tr>
<tr><td></td><td colspan="2">(0.025)</td><td>(0.049)</td><td>(0.047)</td></tr>
<tr><td>Size</td><td colspan="2">0.098***</td><td>0.109***</td><td>-0.092***</td></tr>
<tr><td></td><td colspan="2">(0.007)</td><td>(0.014)</td><td>(0.013)</td></tr>
<tr><td>Education (year)</td><td colspan="2">0.020</td><td>0.043*</td><td>0.011</td></tr>
<tr><td></td><td colspan="2">(0.014)</td><td>(0.023)</td><td>(0.024)</td></tr>
<tr><td>Education square</td><td colspan="2">0.000</td><td>-0.001</td><td>-0.001</td></tr>
<tr><td></td><td colspan="2">(0.001)</td><td>(0.002)</td><td>(0.002)</td></tr>
<tr><td>Market</td><td>-0.127*</td><td>0.035</td><td></td><td>-0.085</td></tr>
<tr><td></td><td>(0.071)</td><td>(0.052)</td><td></td><td>(0.074)</td></tr>
<tr><td>Road distance (km)</td><td>0.002</td><td>-0.022</td><td></td><td>-0.027</td></tr>
<tr><td></td><td>(0.034)</td><td>(0.025)</td><td></td><td>(0.036)</td></tr>
<tr><td>Road impassable</td><td>0.054</td><td>-0.065</td><td></td><td>-0.181**</td></tr>
<tr><td></td><td>(0.066)</td><td>(0.048)</td><td></td><td>(0.080)</td></tr>
<tr><td>Transpown</td><td>0.051</td><td>0.120**</td><td></td><td>0.064</td></tr>
<tr><td></td><td>(0.071)</td><td>(0.049)</td><td></td><td>(0.082)</td></tr>
<tr><td>Density (000'/km^2)</td><td></td><td></td><td></td><td>-0.314***</td></tr>
<tr><td></td><td></td><td></td><td></td><td>(0.055)</td></tr>
<tr><td>Methnic</td><td></td><td></td><td></td><td>0.461***</td></tr>
<tr><td></td><td></td><td></td><td></td><td>(0.128)</td></tr>
<tr><td>Info</td><td></td><td></td><td></td><td>0.005</td></tr>
<tr><td></td><td></td><td></td><td></td><td>(0.081)</td></tr>
<tr><td>Observations</td><td>2,398</td><td></td><td></td><td></td></tr>
<tr><td>Ll</td><td>-4892</td><td></td><td></td><td></td></tr>
</table>

Note: Dependent variable in column one to three is log of food output. In column four the dependent variable is the ordered probit index (Buyer=0, Self-sufficient=1, Seller=2). Covariates not reported in the table but included in the estimation are five district dummies for the six districts in the region, two seasonal dummies for the three growing/harvesting seasons, time dummies and an urban community dummy.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3.8 : Three waves estimation

VARIABLES	(1) Net-Buyers	(2) Net-Sellers	(3) Autarkic	(4) OProbit
Coffee price (log)	0.204***		0.159	0.137
	(0.057)		(0.148)	(0.109)
Food price (log)	0.277***			-0.006
	(0.071)			(0.164)
Kerosene price (log)	0.021		0.205	0.280**
	(0.062)		(0.154)	(0.141)
Wage (log)	0.205***		0.321***	0.075
	(0.037)		(0.121)	(0.083)
Age head	0.015***		0.005	0.0165*
	(0.005)		(0.014)	(0.009)
Age squared	-0.000**		0.000	-0.000
	(0.000)		(0.000)	(0.000)
Female	0.003		0.196	0.039
	(0.041)		(0.120)	(0.078)
Land area (log)	0.188***		0.017	0.268***
	(0.039)		(0.110)	(0.066)
Rainfall (00’ mm)	-0.003		-0.034**	0.005
	(0.004)		(0.016)	(0.008)
Assets (log)	0.084***		0.247***	0.177***
	(0.026)		(0.072)	(0.048)
Size	0.072***		0.077***	-0.072***
	(0.008)		(0.023)	(0.012)
Education (year)	0.031***		0.046	0.030
	(0.012)		(0.030)	(0.021)
Education square	-0.001		-0.001	-0.001
	(0.001)		(0.002)	(0.002)
Market	-0.216***	-0.002		0.014
	(0.056)	(0.052)		(0.077)
Road distance (km)	0.010	-0.010		-0.032
	(0.022)	(0.022)		(0.029)
Road impassable	-0.063	-0.075		-0.177**
	(0.054)	(0.050)		(0.071)
Transpown	-0.050	0.174***		-0.000
	(0.055)	(0.049)		(0.073)
Density (000’/km^2)				-0.309***
				(0.007)
Methnic				0.074
				(0.129)
Info				-0.015
				(0.071)
Observations	2,063			
Ll	-3792			

Note: Dependent variable in column one to three is log of food output. In column four the dependent variable is the ordered probit index (Net-buyer=0, self-sufficient=1, Net-seller=2). Covariates not reported in the table but included in the estimation are five district dummies for the six districts in the region, two seasonal dummies for the three growing/harvesting seasons, time dummies and an urban community dummy.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

3.8 Conclusions

Starting from the theoretical model proposed by Key et al. (2000) we estimate a model of food supply response which incorporates the effect of transaction costs and households' heterogeneity in market participation using a 1991-2004 household panel for Tanzania's Kagera region. Taking advantage of this long-term panel we are able to control for households unobserved heterogeneity in the estimation. We adopt simulated maximum likelihood methods to estimate a random component switching regression with an ordered probit as selection rule.

The results confirm the importance of taking into account the unresponsiveness of self-sufficient producers when estimating supply response in rural contexts characterized by a high degree of self-sufficiency. The estimated price elasticity of 0.3 for households taking part to the market although low shows some degree of responsiveness to price incentives in rural food markets in contrast to pooled estimated which show no response to price incentives.

The results also provide evidence of the importance of transaction costs in developing countries' rural areas. The asymmetric effect of transaction costs on surplus and deficit households shows that policies able to reduce these costs can promote higher specialization and release unexploited productivity gains. The main results are robust to different econometric specifications.

Appendix 1

Table 3.9 : Food supply pooled estimation

VARIABLES	Food Output (log)
Coffee price (log)	0.082*
	(0.046)
Food price (log)	-0.024
	(0.065)
Kerosene price (log)	-0.173***
	(0.055)
Wage (log)	0.136***
	(0.029)
Age	0.008*
	(0.005)
Age square	-0.000
	(0.000)
Female	0.068*
	(0.038)
Land (log)	0.217***
	(0.027)
Rainfall(100mm)	-0.007**
	(0.003)
Assets (log)	0.095***
	(0.019)
Size	0.071***
	(0.005)
Education	0.024**
	(0.010)
Education square	-0.001
	(0.001)
Market	-0.111***
	(0.031)
Road distance	-0.011
	(0.015)
Road impassable	0.002
	(0.033)
Transport ownership	0.072**
	(0.033)
Observations	3,487
Number of HH	732
Sigma	0.718
sigma_e	0.655
sigma_u	0.295
r2_w	0.292
r2_b	0.600
r2_o	0.443

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix 2

Stata routine for the MSL estimation

This appendix reproduces the Stata code developed to implement the error component switching regression model using maximum simulated likelihood techniques.

The first part of the code generates the random draws used for the simulation.

```
capture program drop mysim_d0
matrix p = (7, 11, 13, 17)
global draws "50"
keep id2
sort id2
by id2: keep if _n==1
mdraws, neq(4) dr($draws) prefix(c) burn(15) prime(p)
forvalues r=1/$draws{
gen double random_1`r'=invnormal(c1_`r')
gen double random_2`r'=invnormal(c2_`r')
gen double random_3`r'=invnormal(c3_`r')
gen double random_4`r'=invnormal(c4_`r')
 }
sort id2
save "C:\...\mdraws_$draws.dta", replace
use "C:\...\simulation_panel_2.dta", clear
sort id2
merge id2 using "C:\...\mdraws_$draws.dta"
drop _merge
sort id2
```

The second part of the code defines the parameters to estimate and the likelihood function. The maximization is implemented using the ML Stata routine.

```
program define mysim_d0
args todo b lnf
```

```
tempvar etha1 etha2 etha3 etha4 random1 random2 random3 random4 lj pi1 pi2 pi3
sum lnpi L1 L2 last z1 z2 z3

tempname lnsig1 lnsig2 lnsig3 lnsig4 sigma1 sigma2 sigma3 sigma4 lns1 lns2 lns3 mu0
lndelta athrho1 athrho2 athrho3 rho1 rho2 rho3 delta mu1

mleval `etha1' = `b', eq(1)

mleval `etha2' = `b', eq(2)

mleval `etha3' = `b', eq(3)

mleval `etha4' = `b', eq(4)

mleval `mu0' = `b', eq(5) scalar

mleval `lndelta' = `b', eq(6) scalar

mleval `lnsig1' = `b', eq(7) scalar

mleval `lnsig2' = `b', eq(8) scalar

mleval `lnsig3' = `b', eq(9) scalar

mleval `lnsig4' = `b', eq(10) scalar

mleval `lns1' = `b', eq(11) scalar

mleval `lns2' = `b', eq(12) scalar

mleval `lns3' = `b', eq(13) scalar

mleval `athrho1' = `b', eq(14) scalar

mleval `athrho2' = `b', eq(15) scalar

mleval `athrho3' = `b', eq(16) scalar


qui {

gen double `sigma1'=exp(`lnsig1')

gen double `sigma2'=exp(`lnsig2')

gen double `sigma3'=exp(`lnsig3')

gen double `sigma4'=exp(`lnsig4')


gen double `random1' = 0

gen double `random2' = 0

gen double `random3' = 0

gen double `random4' = 0
```

```
gen double `lnpi'=0
gen double `sum'=0
gen double `L1'=0
gen double `L2'=0
by id2: gen byte `last'=(_n==_N)

gen double `pi1'=0
gen double `pi2'=0
gen double `pi3'=0

gen double `rho1' = tanh(`athrho1')
gen double `rho2' = tanh(`athrho2')
gen double `rho3' = tanh(`athrho3')

gen double `z1'=0
gen double `z2'=0
gen double `z3'=0

gen double `delta'=exp(`lndelta')
gen double `mu1'=`mu0'+`delta'
}


forvalues r=1/$draws{
qui {
replace `random1' = random_1`r'*`sigma1'
replace `random2' = random_2`r'*`sigma2'
replace `random3' = random_3`r'*`sigma3'
replace `random4' = random_4`r'*`sigma4'

replace `pi1' = ln(normalden(($ML_y1 - `etha1'-`random1') / exp(`lns1')))-`lns1' if
a1==1
```

```
replace `z1' = `etha4'+`random4' + `rho1' * ($ML_y1 - `etha1'-`random1') / exp(`lns1') if a1==1
replace `pi1' = `pi1' + ln(normal((`mu0'-`z1')/sqrt(1-`rho1'^2))) if a1==1

replace `pi2' = ln(normalden(($ML_y2 - `etha2'-`random2') / exp(`lns2')))-`lns2' if a2==1
replace `z2' = `etha4'+`random4' + `rho2' * ($ML_y2 - `etha2'-`random2') / exp(`lns2') if a2==1
replace `pi2' = `pi2' + ln(normal((`z2'-`mu0')/sqrt(1-`rho2'^2))- normal((`z2'-`mu1')/sqrt(1-`rho2'^2))) if a2==1

replace `pi3' = ln(normalden(($ML_y3 - `etha3'-`random3') / exp(`lns3')))-`lns3' if a3==1
replace `z3' = `etha4'+`random4' + `rho3' * ($ML_y3 - `etha3'-`random3') / exp(`lns3') if a3==1
replace `pi3' = `pi3' + ln(normal((`z3'-`mu1')/ sqrt(1-`rho3'^2))) if a3==1

replace `lnpi'=`pi1'*a1+`pi2'*a2+`pi3'*a3

by id2: replace `sum'=sum(`lnpi')
by id2: replace `L1' =exp(`sum'[_N]) if _n==_N
by id2: replace `L2'=`L2'+`L1' if _n==_N
}
}
qui gen double `lj'=cond(!`last',0, ln(`L2'/$draws))
qui mlsum `lnf'=`lj'
if (`todo'==0|`lnf'>=.) exit
end
```

Chapter 4

Analysing the impact of trade liberalization and price shocks in rural economies

4.1 Introduction

In this chapter we analyse the impact of agricultural trade liberalization scenarios and world price shocks on a sample of rural households in Tanzania's Kagera region incorporating behavioural responses and the impact on agricultural wage income. We show that taking into account behavioural responses on consumption and production can significantly alter the sign and magnitude of the estimate of the welfare impact. The full-model which incorporates all the main effects on consumption and income also shows that households at the bottom of the income distribution tend to gain from higher prices once consumption, production and wages are allowed to adjust to the new prices. This implies that higher prices for the main crops can increase welfare in rural areas.

