Elizaphan James Oburu Rao

Emerging High-value Food Chains and Implications for Rural Households: The Case of Vegetable Production in Kenya

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Emerging high-value food chains and implications for rural households: The case of vegetable production in Kenya

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By

RAO ELIZAPHAN JAMES OBURU

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To my parents, Charles and Janet, who taught me how to do little things with utmost diligence, to you I am forever indebted.

Abstract

Recent decades have seen significant changes in agri-food systems in many developing countries. While food systems are still largely traditional, dominated by small over-the-counter shops and wet markets, increasing urbanization and rising incomes are creating an urban middle class with a growing demand for a variety of products. Changing lifestyles motivated by wider media penetration and the accompanying westernization of diets also create concern for food quality and food safety. Furthermore, trade and domestic market liberalization have led to a surge in product variety, providing economies of scope for large modern retailers capable of stocking a wide assortment of products. Consequently, food supply chains in developing countries are experiencing rapid modernization with super- and hypermarkets assuming an increasing role.

These trends are already evident in Latin America and developing countries of Asia, but the trend is picking up in Africa, with Kenya among the leading countries. As they become more established, supermarkets will increasingly influence the structure, conditions and performance of agri-food systems in developing countries in general, and in Kenya in particular. Faced with the inherent weaknesses of traditional food systems, modern retailers often adopt tighter vertical coordination, which enables them to meet consumer concerns for food safety and quality. They also impose standards and conditions for product delivery to ensure consistent, year-round supply of products, as demanded by consumers.

Abstract

Tighter coordination mechanisms adopted by supermarkets may have crucial implications for the vast small farm sector, which crucially depends on the urban fresh produce market. The increasing modernization of supply chains presents opportunities for farmers to integrate into high-value markets that frequently offer higher and more stable prices. In addition, integrated high-value supply chains also provide market assurance for farmers. Nevertheless, there are also substantial challenges associated with supplying supermarkets. There is an emerging consensus that stringent requirements imposed by supermarkets could potentially exclude some farmers from these chains. This is especially so for poor, dispersed and remotely located farmers with limited technical capacity and capital to implement supermarket requirements.

The mixed nature of effects has attracted interest among researchers seeking to understand the consequences of the emerging food system transformation in developing countries. Most studies have analyzed determinants of supermarket growth and likely determinants of farmer participation. There is also a strain of literature looking into potential productivity effects of farmer participation in supermarket channels. However, available studies in this area only measure partial productivity, which can potentially mislead or misrepresent farm performance. Little is known about total factor productivity effects. Similarly, none of the studies available has analyzed potential technical efficiency effects, which may result as farms reorganize and alter input application in response to changing market structures.

There are also studies that analyze potential income effects of farmer participation in supermarket channels, but available research is mostly based on enterprise budget comparisons, which do not necessarily imply causality, since other potential causes of differences are not controlled for. Focusing on enterprise budgets alone also ignores other household income sources, which may potentially be affected, too. For instance, supermarket participation may

entail resource reallocations within the household. Finally, existing studies provide indications that farmers supplying supermarkets tend to use more labor. But again, these studies are based on simple comparison approaches that conceal other potential causes, so that robust statements on employment effects are not possible.

We address the gaps in the existing literature by analyzing impacts on farm productivity and technical efficiency, household income and poverty, as well as farm wage employment. Our analysis relies on data collected through a survey of vegetable farm households in Kiambu district of Central Kenya. The sample contains both farmers that supply to supermarkets and farmers that supply to traditional markets.

First, we analyze productivity effects of farmer participation in supermarket channels. Since we expect farmers in traditional and supermarket channels to differ structurally, we use a meta-frontier approach, which acknowledges the potential for technological differences. The approach yields productivity estimates that are easily comparable across groups, because the estimates are derived with respect to a common frontier. To account for sample selection bias, we subject our productivity scores to statistical matching, in order to derive unbiased treatment effects. Second, we analyze household income and poverty effects of supermarket participation. We evaluate these impacts using endogenous switching regression techniques that account for potential endogeneity bias. Finally, we analyze labor market implications. As high-value vegetables are labor-intensive, we expect farmer participation in supermarket channels to have substantial spillovers on farm wage employment. We analyze employment effects using a double-hurdle model, which properly accounts for the two-step decision process involved in hiring in labor, namely (i) the decision whether or not to hire labor and, if that decision is positive, (ii) how much labor to hire.