This finding is in contrast with the recent literature on the impact of high commodity prices which instead finds a negative effect on welfare and poverty (Ivanic and Martin 2008; De Janvry and Sadoulet 2009). While this might be true for both urban and rural households in particular in the short-run we show that rural households tend to gain instead, once all adjustments are considered, from higher commodity prices including food. The effect is positive on average along the entire income distribution and it is so for both net-buyers and net-sellers of food.

During the last decades there has been a considerable emphasis on the potential role for trade liberalization for increasing living standards and reducing poverty in developing countries. Trade liberalization is generally seen as one of the major policies conducive to a path of development, long run economic growth and poverty reduction.

The advice of multilateral organizations to developing countries has been of enhancing market openness and integration into global economy under the assumption that open economies perform much better than closed one and that this is the fundamental step needed to reduce poverty.

Following this advice, developing countries are increasingly signing new free trade agreements in an effort to open their economies and benefit from the process of globalization. The aim is to use trade reforms to enhance employment and economic growth by increasing competition, productivity, technology transfer and foreign investment[25].

However, there is increasing concern that, even if positive in the long run, trade liberalization could have adverse impact in the short run on poverty and on income distribution.

These concerns have given rise to a set of studies that highlight the importance of an ex-ante assessment of the impact that trade reforms have on the income distribution of the population. These studies try to help policy makers in assessing either the desirability of reforms or the trade-off between competitive reform schemes or in building up side policies to alleviate eventual undesirable effects.

[25] The evidence on the growth benefit of openness however is not totally conclusive. See Rodriguez and Rodrik (2001) and Winters (2004).

At the same time the significant increase in international commodity prices and in particular the food crisis in 2008 have spurred concern on the short and long-term impact of these price shocks on developing countries and in particular on rural areas (Ivanic and Martin 2008).

"The demand for more poverty and distributional analysis [..] is pressing. It comes from practically all quarters: civil society, national governments, nongovernmental organizations, bilateral aid agencies, international development agencies, and international financial institutions." (Bourguignon and Pereira Da Silva 2003, 2)

The issue is of particular importance for rural areas in developing countries for several reasons: first, most of the poor are concentrated in developing countries rural areas and have agriculture as their main source of income; second, current talks at the WTO focus on liberalization of the agricultural trade which has been left behind with respect to merchandise trade in the process of multilateral trade liberalization of the past decades. Third, there is a certain consensus that high international food commodity prices will characterize international markets in the medium-run given the structural patterns of high demand and limited or slow supply expansion.

These circumstances have revived the debate on whether higher agricultural prices can help in reducing rural poverty and kick-start a process of rural development and agricultural transformation. We argue that in order to answer this question we need to move away from a short-run analysis and look at the dynamic response both on the demand and supply side and incorporate the impact of price changes on agricultural wages and other agricultural related sources of income.

The structure of the study is the following: the next two sections discuss the links between trade, poverty and income distribution and introduces some of the methodologies used in the literature to assess the impact of trade reforms. Then we describe the theoretical framework we use to simulate the welfare impact at the household level. The final part discusses the results and draws some conclusions.

4.2 Trade, poverty and income distribution: the links

Understanding the links between trade policy, poverty and income distribution has been an important field of research in last decades. There is a certain consensus in the economic literature on the fact that trade openness in the long run has positive effects on growth and per capita income and that this has beneficial effects on poverty.

However, the same consensus has not been reached on the short and medium run effects of trade liberalization. Trade policies have strong redistributive impacts in the short and medium run and some segments of the population could suffer more than others the consequences. If low income households are hurt, there could be negative repercussions on poverty.

A very useful distinction, made by Kanbur (2001), states that the disagreement on fundamental economic issues, and among these on trade policies, lies in differences in perspective and framework in three key aspects of economic policy: Aggregation, Time Horizon and Market structure.

The first disagreement is on the level of aggregation used. Poverty experts and activists have been focused on an high level of disaggregation that considers the welfare impact at the households level or, at least, for groups of the population diversified by rural or urban areas, regional classifications, gender, educational status, ethnicity, and so on. Instead, macroeconomists and trade experts have focused more on the aggregate welfare impact, on average income levels and on aggregate poverty indicators with few diversifications among individuals and households characteristics. The usual approach in the latter case is that of a representative household.

The time horizon used in the analysis has been different too. Many trade experts have focused on the medium-term horizon implied by the equilibrium theory underlined in the analysis. Others have focused more on the short-term impact of reforms worried about the repercussions that short-term adjustment problems can have in the medium and long term.

A further area of disagreement is on the market structure assumed to be prevalent in the economy. Some of the conclusions of the theory on trade are strongly based on the assumption of perfect competitive markets for goods and factors. Different analysts have claimed that such a situation is hardly valid in less developed countries and have tried to assess the impact of distortions in the distributive channel, of different institutional settings, of the power structure and so on. All these aspects could limit competition in both factors and goods markets.

The distributional effects of trade liberalization and the adjustment costs that these policies can create are difficult to assess without taking into account the peculiarities of the poor and of the trade reforms in each singular context (Winters, McCulloch and McKay, 2004). The welfare impact of trade policy will vary according to different circumstances and will depend heavily on the characteristics and habits of the poor, on the specific trade reform put into place and on the structural characteristics of the economy.

"...a crucial part of any specific analysis must be identify the different characteristics of the poor including information about their consumption, production and employment activities. Outcomes will also depend on the specific trade reform measures being undertaken, and the economic environment in which they take place." (Winters, McCulloch and McKay, 2004, p. 73)

Identifying winners and losers from trade reforms is extremely important from a policy perspective in helping design policies able to minimize the impact on disadvantaged segments of the populations.

For the reasons outlined above, the need for an empirical assessment of the possible impact of trade reforms on the income distribution and especially on the poorest has been largely recognized in the literature. In order to do this it is of fundamental importance to understand how trade is linked with poverty and more in general with the income distribution of the population.

Winters (2000), identifies several transmission channels between trade, poverty and income distribution:

1. Price and availability of goods (consumption effect).
2. Factor markets, wages and employment (income effect).
3. Government tax and expenditure.
4. Vulnerability to external shocks (e.g. terms of trade).
5. Incentives for investments and innovation (link to long-run growth).
6. Short-run risk and adjustment costs.

All these links are extremely important for the distributional outcome of any trade reform however, we focus on the first two links which capture the direct effect of trade liberalization on prices. These are generally seen in the literature as the most important effects that trade reforms have on households' welfare.

Trade liberalization acts by changing relative prices at the border. For example, unilateral liberalization acts lowering prices of imports and keeping prices of substitutes for imported goods low. This in turn has an important effect on welfare by modifying households' real income. Which segment of the population will benefit more from lower prices depends on the particular goods whose tariffs or quantitative barriers are reduced and from the particular consumption and production decision of some groups or others of the populations being considered.

The approach usually followed by the studies on the impact of price changes on welfare characterizes households as "farm households". This characterization was first introduced by Singh et al. (1986) and identifies households as making decisions not only on how much to consume, but also on how much to produce and how many hours of labour supply[26].

In this way, price changes have a double effect: they affect not only consumption expenditures but also revenues from production activities. Therefore, the effect of a price change on household welfare, assuming quantities consumed and produced do not adjust, depends on whether the household is a net-producer or a net-consumer of the good whose price has changed. It follows that trade liberalization will not necessarily increase households welfare in the short run.

[26] A complete discussion of the household model is presented in chapter 2.

It is important to notice that usually changes in border prices caused by trade reforms are not passed through to households one to one. The transmission mechanism is strongly influenced by internal factors such as transport costs, institutional settings, local competition, infrastructure and preferences toward domestically produced goods. All these factors can weaken the impact of trade reforms on internal prices (Nicita 2009; Bevan, Collier and Gunning 1993).

The second important link between trade policy, poverty and inequality is the effect of trade liberalization on income and returns to factors of production. The theory behind the link between prices and factor returns is based on the Stolper-Samuelson theorem (Stolper and Samuelson 1941), which is a proposition of the Heckscher-Ohlin model. It states that a raise in a good’s relative price raises the real wage of the factor used intensively in that industry and lowers the real wage of the other factor. Thus, trade theory predicts that reduced protection would increase the return of a country's most abundant factor. According to this theory, following trade liberalization, labour earnings should increase in developing countries where labour is the abundant factor. However, this prediction depends on some strong assumptions such as full employment and perfect competition that are rarely satisfied especially in developing countries. In fact, the empirical evidence seldom confirms the predicted effects on labour earnings (Goldberg and Pavcnik 2004).

The labour market in developing countries is likely to be characterized by high unemployment and an important informal sector and is often segmented by skill, gender and location. This makes the response to trade shocks to differ in terms of its impact on wages or employment and on different segments of the labour market.

Nevertheless, it has an important impact on welfare at the household level that will depend on factor endowments and participation decisions. There is an agreement on the fact that a complete analysis of the welfare impact of trade reforms cannot exclude an analysis of the labour market (Hertel and Reimer 2004; Porto 2006).

However, for most of developing countries' rural areas the main source of income comes from agricultural production either in the form of sales or in the form of auto-consumption. Wage labour although important has a lower importance in a strictly rural setting. In order to contemplate the income effect in these areas understanding households' production decisions is of fundamental importance. This is not to understate the importance that interactions between urban and rural area have also in terms of wages affecting the flow of resources from one area to the other (Harris and Todaro 1970).

4.3 Methodologies in assessing the welfare impact of trade reforms

The studies that try to evaluate the distributional impact of macroeconomic policies in general, and in particular of trade policies have made use of different methodologies in accordance to the specific research question and the data available.

Hertel and Reimer (2004) have grouped these methodologies into two broad categories. They named the first one as the *"cost of living approach"* which is mainly characterized by the high level of disaggregation of the analysis. The second category has applied computable general equilibrium models (CGE) characterized by a higher level of aggregation. More recently the combined use of both of the two approaches has generated a micro-macro synthesis approach.

All the above approaches have their limitations and strength and depending on the main objective of the analysis, the context and the specific shock or reform analyzed one is better able to catch some aspects of the impact of reforms than others.

The same distinction already mentioned, based on Kanbur (2001), on the areas of disagreement in assessing economic policies can be translated into the different methodologies used to investigate welfare impact of trade reforms. Basically, disagreement and differences are on the level of aggregation, on the time horizon and on the market structure. Positions on these three areas will determine the methodology used in the analysis.

One of the pioneering studies on the distributional impact of price changes is Deaton (1989) on the rice price in Indonesia. He uses a households survey with detailed data on households expenditures and rice production to evaluate the impact of changes in the rice price on Indonesian households.

The approach proposed by Deaton combines information on the price change of a specific good, rice in his study, with households data to calculate how a measure of household's welfare changed or would change. This is a quite straightforward way to measure the impact of price changes on welfare at a potentially highly disaggregated level. The key feature of this approach is the use of a living standard household survey to calculate the welfare impact on each single household in the sample. The approach is suitable to analyse the impact of any price shock be this trade policy induced or not.

There are several important studies that use an approach similar to the one proposed by Deaton. Levinsohn, Berry and Friedman (2002) examine the impact on households of the Indonesian economic crisis of 1997-1998. They use a household survey of 1993 with data on consumption for 58,100 households to determine a specific cost of living change for each household after the increase in prices following the crisis. They found that given their consumption habits and the heterogeneous price increase in rural and urban areas the urban poor households were hurt the most from the crisis. Rural households were better able to counteract the shock by growing their own food.

This approach has formed the basis for the analysis of the distributional impact of trade policy changes in several studies as Porto (2006), Nicita (2009) and Chen and Ravaillon (2003) among others which extend previous studies in different directions. Ivanic and Martin (2008) and de Janvry and Sadoulet (2009) use this approach to analyse the impact of increasing international food prices.

This approach has some important advantages. The first strong advantage is that these models are relatively simple and understandable and require few assumptions and restrictions on the parameters than macroeconomic models. They require also a relatively small amount of data that are easily available in modern household surveys.

The second, and probably the most important, strength of this approach is that it is able to fully exploit the heterogeneity present in the survey data and focuses on the characteristics and behaviour of real households instead of relying on representative households. This is a very important characteristic for so multifaceted phenomena as poverty and inequality that, to be fully explored, require the high level of disaggregation possible with these studies.

However, most of the studies pertaining to this stream of the literature do not explore the labour market effect of trade reforms (point 2 in the above classification). This is a usual but not exclusive feature of these studies[27]. This characteristic comes from the lack of good data on the income side present in most of the household surveys especially in the past but also from the major complexity of modelling the employment and wage effect of trade reforms. This is a serious limitation that has been recognized in the literature given the importance that labour market effects have on household's welfare. Hertel and Reimer (2004) have pointed out that empirical observations tend to show that households differ more in their income generation than in consumption behaviour. The composition of incomes differs much more than consumption baskets which instead are similar across households. If that is really the case, then what drives differences in the impact of trade reforms across different households can be the income side more than the consumption structure. Failing to take this aspect into account could be misleading or at least unsatisfactory from the point of view of distributional effects.

Some more recent studies try to estimate the effect of trade reforms on the distribution of income and poverty including also the effect on income. Porto (2006) calculates the effect of Mercosur agreement on prices in Argentina and then estimates a set of elasticities of wages to the price for skilled, unskilled and semi-skilled workers. He then uses these elasticities to estimate the impact of Mercosur on wages. Coupling this analysis with the consumption impact for all the households in the Argentinean survey he computes the aggregate effect and finds a pro-poor impact of the reform. An important result of Porto's analysis is that he found an anti-poor bias on the consumption side and instead a pro-poor bias on the labour side that outweighs the former effect. This further highlights the importance of the latter link.

[27] Ravallion 1990 and Porto 2006 are among the exceptions.

A limitation of this micro-econometric approach is that the behavioural response of the households is in general not taken into account. Substitution effects are not considered in most of the cases and the analysis limits to a first order response to price changes. Friedman and Levinsohn (2002) try to incorporate these second order effects into their previous analysis of Indonesian crisis estimating a set of own and cross elasticities of demand to modify their previous results. They show that these households' responses could be important in assessing welfare impact of reforms[28].

One of the limitation of these studies is related to the partial equilibrium nature of the exercise. The interaction between different sectors is not taken into account and each sector is treated separately. This could be a quite good approximation of the real impact if the analysis is focused on a trade reform accomplished on a single or few sectors of the economy, but could be misleading when dealing with widespread liberalizations. The between sector impact of such reforms is supposed to have important effects and should be taken into account using a general equilibrium model even if CGE models are not free from limitations.

Several studies make use of computable general equilibrium (CGE) models. These models have been extensively used for macro simulations in the past decades as well as to examine the distributional impact of macroeconomic reforms. CGE analysis has been applied to a wide range of policy issues, which include, among others, income distribution, trade policy, development strategy, taxes, long-term growth and structural change in both developed and less developed countries. CGE models are able to capture the overall functioning of an economy with all its macroeconomic features and the

[28] See also Nicita (2004), who takes into account second-order effects in consumption.

interactions among different sectors and different agents of the economic system as households, government and firms.

These models have the important feature of allowing the simulation of policy alternatives as a controlled experiment that permits one to abstract from other shocks that could influence the results. This is a great advantage relative to the strictly micro-simulation analysis of the previous section when dealing with ex-post analysis.

The first application of this a CGE model to assess the distributional impact of policy changes was made by Adelman and Robinson (1978) for South Korea. To assess the distributional impact of reforms they introduce a further micro framework to model the distribution of income for each group of household in the model. They assume an a-priori income distribution with fixed variance among representative households. Changes in the average income among groups determine income distribution variations while changes in the average group income determine poverty variations.

The major disadvantages of CGE models are in their complexity, in the intensive use of assumptions, including on key parameters values, and in the level of aggregation needed to keep the model tractable. It is also difficult to measure their results against reality and thus to check their validity and sensibility.

In order to model the entire economy, these models are quite complex and difficult to understand for non-specialists as opposed to the simplicity of partial equilibrium models. To clear all the markets several assumptions have to be imposed to the model and is difficult to understand if the result is driven by the data or by the assumptions imposed. In fact, sensitivity analysis has an important role in checking the robustness of the results to different assumptions.

The assumptions made on the income distribution of groups, and the own households classification, can sensibly affect the results. In fact, if there are important behavioural variations inside the group, aggregation could lead to errors in the measurement of the effects of a shock. However, the progress made in computational capacity has improved substantially the ability of building much more disaggregated models.

More recently several studies on distributional effects of trade reforms have combined CGE models with the micro-simulation based on household surveys data giving birth to what has been named as “micro-macro synthesis”. The approach aims at exploiting the advantages of both cost of living and CGE models while reducing the impact of their limitations. The aim is to fully exploit the detailed survey dataset and at the same time keeping the CGE tractable.

This procedure is typically a two-step procedure. In the first step, a CGE model is used to simulate the impact on goods and factor prices of a trade reform and then, in a second step, these are fed back into a cost of living analysis carried on using a household survey.

One example of these studies is Chen and Ravallion (2003) that analyses the impact of China accession to WTO. They use a Global Trade Analysis Project (GTAP) model to explore the general equilibrium impact of trade liberalization and then apply the simulated price changes to calculate a measure of welfare change for each household in a Chinese survey. They take into account budget shares and net sales by the households to compute an index of the gain/loss following the reform.

Other examples of this approach are: Bourguignon, Robilliard, and Robinson (2003) on the financial crisis in Indonesia, Bussolo and Lay (2003) on trade policy in Colombia, and Ferreira and Leite (2003) on Brazil. Ianchovichina, Nicita, and Soloaga (2001) estimate the impact of full trade liberalization in Mexico; Ravallion and Lokshin (2004) apply the method to Morocco. Essama-Nssah et al. (2007) use this framework to assess the welfare impact of higher oil prices and Bibi et al. (2010) study the impact of the global crisis on children well-being. Also all the studies presented in Hertel and Winters (2006) on the impact of the Doha development agenda are based on this methodology.

The great advantage of this approach is that while completely exploiting the full set of information present in the household survey, it generates the price changes using a CGE model and so taking into account the interaction between different sectors of the economy. This permits also to keep the CGE model tractable and the data requirement low with respect to complex disaggregated general equilibrium models. It also makes it easier to obtain the effect on wages and employment in the different sectors and this, coupled with a detailed survey of income sources, can help in taking into account the labour effect of reforms.

One problem with this kind of approach is that there is no feedback between the survey analysis and the CGE and full consistency between the macroeconomic and the microeconomic models is not guaranteed. In fact the equilibrium would be modified by the household behavioural response and this should be taken into account in a fully interacted model.

Cogneau and Robillard (2000), Rutherford, Tarr and Shepotylo (2003) and more recently Rutherford and Tarr (2008) make an attempt to incorporate large number of households into a standard CGE combining micro-simulation and a general equilibrium framework to avoid the necessity to assume an a-priori income distribution for each group of households. This approach is promising but further increases the data requirement and the computational costs of the model already high for standard CGE models.

4.4 Households' behavioural response: a medium term impact analysis

In this study we follow the "cost of living" approach to take full advantage of the detailed information at the household level available in the KHDS survey to undertake a highly disaggregated analysis of the impact of different trade reforms and price shocks scenarios. In this section we explain the methodology used to overcome some of the shortcomings of previous studies and provide a better assessment of the impact which takes into account behavioural responses and the impact on income.

The simplest and most commonly used methodology to evaluate the impact of trade policies and of price changes in general on households' welfare consists of a first order approximation of the compensating variation needed, after the price change, to maintain the household at the same level of utility attained before the price change[29].

Introducing a standard household model where households produce and consume a set of goods c_i and are assumed to maximize utility subject to a technology and a cash constraint $\sum_i p_i c_i = \sum_i p_i q_i + E$ we can derive the indirect utility function which is a representation of households' living standards.

$$V = \psi(p, y)$$

[29] The compensating variation is defined as the minimum amount by which a consumer would have to be compensated after a price change in order to be as well off as before. It can be defined implicitly through the indirect utility function: $\psi(y^0 - CV, p^1) = \psi(y^0, p^0)$. Most studies, included this one, actually use the negative of the compensating variation as a money-metric measure of the change in welfare due to changes in prices.

Where V is utility or real income, p is a vector of prices of commodities consumed, $y = \pi + E$ is total income which can be decomposed into farm profits $\pi = \sum_i p_i q_i$ (with $q_i < 0$ indicating farm inputs) and other incomes E, here assumed to be exogenous.

Since by assumption profits are maximized we can think of π as a profit function π(***p***). The effect of a change in price for good *i* when all other prices are kept constant is obtained by totally differentiating V[30]:

$$dV = \frac{\partial V}{\partial p_i} dp_i + \frac{\partial V}{\partial y}\frac{\partial y}{\partial p_i} dp_i = (q_i - c_i)\frac{\partial V}{\partial y} dp_i$$

where c_i and q_i represents respectively household consumption and production of good *i*. Expressed as a share of expenditure *y* we obtain:

$$dV / y = (\frac{p_i q_i}{y} - \frac{p_i c_i}{y}) d \ln p_i \qquad (0.0)$$

Thus, the measure of welfare gain/loss for each household is the proportional price variation weighted by the consumption and production shares[31]. A household that is a

[30] The derivation makes use of two standard microeconomics results: the Hotelling lemma $\frac{\partial \pi}{\partial p_i} = q_i$ where q is gross production of good i by the household and Roy's identity $\frac{\partial V}{\partial p} = -c\frac{\partial V}{\partial y}$ where c is consumption of good *i*.

[31] Expressed as a compensating variation dB for a change in price dp it would be equal to the negative of dV:

$$dB = -\frac{dV}{dV / dy} = (\frac{p_i c_i}{y} - \frac{p_i q_i}{y}) d \ln p_i$$

$(\frac{p_i c_i}{y} - \frac{p_i q_i}{y})$ is the net-consumption ratio and is the elasticity of the cost of living with respect to the price of good *i*.

net-consumer of a good will lose from an increase in the price of that good, while a net-producer will gain. The opposite is true if we consider a reduction in prices.

This methodology is particularly suited in cases where the absence of price data doesn't permit to estimate a complete set of demand and supply functions. This approach is used in a number of studies on the incidence of trade reforms (Ravallion 2004; Levinsohn, Berry and Friedman 2003; Chen and Ravallion 2004) and price shocks (Ivanic and Martin 2008; Coady et al. 2008).