Abstract

Our findings confirm significant differences in technology between farmers in the two market channels, which lead to 35-38% higher productivity among supermarket suppliers. Better market systems embodied in supermarket channels can therefore lead to productivity improvement, which is needed to spur agricultural growth in Sub-Saharan Africa. We also find that farmer participation in supermarket channels results in significant improvement in household income and reduction in poverty. While household income among participants increases by 48%, poverty is reduced by 20%. There are also substantial gains for the rural labor force employed as farm wage laborers. Compared to vegetable production for traditional channels, production for supermarket channels increases wage employment by 38%. Gender disaggregation reveals that this effect is particularly pronounced for female wage laborers. Farmer participation in supermarket channels therefore presents an important avenue for broader poverty reduction and rural development, given the predominance of wage laborers among the poorest segment of the rural population.

However, the results also show that there are certain constraints for disadvantaged farm households. Better educated farmers and households with more assets are more likely to be involved in supermarket channels. Moreover, infrastructure and access to transportation are factors that facilitate participation significantly. To a large extent, these are the same types of problems that also limit smallholder participation in more traditional markets. They need to be overcome through appropriate rural development policies, in order to fully harness the potentials of emerging modern supply chains for the poor.

Zusammenfassung

Im Laufe der Jahrzehnte haben sich die Produktions- und Vermarktungsformen in der Landwirtschaft vieler Entwicklungsländer stark verändert. Zwar wird das Bild nach wie vor von traditionellen Märkten geprägt, doch führen schnelle Urbanisierung und steigende Einkommen zur Etablierung eines städtischen Mittelstandes, der durch veränderte Konsumpräferenzen gekennzeichnet ist. Auch der Einfluss von Medien und die damit einhergehende „Verwestlichung“ des Lebensstils haben einen starken Einfluss auf die Essgewohnheiten vieler. Gleichzeitig steigt auch der Anspruch an die Lebensmittelqualität. Außerdem hat die Handelsliberalisierung vielerorts zu mehr Produktvielfalt geführt. Innovative Einzelhändler nutzen Größendegressionseffekte und bieten heute eine Vielzahl verschiedener Lebensmittel an. Im Zusammenspiel dieser Faktoren steigt die Bedeutung von Supermärkten in Entwicklungsländern, deren Agro-Supply Chains“ aktuell einen Modernisierungsprozess durchlaufen.

Während diese Entwicklung in Lateinamerika und in den weniger entwickelten Staaten Asiens bereits länger beobachtet werden kann, ist dieser Trend in Afrika noch recht neu. Kenia ist ein führendes Beispiel. Wenn die Bedeutung von Supermärkten in den Entwicklungsländern Afrikas, insbesondere in Kenia, weiter steigt, wird dies mehr und mehr strukturelle Veränderungen der Supply Chains zur Folge haben und deren Leistungsfähigkeit steigern. Große Einzelhändler sehen sich häufig mit den systemimmanenten Schwierigkeiten traditioneller Supply Chains konfrontiert und setzen verstärkt auf vertikaler Integration, um die Kundenbedürfnisse

hinsichtlich einheitlicher Produktqualität zu befriedigen. Die Einzelhändler stellen auch Regeln bezüglich der Liefermengen und Produktstandards auf, um den Kunden ganzjährig mit ausreichenden Mengen qualitativ hochwertiger Produkte versorgen zu können.

Wenn Supermärkte ihre Versorgungskanäle stärker koordinieren, dann kann dies auch bedeutende Implikationen für Kleinbauern haben, die in erheblichem Maße von der Vermarktung ihrer Produkte in den Städten abhängig sind. Für Kleinbauern birgt die Entstehung moderner Supply Chains für hochwertige Agrarprodukte die Chance, einen meist sicheren Markt zu beliefern, der häufig höhere und weniger stark fluktuierende Preise bietet. Trotz dieser Vorteile stellt die Belieferung von Märkten für hochwertige Agrarprodukte auch eine große Herausforderung dar. Es besteht heute Konsens darüber, dass die strikten Standards, die von Supermarktketten aufgestellt werden, dazu führen können, dass bestimmten Kleinbauern der Zugang zu diesem Markt erschwert wird. Dies betrifft insbesondere arme Kleinbauern in entlegenen Regionen, die über vergleichsweise einfache Produktionstechnologie und wenig Kapital verfügen und somit Schwierigkeiten haben, die Supermarkstandards zu erfüllen.