This analysis is a valid approximation only if price variations are small and so we are moving around the consumer optimum. This is not completely the case in several important scenarios where products show a substantial price variation. In these cases large price variations are likely to induce quantity adjustments that should be taken into account. Probably, consumers will move towards goods that show high price reduction and become relatively cheaper. Conversely, producers will orient their production choices toward goods that have shown a lower price reduction and provide a higher profit.

The limitation of a first order analysis can be relaxed only through the estimation of demand and supply elasticities which identify the households' response to price shocks and permits a more complete analysis of the welfare impact.

A second order Taylor expansion[32] of the indirect utility function permits to go beyond a first-order analysis to incorporate households' behavioral response both on the

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[32] A second order Taylor approximation of a function $f(x)$ around a given point x_0 is given by the formula $f(x) = f(x_0) + f'(x_0)(x - x_0) + \frac{1}{2} f''(x_0)(x - x_0)^2$. In our case the approximation is around the starting price p_1 and by rearranging and computing the first and second order derivatives of

consumption side through the estimation of demand elasticities and on the production side through supply elasticities.

$$\Delta V = p_i(q_i - c_i)d\ln p_i + \frac{1}{2}p_i(q_i\varepsilon_i^q - c_i\varepsilon_i^c)d\ln p_i^{\,2} \qquad (0.0)$$

where ε_i^c and ε_i^q are respectively the demand and supply price elasticity for good *i*.

This method considers the behavioural responses both on the demand and on the supply side and thus it is much more suitable to analyse non-marginal price shocks. In fact, the bigger is the price change the less reliable is the first-order approximation of its impact (Friedman and Levinsohn 2002).

To consider the effect that a change in price has on other sources of income we need to relax the assumption that all income coming from sources different from sales of the main crop is exogenous. We thus split other income into the agricultural wage income that can be indirectly affected by a change in price and a part which remains exogenous (i.e. transfers).

Let's define the agricultural wage income *W* as the sum of the income coming from working outside the farm in agricultural related activities *L* (net of hired labour *H*) and income derived from sales of other residual crops or livestock or by-products of the main activity *s* (e.g. selling banana beers).

$$W = w(L - H) + p_{oth}s_{oth}$$

Total income is then defined as:

the indirect utility function we get equation 4.2. Only the price of good *i* changes while all other prices stay constant so in the derivation we are not considering cross-price effects.

$$y = \sum_i p_i q_i + W + E$$

where *E* is now the residual income component assumed to be exogenous. The first-order effect of a change in price is now:

$$dV = \frac{\partial V}{\partial p_i} dp_i + \frac{\partial V}{\partial y}\frac{\partial y}{\partial p_i} dp_i = (q_i - c_i)\frac{\partial V}{\partial y} dp_i + \frac{\partial V}{\partial y}\frac{\partial W}{\partial p_i} dp_i =$$
$$= \frac{\partial V}{\partial y} d\ln p_i \left[p_i (q_i - c_i) + \eta_i W \right]$$

where η is the price elasticity of the agricultural wage income with respect to the price of good *i*. The full-model second order response would then be:

$$(0.0) \qquad \Delta V = d\ln p_i \left[p_i (q_i - c_i) + \eta W + \frac{1}{2} d\ln p_i \left(q_i \varepsilon_i^q - c_i \varepsilon_i^c \right) \right]$$

This method permits overcoming the shortcomings of a pure first-order analysis and accounts for the impact on outputs, agricultural wages and other income generating activities related to agriculture. Porto (2007) studies the impact of price changes in rural economies incorporating outputs, wages and income responses in the analysis of price shocks for Mexico[33]. However he is forced by data restrictions to pool outputs, wages and other income into a single agricultural wage income aggregate and to estimate a unique elasticity to prices[34]. Here we have separated the output elasticity from the wage income aggregate avoiding in this way to impose the restriction that the two responses are the same.

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[33] Friedman and Levinshon (2002) and Nicita (2004) also compute second order effects but their analysis is limited to the consumption side and does not consider the effects on outputs.

[34] Using our notation the agricultural wage income in Porto incorporates sales of all crops and is thus defined as $W = \sum_i p_i s_i + w(L - H) + p_{oth} s_{oth}$ and the welfare effect is calculated as

$$dV = d\ln p_i \left[p_i (q_i - c_i) + \eta W - \frac{1}{2} d\ln p_i (c_i \varepsilon_i^c) \right].$$

We use the above methodology to simulate the impact of changes in key tradable goods prices as food and coffee and their indirect impact on other agricultural incomes. We are not able given the lack of reliable time series data on prices to estimate the response of other non-traded good prices to the price change of tradable goods as done in Porto (2006). At the same time we do not have enough data on wages to carry on an analysis on the wage impact alone. We thus opt for estimating the aggregate agricultural wage elasticity.

In the following section we explain the methodology used to obtain the set of elasticities needed to implement the above analysis before analysing the results.

4.5 Estimation of demand, supply and wage-income elasticities

In this section we present the results of the estimation of supply elasticities for food and coffee, demand elasticities for staple food, other food and non-food goods and the wage income elasticity. These set of elasticities permits a complete analysis of output, consumption and income response to price changes. A summary of the full set of elasticities is reported in table 4.4.

We first estimate (see chapter two and three) supply elasticities for staple food and coffee. Estimation of the food and coffee supply elasticities permits taking into account the output response to prices and thus an important part of the income effect of price changes. In fact, food and coffee production on average account for around 35% of total income as we shall see in figure 4.1 below. How important the behavioural response will be depends on the supply elasticities which in our case are quite low. We estimated two models of supply response for food, a *"wrong"* pooled model which does not take into account different regimes of market participation and a second one in chapter three which instead estimates the supply function conditional on the market participation regime and takes into account the unresponsiveness of self-sufficient households. We are thus in a position to first look at the effect on welfare using the wrong model and then compare this results with the one obtained using the correct model.

Demand elasticities

We estimate demand elasticities using the AIDS proposed by Deaton and Muellbauer (1980) which derives an econometric specification consistent with a constrained maximization of a single-period utility function.

In the AIDS the expenditure shares of the j^{th} commodity group s_j are a function of total expenditure E and prices p:

$$s_j = \alpha_j + \sum_i \beta_{ji} \ln p_i + \delta_j \ln(E_j / P) + u_j \qquad j, i = \text{commodity groups}$$

P is the composite price index obtained as:

$$\ln P = \alpha + \sum_j \alpha_j \ln p_j + \frac{1}{2} \sum_j \sum_i \beta_{ij} \ln p_{ij} \ln p_{ij}$$

and $\sum_j s_j = 1$

With this system in place we can impose the theoretical restrictions of adding-up, symmetry and homogeneity:

Adding-up: $\sum_j \alpha_j = 1 \quad \sum_j \beta_{ij} = 0 \quad \sum_j \delta_j = 0$

Symmetry: $\beta_{ij} = \beta_{ji} \quad \forall ij$

Homogeneity: $\sum_j \beta_{ij} = 0$

The adding-up and homogeneity restrictions are imposed by dropping one of the share equations from the system and obtaining the remaining parameters using the adding-up restrictions. The symmetry restrictions are obtained by restricting the parameters of the equations.

Income elasticity is then obtained from the estimated parameters as:

$$\eta_j = 1 + \frac{\delta_j}{\bar{s}_j}$$

Where $\bar{s}_j$ is the sample average expenditure share of commodity group j.

Uncompensated Marshallian own and cross price elasticities are obtained respectively as:

(0.0) $$\varepsilon_j = -1 + \frac{\left[\beta_{jj} - \delta_j \left(\alpha_j + \sum_i \beta_{ji} \ln p_i\right)\right]}{\bar{s}_j}$$

(0.0) $$\varepsilon_{ji} = \frac{\left[\beta_{ji} - \delta_j \left(\alpha_i + \sum_i \beta_{ji} \ln p_i\right)\right]}{\bar{s}_i}$$

Compensated Hicksian own and cross price elasticities are:

(0.0) $$\varepsilon_j = -1 + \bar{s}_j + \frac{\left[\beta_{jj} - \delta_j \left(\alpha_j + \sum_i \beta_{ji} \ln p_i - \bar{s}_j\right)\right]}{\bar{s}_j}$$

(0.0) $$\varepsilon_{ji} = \bar{s}_i + \frac{\left[\beta_{ji} - \delta_j \left(\alpha_i + \sum_i \beta_{ji} \ln p_i - \bar{s}_i\right)\right]}{\bar{s}_i}$$

We use the full KHDS panel data to estimate the above system exploiting both geographical and time price variation[35]. The households' consumption module collects information on a wide range of food and non-food commodities. We exploit the presence of a market price survey which collects prices in each of the 51 clusters for the main commodities to avoid the issues involved in using unit values as a proxy for market prices (Deaton 1987). Expenditures are grouped into staple food, other food and non-food items[36]. We adopt this aggregation to be consistent with the supply estimations and to exploit fully the market price module of the survey. The group prices are then calculated as the weighted average of the individual good prices using the cluster average of the budget shares of each good in the group expenditure as weights. Total expenditure is the sum of households' expenditure on the three commodity aggregates.

As controls we use a number of variables able to capture the demographic composition of the households that can influence preferences. These variables are the age of the head, year of education of the head, the size of the household, a dummy for female

[35] As a robusteness check we repeat also the estimation exploiting the time variation only. Results for the elasticity show no significant difference with respect to the pooled estimation presented above.

[36] Staple food comprise bananas, beans, maize and cassava; Other food comprises other cereals, roots, fruits and vegetables, dairy products, meats, oils, sugar and salt. Non-food comprises kerosene, charcoal, firewood, batteries, soap, linen and utensils.

head, the proportion of adults and elder for both genders and the proportion of children, year and district dummies.

The system is estimated as a Non-Linear Seemingly Unrelated Regressions (NLSUR). NLSUR is the non-linear extension of Zellner's seemingly unrelated regression model (Zellner 1962). The non-linearity results from the composite price index which is not linear in the parameters. Formally, the model fit by nlsur is:

$$y_{i1t} = f_1(x_{it}, \beta) + u_{i1t}$$
$$y_{i2t} = f_2(x_{it}, \beta) + u_{i2t}$$
.
.
$$y_{imt} = f_m(x_{it}, \beta) + u_{imt}$$

with *m* equations commodity and $n \times t$ observations. A multivariate normal distribution is assumed for the error term as the errors for the ith observation may be correlated and thus fitting the *m* equations jointly may lead to more efficient estimates. Moreover, fitting the equations jointly allows us to impose cross-equation restrictions on the parameters.

Results of the estimation are reported in table 4.1. Table 4.2 shows the price and income elasticities of demand obtained from the estimated coefficients using the above formulas (0.0) to (0.0).