Diese Ambivalenz in der Wirkung und dem Einfluss der veränderten Bedingungen im Wachstumsmarkt für hochwertige Agrarprodukte in Entwicklungsländern beschäftigt die Wissenschaft. Bislang haben sich die meisten Studien mit den Determinanten des Marktwachstums und der Marktteilhabe von Kleinbauern beschäftigt. Daneben gibt es Untersuchungen, die Produktivitätseffekte analysieren, die mit Belieferung von Supermärkten einhergehen können. Allerdings liegt das Hauptaugenmerk dabei meist auf partieller Produktivität, eine Größe, die die Leistungsfähigkeit der bäuerlichen Betriebe potenziell falsch abbildet und zu Schlüssen führen kann, die nicht korrekt sind. Bislang ist nur wenig über den Einfluss auf die totale Faktorproduktivität bekannt. Außerdem hat bis dato keine Untersuchung

Ergebnisse zu möglichen Auswirkungen auf die technische Effizienz geliefert. Diese könnten sich ändern,, wenn landwirtschaftliche Betriebe ihre Ressourcenallokation anpassen, um auf veränderte Produktionsbedingungen im Zusammenhang mit der Belieferung von Supermärkten zu reagieren.

Darüber hinaus wurden in verschiedenen Beiträgen mögliche Einkommenseffekte untersucht, die im Zusammenhang mit der Belieferungen von Supply Chains für hochwertige Agrarprodukten steht. Allerdings basieren diese Studien meist auf dem Vergleich einzelner Betriebszweige, so dass meist kein eindeutiger und überzeugender Kausalzusammenhang nachgewiesen werden kann, da nicht ausreichend für verzerrende Faktoren berichtigt wurde. Außerdem werden andere Einkommensquellen der untersuchten Haushalte vernachlässigt, wenn der Fokus der Analyse allein auf den Deckungsbeiträgen der entsprechenden Produktionszweige liegt. Beispielsweise könnten Kleinbauern, die Supermärkte beliefern, Ressourcen in ihrem Haushalt anders einsetzen als solche, die ihre Produkte auf traditionellen Märkten absetzen. Daneben gibt es auch Studien, deren Ergebnisse darauf hindeuten, dass Kleinbauern, die in Märkte für hochwertige Agrarprodukte integriert sind, mehr Arbeit aufwenden. All diese Ergebnisse müssen allerdings mit großer Vorsicht interpretiert werden, da diese Untersuchungen auf einfachen Vergleichsansätzen ohne spezielle Kontrollgruppe basieren und somit robuste Aussagen über Arbeitseffekte nur schwer möglich sind.

Wir versuchen, die bestehenden Forschungslücken zu schließen, indem wir den Einfluss auf die Produktivität und technische Effizienz von landwirtschaftlichen Betrieben, sowie das Haushaltseinkommen und das Armutsniveau der kleinbäuerlichen Familien genauso analysieren, wie den Einfluss auf die Beschäftigung von Lohnarbeitskräften auf den Betrieben. Unsere Grundannahme ist, dass sich Bauern in traditionellen Märkte fundamental von Supermarktbauern

unterscheiden. Deshalb verfolgen wir den Meta-Frontieransatz, der flexible genug ist, um Unterschiede in der Produktionstechnologie zuzulassen. Mit diesem Ansatz erhalten wir Produktivitätskennzahlen, über die beide Gruppen miteinander verglichen werden können, da die Kennzahlen von einer beiden Gruppen gemeinsamen Frontier abgeleitet werden. Um für einen möglichen Selektionsbias zu kontrollieren, durchlaufen die geschätzten Produktivitätskennzahlen durch ein statistisches Matchingverfahren, damit der Effekt zwischen den Gruppen unverzerrt abgebildet werden kann. Weiterhin untersuchen wir Unterschiede im Haushaltseinkommen und Armutseffekte im Zusammenhang mit der Belieferung von Supermärkten. Dabei evaluieren wir den Einfluss mit Hilfe von Endogenous Switching Regressionen, um für einen möglichen Endogenitätsbias zu kontrollieren. Schließlich untersuchen wir Auswirkungen auf den Arbeitsmarkt. Da die Produktion von hochwertigen Agrarerzeugnissen arbeitsintensiv ist, erwarten wir, dass die Belieferung von Supermärkten signifikante externe Effekte auf den landwirtschaftlichen Arbeitsmarkt hat. Diese Arbeitsmarkteffekt isolieren wir mit Hilfe eines Double-Hurdle Modells, das geeignet ist, die zwei zentralen Stufen innerhalb des Entscheidungsprozesses bei der Anwerbung von Arbeitskräften abzubilden. Diese sind (i) die Entscheidung, ob Lohnarbeiter beschäftigt werden sollen und, wenn ja, (ii) in welchem Maßstab Arbeitskräfte eingesetzt werden.

Wie unsere Ergebnisse zeigen, gibt es statistisch signifikante Unterschiede bei der Produktionstechnologie zwischen den beiden Vermarktungswegen: Kleinbauern, die an Supermärkte liefern, sind um 35 bis 38 Prozent produktiver. Verbesserte Vermarktungswege, für die Supermärkte ein Beispiel sind, können offenbar zu Produktivitätssteigerungen führen, die gerade in Sub-Sahara Afrika für Wachstum im Agrarsektor vonnöten sind. Darüber hinaus zeigen die Analysen, dass die Belieferung von Supermärkten zu signifikant höheren

Haushaltseinkommen geführt hat, mit entsprechenden Armutseffekten. Das Einkommen von Supermarktbauern lag um 48 Prozent höher, die Armutsraten gingen um 20 Prozent zurück. Die positiven Effekte schließen auch nicht selbständig Beschäftige in der Landwirtschaft ein. Verglichen mit den traditionellen Vermarktungsschienen im Gemüsesektor erhöht sich die Beschäftigungsrate im modernen Sektor um 38 Prozent, wobei insbesondere Frauen profitieren. Modernen Vermarktungswegen mit Supermärkten kommt folglich eine besondere Bedeutung bei Armutsreduktion und ländlicher Entwicklung zu, wenn man bedenkt, dass gerade die in der Landwirtschaft Beschäftigten zu den Ärmsten innerhalb der ländlichen Bevölkerung gehören.

Gleichwohl zeigen die Ergebnisse auch, dass es für benachteiligte Kleinbauern mitunter schwer sein kann, von dieser Entwicklung zu profitieren. Bauern mit besserer schulischer Bildung und solche, die über mehr Kapital verfügen, liefern vergleichsweise häufiger an Supermärkte. Darüber hinaus beeinflusst die vorhandene Verkehrsinfrastruktur signifikant den Zugang zur modernen Vermarktungsschienen. Dies sind häufig dieselben Gründe, die Kleinbauern auch den Anschluss an traditionelle Märkte erschweren. Es gilt, diese Hemmnisse durch angepasste Strategien der ländlichen Entwicklung auszuräumen, um das Potential entstehender moderner Vermarktungswege, wie dem Supermarkt, besser im Sinne der Armutsbekämpfung nutzen zu können.

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Abbreviations

AIV	African Indigenous Vegetables
ATT	Average Treatment effect on the Treated
CAPE	Conditional Average Partial Effect
CDF	Cumulative Distribution Function
CIAT	International Centre for Tropical Agriculture
DAO	District Agricultural Office
DH	Double Hurdle
FAO	Food and Agriculture Organization
FCI	Farm Concern International
FFV	Fresh Fruits and Vegetables
FIML	Full Information Maximum Likelihood
GDP	Gross Domestic Product
IBRD	International Bank for Reconstruction and Development
IMR	Inverse Mill Ratio
KBM	Kernel-Based Matching
MF	Meta-Frontier
ML	Maximum Likelihood
MTR	Meta Technology Ratio
NARO	National Research Organization
NGO	Non Governmental Organization
NNM	Nearest Neighbor Matching
PPP	Purchasing Power Parity
PS	Propensity Score
PSM	Propensity Score Matching
SPF	Stochastic Production Frontiers
TE	Technical Efficiency
UAPE	Unconditional Average Partial Effect
UN	United Nations
WTO	World Trade Organization