Table 4.1 : Almost Ideal Demand System

	Staple food	Other food	Non-food
Price staple food	-0.103***	0.0558***	0.0470***
	(0.0119)	(0.00825)	(0.00498)
Price other food	0.0558***	-0.0284***	-0.0274***
	(0.00825)	(0.00686)	(0.00336)
Price non-food	0.0470***	-0.0274***	-0.0196***
	(0.00498)	(0.00336)	(0.00269)
Expenditure	-0.0649***	0.0395***	0.0254***
	(0.00442)	(0.00294)	(0.00204)
HHD Size	0.00838***	-0.00491***	-0.00347***
	(0.00134)	(0.000890)	(0.000617)
Age head	-0.000790	0.00122*	-0.000431
	(0.00105)	(0.000697)	(0.000483)
Age squared	1.08e-05	-1.22e-05*	1.36e-06
	(1.00e-05)	(6.65e-06)	(4.61e-06)
Female head	0.0292***	-0.0244***	-0.00474
	(0.00906)	(0.00599)	(0.00416)
Education head	-0.00621***	0.00368**	0.00253**
	(0.00218)	(0.00144)	(0.00100)
Edu squared	-6.69e-05	0.000124	-5.67e-05
	(0.000173)	(0.000114)	(7.93e-05)
Prprimemale	-0.0240	0.0177	0.00630
	(0.0223)	(0.0147)	(0.0102)
Prprimefemale	-0.0531**	0.0168	0.0363***
	(0.0236)	(0.0156)	(0.0108)
Preldermale	-0.0385	0.0245	0.0140
	(0.0351)	(0.0232)	(0.0161)
Prelderfemale	-0.0641**	0.0329*	0.0312**
	(0.0288)	(0.0190)	(0.0132)
Prchild	-0.0468**	0.0230	0.0238**
	(0.0228)	(0.0151)	(0.0105)
Constant	0.444***	0.303***	0.252***
	(0.0375)	(0.0250)	(0.0169)
Observations	3,584		
r2 1	0.874		
r2 2	0.889		
Ll	7114		

Note: The table reports results from the Almost Ideal Demand System estimation. Demand own and cross elasticities are derived from a transformation of the above coefficients (see table 4.2). The estimation uses the five waves of the KHDS. Additional controls not reported in the table are dummies for the six Kagera districts and time dummies.

Table 4.2: Own, cross-price and income elasticities

	Marshallian uncompensated price elasticity			**Income Elasticity**	**Hicksian compensated price elasticity**		
	Staple Food	Other Food	Non-Food		Staple Food	Other Food	Non-Food
Staple Food	-1.14 (0.026)***	0.1 (0.025)***	0.15 (0.024)***	0.86 (0.01)***	-0.74 (0.017)***	0.61 (0.024)***	0.7 (0.026)***
Other Food	0.15 (0.02)***	-1.11 (0.021)***	-0.16 (0.016)***	1.12 (0.01)***	0.43 (0.017)***	-0.74 (0.02)***	0.19 (0.017)***
Non-Food	0.13 (0.01)***	-0.1 (0.01)***	-1.12 (0.013)***	1.12 (0.01)***	0.30 (0.01)***	0.13 (0.01)***	-0.88 (0.01)***

Note: Elasticities are derived from a transformation of the AIDS coefficients using formulas (0.0) to (0.0) All elasticities are computed at the sample mean expenditure share.

Agricultural wage elasticity

The effect on wages and income is accounted for by estimating the agricultural wage income elasticity as proposed by Porto (2007). Agricultural wage income accounts on average for 6% of total expenditure but it has higher weight for households at the bottom of the distribution which thus rely more on off-farm wage income and other agricultural income generating activities as shown in Figure 4.1 below.

We estimate a simple model of agricultural wage income determinants to obtain the estimates used to compute the income effect of price changes. By agricultural wage income we mean sources of income related to agriculture but different from coffee and food sales which we account for through the estimation of demand and supply elasticities. These income sources are agricultural wages from off-farm labour, sales of products derived from crops, sales of livestock and dairy products and sales of crops different from food and coffee. By estimating an aggregate agricultural wage relationship without distinguish between the different agricultural activities where these wages are earned we are able to identify only the average response to prices weighted by the shares of each type of activity on total labour supply.

We estimate the wage elasticity to tradable goods prices only as these prices are exogenously set on the international markets unlikely other non-traded goods prices.

The reduced form estimation is:

$$\ln w_{ij} = \alpha + \beta X_{ij} + \eta \ln p_{ij} + \varphi_j + \varepsilon_{ij}$$

where the dependent variable is the logarithm of the agricultural wage income of household *i* in cluster *j*, p_{ij} is a vector of prices of coffee and food faced by household *i* in cluster *j*; X is a vector of controls including age, education, size of the household, gender of the head, the proportion of children and men in the household, average rainfall and seasonal dummies. φ_j is a vector of cluster fixed effects and ε_{ij} is a normally distributed error term. The sample is composed of 1215 households which report earnings from these activities and is restricted to the fifth wave of the survey.

Results of the above estimation are reported in table 4.3. The elasticities of the agricultural wage income to the coffee and food prices are both positive and higher for the coffee price than the food price.

Table 4.3 : Wage-income elasticity

VARIABLES	(1) Agriculture wage income W (log)
Coffee P (log)	0.557***
	(0.191)
Food P (log)	0.277***
	(0.0831)
Size	0.0682***
	(0.0233)
Age head	0.0306*
	(0.0173)
Age squared	-0.000341**
	(0.000170)
Female head	-0.132
	(0.142)
Education (years)	0.0386
	(0.0414)
Education squared	0.000917
	(0.00347)
Rainfall (mm)	0.000315
	(0.00130)
Proportion children	-0.951***
	(0.282)
Proportion male	0.541**
	(0.241)
Constant	3.347*
	(1.756)
Observations	1,215
R-squared	0.150
F	3.838

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

Table 4.4 : Demand, Supply and wage income elasticities

	Demand[1] (ε^c)	Supply[2] (ε^q)	Wage income[3] (η)
Food	-1.14	0.021	0.28
Coffee	---	0.78	0.56
Other Food	-1.11	---	---
Non-food	-1.12	---	---

1. Demand elasticities are estimated through an AIDS using the full KHDS panel.
2. Supply elasticities are estimated in chapter 2 for coffee and food using the full KHDS panel. Food supply elasticity derives from the pooled *"wrong"* model.
3. Agricultural wage income elasticities are estimated through OLS using only 2004 KHDS data.

4.6 Empirical analysis: evaluation of trade reforms and price shocks

We use the 2004 Kagera Health and Development Survey to evaluate the impact of different trade and world price changes scenarios. The sample comprises 2073 households for which we have complete data on production and consumption (out of the 2774 KHDS 2004 full sample). We are thus restricting the sample to farming households as we want to focus on the impact that price changes can have on agriculture in the region and see if higher prices can generate growth in the agricultural sector more than look at the overall impact on welfare in the region.

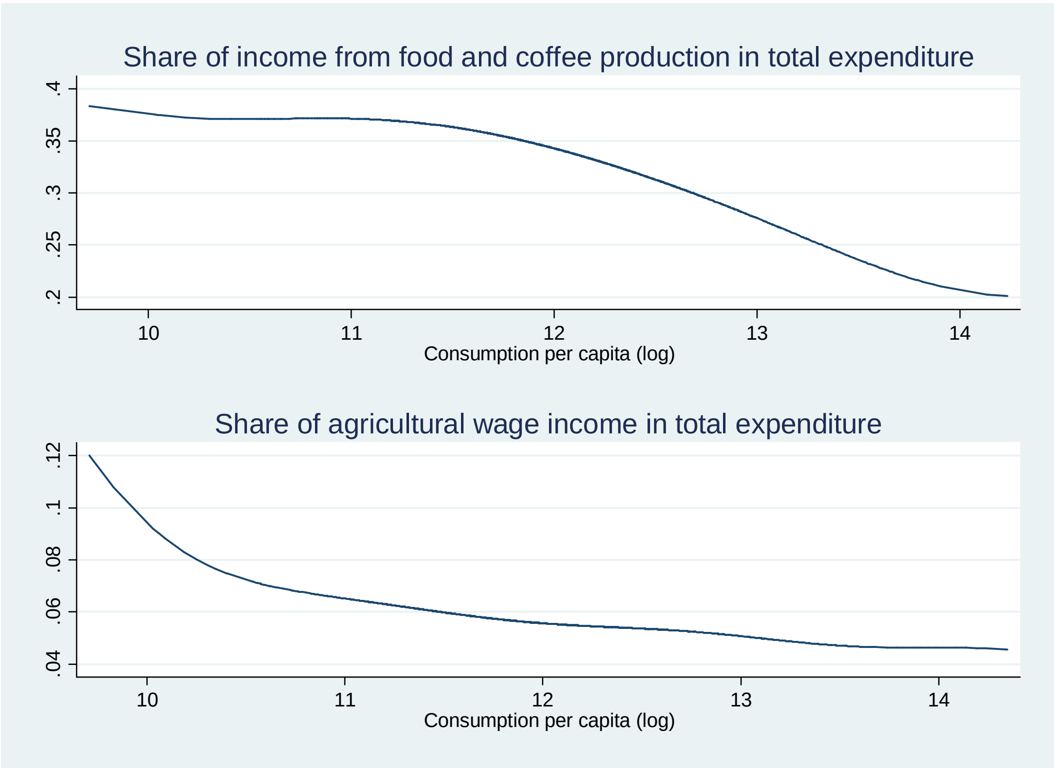
The first-order distributional impact on any price change will depend on the net-consumption ratio of each household: net-producers will gain from a price increase while net-consumer will lose. The prevalence of net-producers or net-consumers will determine the overall welfare impact of any price shock and the variation across the income distribution will determine which sector of the population will be more or less affected.

In our sample the average net-consumption ratio is positive on average but quite low as a share of total expenditures indicating a substantial balance between food production and consumption. Net-consumers seem to be concentrated more at the bottom of the income distribution (Figure 4.2). This tells us that on average gains will tend to prevail, a fact that is not surprising given that we are considering a strictly rural area where agriculture is the main economic activity (Figure 4.2), but also that the poor are more vulnerable to an increase in food prices. Above all what these figures suggest is that any impact would be limited by the fact that auto-consumption has such an important role

(Figure 4.2) averaging around 35% of total expenditures and 80% of total production[37]. Here we face what is substantially an autarkic economy where exchange plays a limited role and where price policies can clearly only have a limited impact.

However, when we take into account households' behavioural response on the consumption and production side the net-consumption ratio becomes endogenous and previously net-consumers can become net-producers as a consequence of the shock. Thus, the behavioural response permits to endogenize the net-supply position.

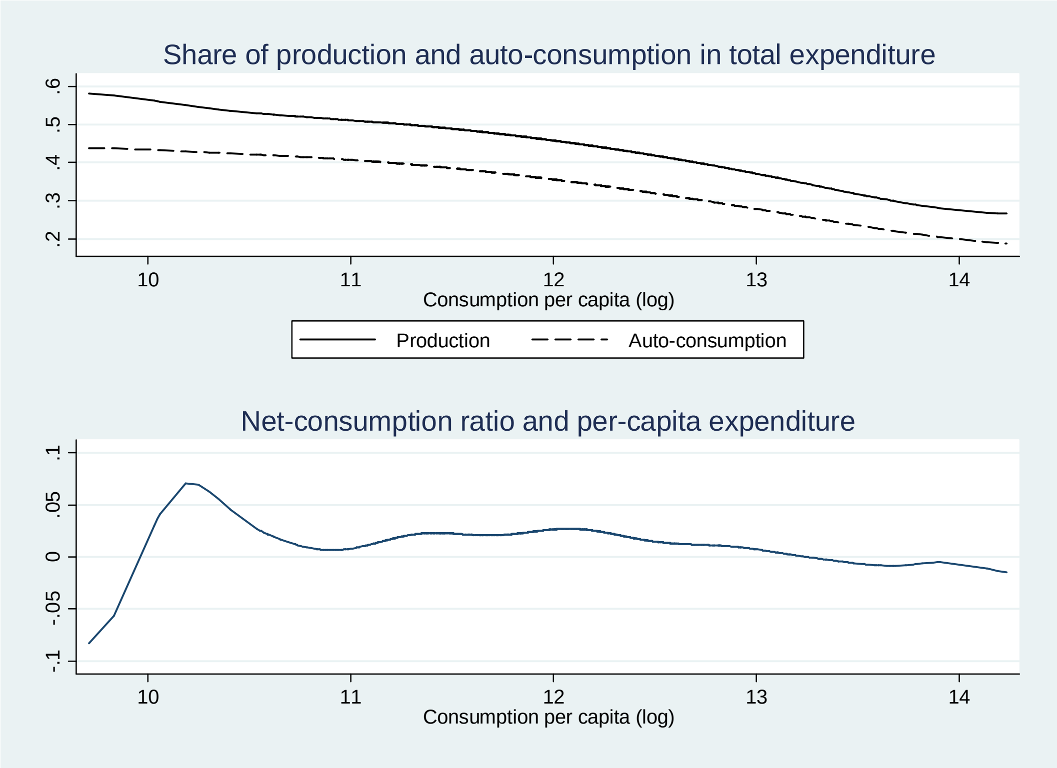
Figure 4.1: Shares of food, coffee and agricultural wage income



Note: Shares of food and coffee (upper panel) is the ratio of the sum of the value of food and coffee output over total expenditure. The share of the agricultural wage income (bottom panel) is the ratio of the value of the agricultural wage income over total expenditure. The graphs show how these shares vary along the income distribution (proxied by per-capita consumption). The lines are obtained by a non-parametric local polynomial smooth and represent the average share conditional to the income level.