1. General introduction

The agricultural sector remains crucial to growth and development of many developing economies. In the agriculture-based developing countries in particular, the sector generates about 29% of the gross domestic product (GDP) on average and employs 65% percent of the labor force (World Bank, 2007). Furthermore, the agriculture-based developing countries are presently home to more than half a billion people, half of whom live below the poverty line of $1.25 a day. About 68% of this population living below the poverty line is found in rural areas, where agriculture is the predominant economic activity. Indeed, agriculture is a direct source of livelihood for close to 86% of the rural population (World Bank, 2007). Agriculture therefore presents an important avenue for enhancing development goals and realizing the much needed poverty reduction in these countries.

In rural areas of developing countries, most households are smallholder farmers engaging in subsistence production, mostly producing staples for direct consumption and occasional surplus for domestic trading(McCullough *et al.*, 2008; World Bank, 2007). Besides providing a direct source of livelihood, agriculture therefore plays an equally important role of ensuring household food security. Furthermore, there are also rural landless households often employed as agricultural wage laborers. Through such wage employment, agriculture provides an important source of income for sustaining household consumption. Income from agricultural wage employment also provides additional cash flow for investment in agricultural production (Babatunde & Qaim, 2010; Maertens, 2009). Additionally, some rural households are also

involved in non-farm wage employment in agribusinesses that are directly linked with agriculture.

Agriculture-based developing countries also benefit a great deal from agricultural export that has traditionally been dominated by bulk commodities such as coffee, tea, and cocoa among others (Jaffee, 1992). These exports provide an important source of foreign exchange for developing countries (World Bank, 2007). However, most traditional tropical bulk commodities have experienced a major decline in world market prices that has undermined competitiveness of agricultural exports from developing countries. However, there are emerging international demands for non-traditional exports that open further market avenues for developing country agriculture.

1.1. Transformation of agriculture: emerging high-value markets in developing countries

Despite the declining world prices of many bulk commodities, agricultural exports continue to play a significant role in the economies of developing countries. The past three decades, however, have seen notable changes in international trade of agri-food products with processed products becoming increasingly important (Senauer & Venturini, 2005). The composition of processed food exports has also undergone remarkable changes with high-value commodities like processed fish and fresh fruits and vegetables (FFVs) assuming an increasing share of developing countries' exports (Kiggundu, 2006; Maertens & Swinnen, 2009; Mayer *et al.*, 2002; Watts, 1994; Whitaker *et al.*, 2006; Wilkinson, 2004). These changes constitute expanding opportunities for exports of high-value products that can offset export stagnation triggered by

declining world prices of traditional exports. Figure 1.1 shows an increasing trend in the export of non-traditional exports from developing countries.

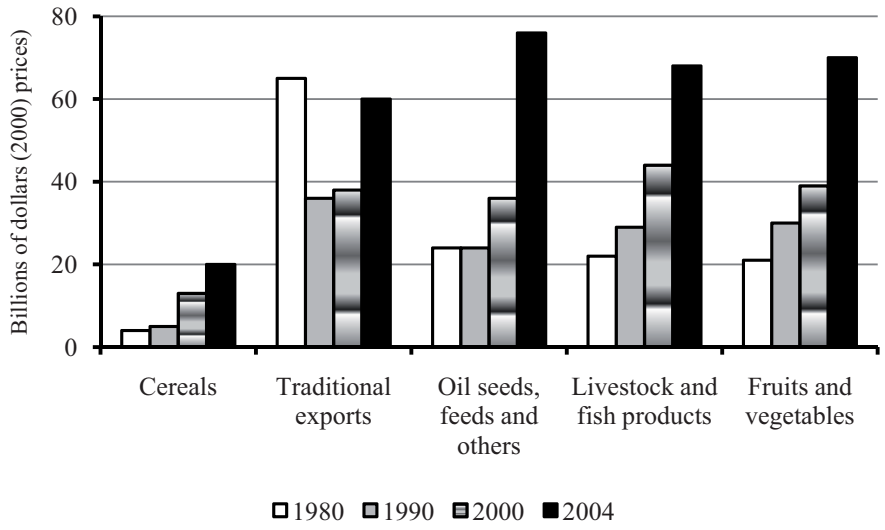


Figure 1.1: Expanding high-value exports from developing countries

Source: World Bank (2007)

Courtesy of this export diversification, high-value exports such as horticulture, livestock, fish, cut flowers and organic products currently account for 47% of developing countries' agricultural exports (World Bank, 2007). This is in comparison to 21% held by traditional exports such as tea, coffee, and cotton among others. These high-value exports do not only provide foreign exchange for developing economies, but also provide a major source of household income for farm households (Maertens & Swinnen, 2009). High-value exports also generate employment opportunities for wage laborers since their production is often more labor intensive (Weinberger & Lumpkin, 2007).