[37] As shown in chapter one agricultural ouput accounts on average for around 45% of total income while the agricultural wage (the sum of off-farm wages, sales of agricultural by-products, livestock and dairy products) accounts on average for 6% of total income. Other sources of income are wages in non-agricultural employment, business income, transfers and other non-labour income, rent income and autoconsumption of livestock raised by the households.

Figure 4.2: Shares of total output, auto-consumption and food net-consumption ratio



Note: Shares of production (upper panel full line) is the ratio of the sum of the value of all crops output over total expenditure. The share of auto-consumption (upper panel dashed line) is the ratio of the value of own-produced crops kept for own-consumption over total expenditure. The net-consumption ratio (bottom panel) is given by the difference between the share of consumption and the share of production of food. The graphs show how these shares vary along the income distribution (proxied by per-capita consumption). The lines are obtained by a non-parametric local polynomial smooth and represent the average share conditional to the income level.

We consider four different scenarios (Table 4.5) which have an impact on agricultural prices and evaluate the distributional effects using the methodology discussed in the previous section. The first two scenarios are trade reforms. The first is the Doha round reform under discussion which was supposed to introduce a series of liberalizations in the agricultural sector mainly cutting domestic support and export subsidies in developed countries. The potential effects of this reform have attracted a considerable amount of attention and different models have been employed to evaluate the impact on world prices and trade flows. The second trade reform scenario is a full multilateral liberalization. For these two we use as a measure of the price changes induced by these reforms the ones obtained by Hertel and Winters (2006) which forecast a small increase in world agricultural prices following implementation of the Doha agenda and a full multilateral liberalization.

The third and fourth scenarios are increases in world prices for food and coffee. The third is a simulation of a 50% increase in food prices in line with the kind of price shock experienced during 2007/2008 and the fourth is a 30% increase in the coffee price in line with the change in international coffee price experienced during the nineties.

Table 4.5 : Price change scenarios

	Doha	Full liberalization	Food price	Coffee price
Food	+1.1%	+6.1%	+50%	---
Coffee	---	---	---	+30%

Source: Hertel and Winters (2006) for Doha and full liberalization scenarios.

For each scenario we calculate the welfare effect using formula (0.0) for each household and then look at the variation of the average welfare effect along the income distribution.

There are two interesting ways in which the “full model” overall welfare impact can be decomposed to better understand which underlying factors are driving the results. First, the overall effect can be decomposed into a consumption effect which incorporates the first-order consumption impact plus the behavioural response given by the demand elasticity[38] and an income effect which includes the output (first order and supply response) and the wage-income impacts[39]. A second decomposition is the one between the classical first-order impact on consumption and production (eq. (0.0)) and the full-model impact which includes the behavioural response on consumption, outputs and wage-income[40]. The full-model impact can be further decomposed into the consumption and the income response[41]. Table 4.6 shows results of the overall welfare impact and its decompositions.

To analyse how the average impact varies across the income distribution we use a non-parametric locally weighted polynomial smoothing (Figure 4.3 to 4.6). This approach runs a series of regressions using only points in a neighborhood of each x of interest, which means only points comprised into a bandwidth that has to be chosen. A weighting function is then applied to weight observations further away from the central point. The choice of the bandwidth is important in this analysis and is based on the trade-off between smoothness on the one hand and precision on the other: the larger the bandwidth, the higher the bias and the higher the smoothness, the opposite is true for a smaller bandwidth that increases precision but at the cost of a higher complexity. There are rules to make the best choice minimizing the tradeoff but usually the visual

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[38] Consumtion effects (CE) is defined as: $CE = -d\ln p_i\left[p_i c_i + \frac{1}{2}d\ln p_i(c_i\varepsilon_i^c)\right]$

[39] Income effect (IE) is defined as: $IE = d\ln p_i\left[p_i q_i + \eta W + \frac{1}{2}d\ln p_i\left(q_i\varepsilon_i^q\right)\right]$

[40] The full model impact is defined as: $FMI = d\ln p_i\left[\eta W + \frac{1}{2}d\ln p_i\left(q_i\varepsilon_i^q - c_i\varepsilon_i^c\right)\right]$

[41] The income response is $IR = d\ln p_i\left[\eta W + \frac{1}{2}d\ln p_i\left(q_i\varepsilon_i^q\right)\right]$ and the consumption response is $CR = -d\ln p_i\left[\frac{1}{2}d\ln p_i\left(c_i\varepsilon_i^c\right)\right]$

inspection is appropriate as suggested by Deaton (1997). After experimenting with different bandwidth we choose a value of 0.2 in figure 4.3 to 4.6[42].

[42] The units of the width are the units of the x variable, the logarithm of per capita consumption in our case.

Table 4.6 : Welfare impact

	Doha	Full liberalization	Food price	Coffee price
Overall welfare effect (%)	0.04	0.27	6.0	1.6
		Consumption/Income decomposition		
Consumption effect (%)	-0.32	-1.74	-10.6	---
Income effect (%)	0.36	2.01	16.6	1.6
		First-order/Full-model decomposition		
First-order impact (%)	0.02	0.11	0.9	0.5
Full-model impact (%)	0.02	0.16	5.1	1.1
Consumption response	0.00	0.06	4.2	--
Income response	0.02	0.1	0.9	1.1
		Poverty impact		
Poverty head-count First-order impact (change)	-0.05	-0.2	-0.43	-0.42
Poverty head-count Full-model impact (change)	-0.1	-0.25	-2.89	-0.9

Note: The overall welfare effect and its decompositions are simple averages of the welfare effect derived for each household using the respective formulas and expressed as a percentage of total expenditure. The head-count impact is the absolute change from the baseline pre-scenario head-count index.

The first thing to notice is that multilateral trade liberalization scenarios would have only a minor impact on households in the region. This is a consequence of the low impact estimated on world agricultural prices. It is important to notice that these estimates provide an upper bound impact as we are assuming full price transmission but it is likely that imperfect transmission from world to local prices would attenuate even more the impact on the local economy. Even if small the impact is notwithstanding positive on average and the income effect tend to prevail on the negative consumption effect.

For the two trade scenarios the breakdown of the overall impact into its first-order component and the full-model response which includes the behavioural adjustment of consumption, outputs and income shows that these adjustments account for about half of the overall effect. The income response is more important than the consumption response in these two scenarios a fact driven by the small price increase which generates only a small consumption response. The two trade scenarios show a slight improvement of the poverty head-count (Table 4.6).

In order to look at the distributional impact of the two trade scenarios we report the non-parametric regression of the welfare impact on per-capita expenditures in figure 4.3 and 4.4. The effect is negative for households at the very bottom of the distribution which are net-consumers of food and this is the case both for the first-order impact and the full-model when income and consumption responses are incorporated.

The situation is quite different for the food price shock scenario. Here we simulate the impact of a strong price increase of food products and the impact on households' welfare is clearly stronger as well. The average impact is positive and the income effect overcomes the negative impact on the consumption side, a reflection of the prevalence of net-producers in the sample and of the positive wage-price elasticity which brings an increase in the agricultural wage income. The most interesting thing is that the adjustments included in the full-model impact account for almost 90% of the overall effect. This shows the importance of taking into account households' behavioural response in particular when price changes are substantial. In fact, the suitability of a first order approximation relies of the assumption that price changes are only marginal. The consumption response accounts for two thirds of the full-model adjustment and the income response accounts for the rest.

In this scenario we have an improvement of the poverty head-count reflecting the fact that also households at the bottom of the distribution gain from the increase in food prices once their dynamic responses on consumption and income are taken into account (Figure 4.5). Consumption response seems to be the main driver of the adjustment for low income households reflecting the higher share of food consumption.

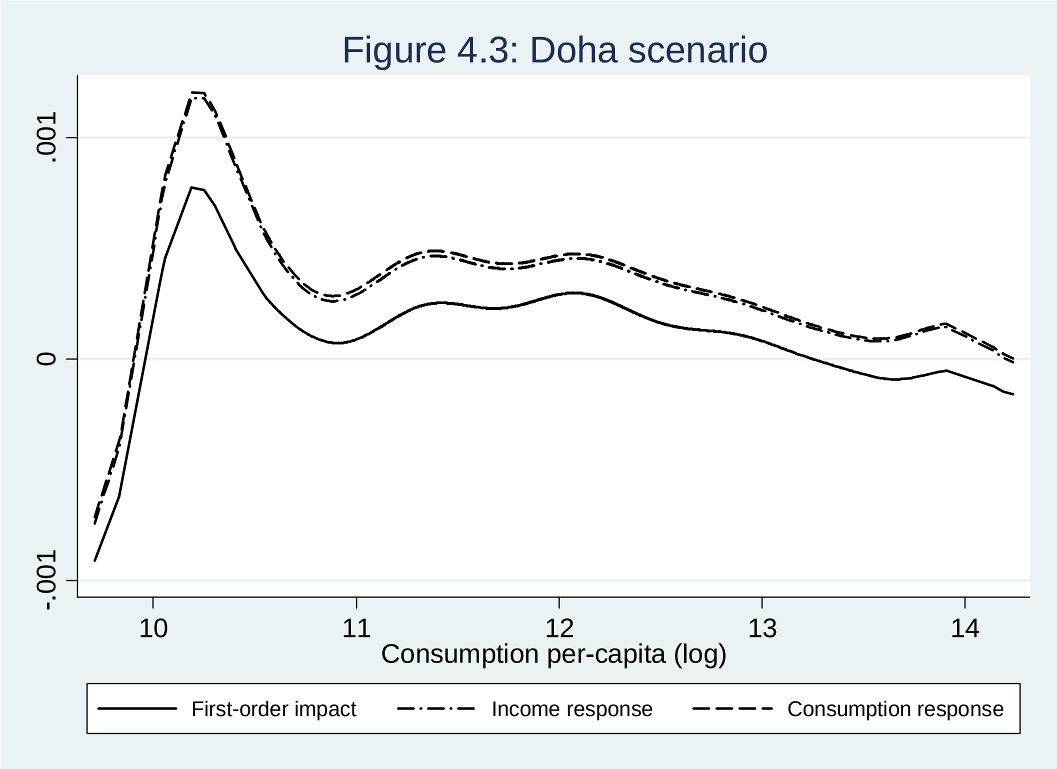

Figure 4.3: Doha scenario
.001
0
-.001
10
11
12
13
14
Consumption per-capita (log)
First-order impact
Income response
Consumption response

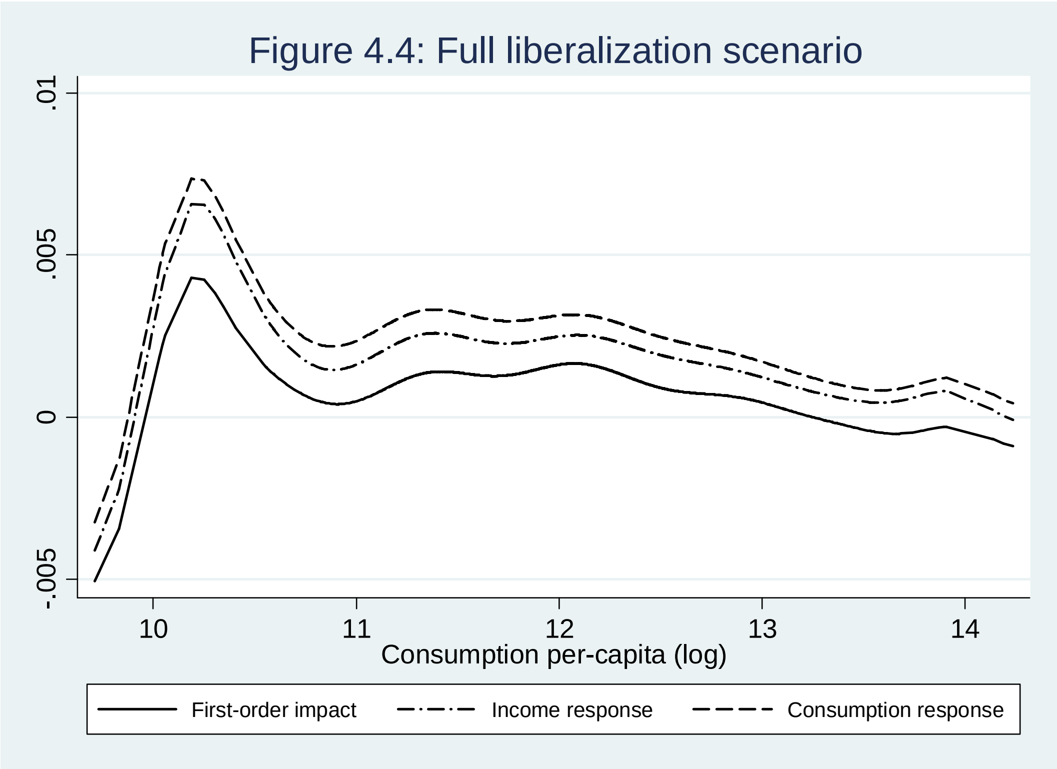

Figure 4.4: Full liberalization scenario
.01
.005
0
-.005
10
11
12
13
14
Consumption per-capita (log)
First-order impact
Income response
Consumption response

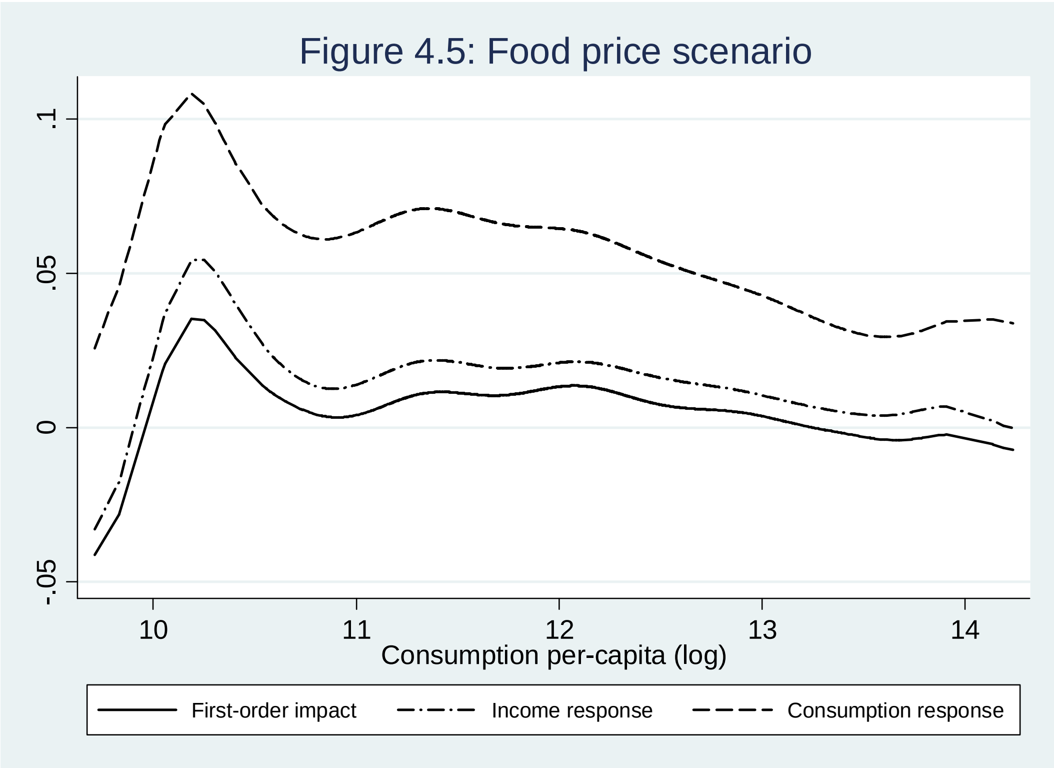
Figure 4.5: Food price scenario
-.05
0
.05
.1
10
11
12
13
14
Consumption per-capita (log)
First-order impact
Income response
Consumption response

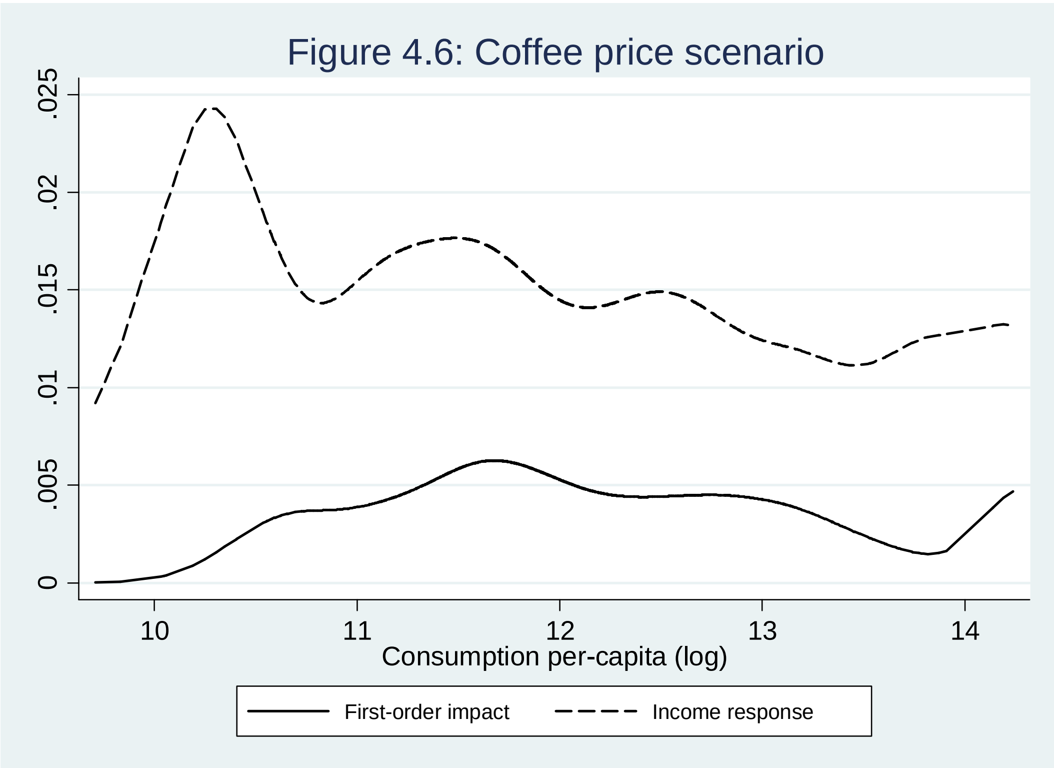
Figure 4.6: Coffee price scenario
0
.005
.01
.015
.02
.025
10
11
12
13
14
Consumption per-capita (log)
First-order impact
Income response

The non-parametric regression of the welfare impact on per-capita expenditures shows again that the first-order effect is negative at the bottom of the distribution but when income and consumption responses are considered the effect becomes positive along the entire income distribution.

The coffee price scenario also shows a positive welfare impact as expected given that coffee is not consumed in the region but represents an additional form of income. The main component of the overall welfare effect is the income response both in the form of higher output and an increase in the wage income component that are both more responsive to the coffee price than to the food price. This is an indication of the importance that coffee has in the region not only directly as the main cash crop but for its spill-over effects on other wage and income generating activities. The indirect effect that coffee price has on the agricultural wage income has the effect of reversing in part the distributional impact of the price increase in favour of lower income households which derive a higher share of their total income from off-farm wages and other income generating activities. This can be seen in figure 4.6 which plots the average welfare impact as a function of per-capita household expenditure.

Overall what we notice is that the kind of rural economy we are analysing are sheltered from price changes because of the high degree of autarky where market transactions account only for a limited part of total income. However, when price changes become bigger the behavioural response implies a change in the net-consumption ratio, the endogeneity of the net-supply position becomes relevant and market transaction increase their weight in the economy. On the one hand this is encouraging for trade policy as it shows that price changes can in principle have important dynamic effects and can favour the building of a market-oriented economy. On the other hand, it is disappointing because it shows that for these dynamic effects to be meaningful we need price changes of a magnitude which is difficult to be reached exclusively with trade policy instruments.

On the methodological side we notice that taking into account households' behavioural response and the income effect of price changes is very important and can change significantly the assessment of the welfare impact of trade policies and price shocks in particular as the price changes become higher. The predictions of the full-model, for the food price scenario in particular, not only differ substantially in magnitude but also imply a change in the sign of the welfare impact for households at the bottom of the income distribution. An assessment based on the first-order impact only would have had very different policy implication.

4.7 The role of market participation and transaction costs

The above analysis shows the distinct role of households' response in muting the short-term impact of price changes as households have time to adjust to the new set of prices. However, this analysis hides the fact that some households are completely out of the market economy and produce only for self-consumption.

These households will not respond to price changes unless there are price or non-price factors that push them into the market exchange. In the previous chapter we estimated a model of market participation and supply response that takes into account this heterogeneity in market participation and accounts for self-selection into market regimes. The results of the analysis show that price changes are not important determinants of households' choice of whether to take part in the market exchange or not while other factors as endowment, risk and environmental factors seem to matter the most. According to these estimates a change in the food price will not alter significantly the participation choice implying that self-sufficient households will likely remain self-sufficient after a price shock. These households are thus sheltered from any change in food prices and this should be taken into account when evaluating the welfare impact.

A further result of the model estimated in chapter 3 is that the supply elasticity for households that do take part to market is actually higher than the one estimated using the pooled model of chapter 2. We thus review the simulation of the welfare impact of the previous section incorporating the correct model of supply response into the analysis. Table 4.7 reports the new set of elasticities used[43].

Table 4.7 : Demand, Supply and wage income elasticities

	Demand[1] (ε^c)		Supply[2] (ε^q)		Wage income[3] (η)
	Net-Buyers Net-Sellers	Self-sufficient	Net-Buyers Net-Sellers	Self-sufficient	
Food	-1.14	0	0.3	0	0.28

1. Demand elasticities are estimated through an AIDS using the full KHDS panel.
2. Supply elasticities are estimated in chapter 3 conditional on market participation regimes and using the full KHDS panel.
3. Agricultural wage income elasticities are estimated through OLS using only 2004 KHDS data.

We need to notice that while self-sufficient households do not participate to any market exchange they can still be net-producers as part of the output can be devoted to payments in kind and it is appropriate to consider this in the computation of the household's net position and thus in the first-order welfare impact analysis as noted by

[43] A fully consistent model would estimate also food demand elasticities conditional on market participation as done for the supply response model. However, given the high complexity and nonlinerities of the AIDS model this correction goes beyond the scope of this paper and we use the pooled estimates presented above for the demand elasticity of households taking part to the market either as sellers or buyers. We just restrict self-sufficient households' demand elasticity to zero for consistency.

Budd (1993). However, the lack of any market transactions implies that these households will not have any behavioral response of consumption and output to the market price.

A second factor arising from the analysis of the previous chapter is that transaction costs have an important reallocation effect. A reduction in transaction cost in changing the effective price received and paid by sellers and buyers respectively will shift production from net-buying households towards net-sellers. While this is a welfare enhancing policy and can also increase efficiency by encouraging a higher degree of specialization, it can have side effects when combined with an increase in prices. In fact, net-buyers will rely more heavily on market purchases to satisfy their food needs allocating their effort to activities where they have a higher comparative advantage but also potentially exposing themselves to changes in market prices. If households at the bottom of the distribution are also net-buyers this shift can hurt them. We are thus in a position to analyze the combined effect of a reduction in transaction costs and a food price increase.

We thus first introduce the unresponsiveness of self-sufficient households into the analysis to see how this changes the previous results and then simulate the combined effect of a reduction in transaction costs followed by the price change. To simulate the impact of a reduction in transaction costs we assume a hypothetical policy which provides each community with access to a market and makes roads passable over all the year. We calculate the impact on food output for both net-buyers and net-sellers using the change in the predicted values from estimation of the previous chapter and apply this change to actual quantities to obtain the hypothetical output after the policy implementation[44]. Results of the simulation imply that food output decreases on average by around 6% for net-buyers while it increases by around 3% for net-sellers. On this new vector of output we apply the same methodology applied before for a 50% increase in food prices and look at the implication in terms of welfare.

[44] Defining $\hat{q}_i^b$ as household *i* predicted food output from the food supply model of chapter 3 in the baseline scenario and $\hat{q}_i^T$ as the predicted food output from the same model but with transaction costs set to zero then $\Delta\hat{q}_i = (\hat{q}_i^T - \hat{q}_i^b) / \hat{q}_i^b$ is the predicted change in food output following the disappearance of transaction costs and $q_i^s = q_i + q_i \Delta\hat{q}_i$ is the hypotethical food output in absence of transaction costs being q_i the actual output produced by household *i*.

Table 4.8 : Welfare impact Food price shock

	Baseline food price scenario	Market participation	Transaction costs
Overall welfare effect (%)	6.0	6.3	6.2
Consumption effect (%)	-10.6	-11.2	-11.2
Income effect (%)	16.6	17.5	17.4
First-order impact (%)	0.9	0.9	0.8
Medium-term impact (%)	5.1	5.4	5.4
Consumption response	4.2	3.6	3.6
Income response	0.9	1.8	1.8
Poverty head-count First-order impact (change)	-0.43	-0.44	-0.50
Poverty head-count Medium -run (change)	-2.89	-3.48	-3.63

Note: The baseline scenario is the one considered in the previous section which does not take into account market participation decisions and applies to all households the pooled supply elasticity. The market participation scenario takes into account different regimes of market participation and applies the elasticity of supply obtained taking market participation decisions into account. The transaction costs scenario gives the effect of the price change given a prior reduction in transaction costs. The overall welfare effect and its decompositions are simple averages of the welfare effect derived for each household using the respective formulas and expressed as a percentage of total expenditure. The head-count impact is the absolute change from the baseline scenario head-count index.

Table 4.8 shows how the results change when including household market participation into the analysis. The second column shows that in the market participation scenario the consumption response is lower while the output response is higher. The overall welfare impact in the medium-term is higher. The lower consumption response caused by the irresponsiveness of self-sufficent households is more than compensated by the higher income effect caused by the higher elasticity of supply. The positive impact on the poverty head count is also higher in the medium term.

The third column of table 4.8 shows results for the simulation following the reduction in the transaction costs. There are no major differences with respect to the scenario in the second column which is consistent with the fact that the overall output will remain substantially unchanged following a reduction in transaction costs and the main effect instead will be a reallocation of output from net-buyers to net-sellers. The effect on the poverty head count seems however to be slightly higher.

Table 4.9 : Net-Buyers, Self-sufficient and Net-sellers welfare impact Food price shock

		Net-Buyers	Self-sufficient	Net-Sellers
Baseline	First-order	-2.3	1.2	5.6
	Medium-term	2.5	6.1	11.2
Market participation	First-order	-2.3	1.2	5.6
	Medium-term	3.4	1.6	12.7
Transaction costs	First-order	-3.1	1.2	6.2
	Medium-term	2.5	1.6	13.4
N		1047	292	722

Table 4.9 presents the disaggregation of the welfare impact for net-buyers, self-sufficient and net-sellers households for the baseline food price scenario and for the market participation and transaction costs adjustments. The disaggregation shows that

not taking into account the fact that self-sufficient households are not responsive to changes in market prices overstates significantly their estimated welfare impact in the medium-term. While in our sample the number of households that is completely self-sufficient for food is not very high and thus the average welfare effect is not disproportionately affected this correction can be potentially important for goods and regions where autarky is more widespread.

The disaggregation also shows that while net-buyers are adversely affected in the short-run by the increase in food prices, on average also for them the response of consumption, output and wage income reverse the losses into a welfare gain. Clearly most of the benefit goes to net-sellers.

The last panel of table 4.9 shows the effect on net-buyers and net-sellers of the change in food prices given the reduction in transaction costs. As output reallocates from net-buyers to net-sellers the first experience higher losses in the short-run which still reverts to a welfare gain in the medium-run but lower than in the previous scenario. The opposite is true for net-sellers which instead increase their gain as a result of the higher food output.

Figure 4.7 shows the first-order welfare impact under the baseline food price scenario and the transaction costs simulation. While the overall impact is limited we do notice that the main effect is an increase of the losses at the bottom of the distribution meaning that these poorer households will rely heavily on the food market to satisfy their consumption needs after the reduction in transaction costs and thus they are more adversely affected by a food price increase in the short-run. This is an important consequence of a more market oriented economy were households tend to specialize in some activities and rely on the market to satisfy consumption needs but at the same time become more vulnerable to market price changes.

Figure 4.7: Baseline and transaction costs scenarios: First-order impact

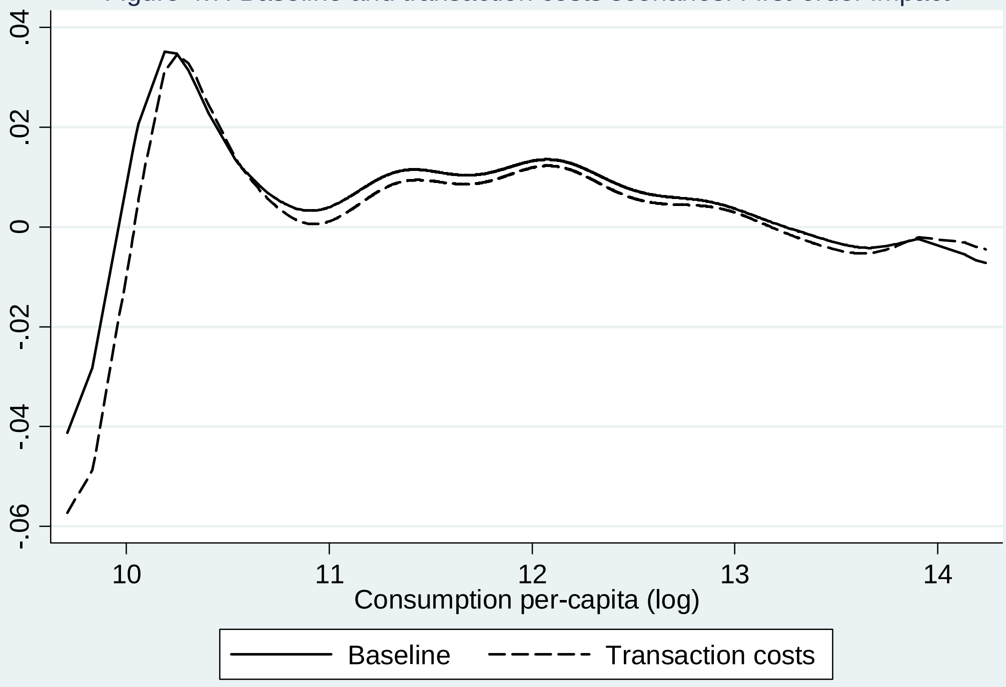

Figure 4.8 : Baseline, Market participation and transaction costs scenarios: Full-model impact

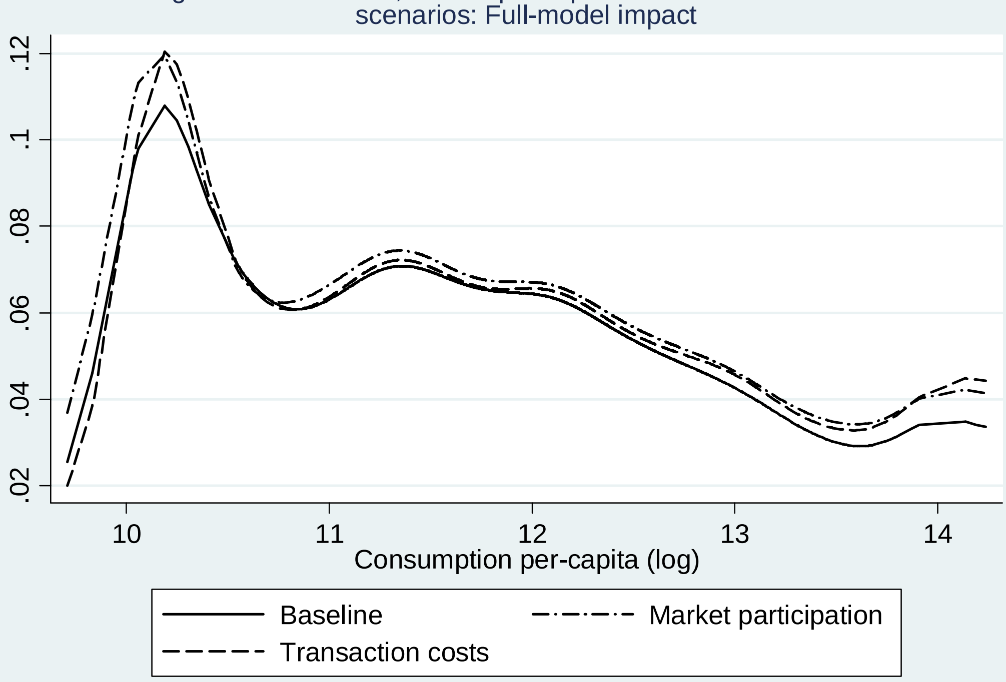

Figure 4.8 finally compares the medium-term welfare effects for the baseline, market participation and transaction costs scenarios. Taking into account the non-responsiveness of self-sufficient households has an impact mainly in the middle part of the income distribution while again the transaction costs reduction mainly reduces the gains at the bottom of the distribution where net-buyers are concentrated.

4.8 Conclusions

We have analyzed the welfare impact of different trade policy and price shocks scenarios for a sample of households in the Kagera region of Tanzania. We depart from the classic first-order impact analysis to include households' consumption, outputs and wage-income response showing that these can substantially change the results of the analysis of price variations on welfare. We also consider the impact of heterogeneity in households' market participation with its implication that some households that do not take part to market are unresponsive to prices.

The structural characteristic of the typical rural economy under analysis clearly implies that any effect of price variations is limited by the low degree of commercialization of the economy which is mainly based on semi-subsistence agriculture. However, when price changes are 'non-marginal' our analysis shows that while the effect is still low in the short-run it becomes much higher when we take into account households response on consumption and income and thus endogenize households' net position.

The conclusion we draw is that the effect of higher prices will be low but generally positive and that it can be able to generate important dynamic responses and spillovers that can mobilize resources in agriculture and increase the degree of commercialization with potentially important long-run gains.

For the two trade policy scenario considered we do not find very big impacts, a fact due to the low impact estimated on world prices and to the low degree of commercialization of the economy we are analyzing.

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