Several factors are responsible for these changes. First, consumer preferences in industrial countries, characterized by demand for off-season products are opening new markets for fresh

produces from developing countries (World Bank, 2007). In addition, declining tariff barriers and ability of developing countries to maintain year round supply of products also enhance developing countries' competitiveness in exports of high-value products. Advances in production, transport and other supply-chain technologies also make it increasingly possible for developing countries to export fresh produces (World Bank, 2005).

The growth in demand for high-value crops is not restricted to export markets. Domestic economies of developing countries are also experiencing increasing demand for high-value food products (McCullough *et al.*, 2008; World Bank, 2007). As can be observed from figure 1.2, developing countries are showing a shift in consumption patterns from staples to high-value fresh products. Remarkable shifts are particularly more evident in the demand for horticultural products.

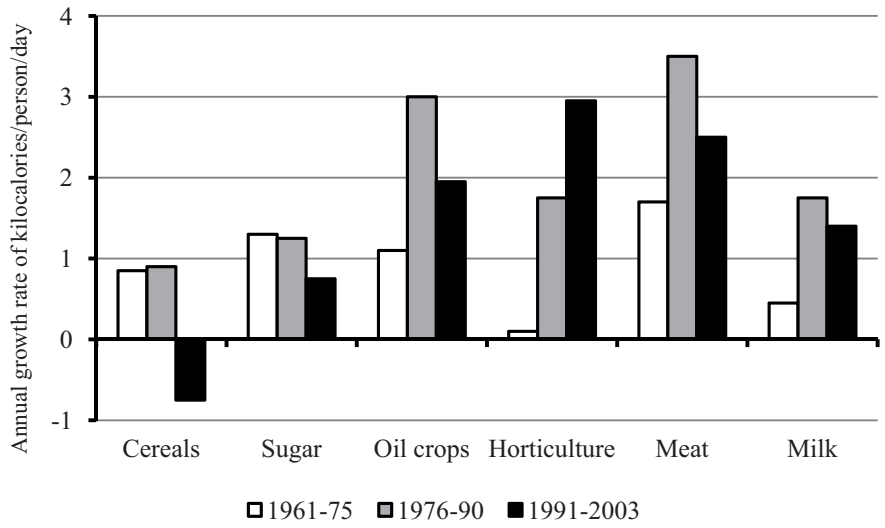


Figure 1.2: Shifts in per capita food consumption in developing countries
Source: World Bank (2007)

The dietary shifts are driven by several factors. First, recent decades have seen substantial growth in per capita incomes in developing countries – rising from 1% annually in the 1980s and 1990s to 3.7% between 2001 and 2005 (World Bank, 2006), with important implications for food demand patterns in the developing world (Mergenthaler *et al.*, 2009b; Pingali, 2007). Rising incomes generally increase demand for processed food. Higher incomes also increase consumer concerns for food quality and food safety, often associated with high-value products (Mergenthaler *et al.*, 2009a; World Bank, 2007). Furthermore, growth in income is often associated with more diversified consumption patterns (Beng-Huat, 2000). Finally, increasing demand for high-value food products is also encouraged by wider media penetration and greater participation by women in the labor force usually associated with rapid urbanization (McCullough *et al.*, 2008; Pingali, 2007). In particular, media penetration often leads to westernization of diets and local adoption of high-value diets that are already commonplace in industrialized countries. These factors are currently driving demand for high-value commodities in developing countries. As a result, new frontiers are opening up for a wide range of high-value agricultural products with the former niche phenomenon beginning to have wider market implications.

1.2. Implications for the supply chain: expansion of supermarkets

Increasing demand for high-value food products in developing countries has important implications for domestic agri-food supply chains. First, the year-round demand for products require retail outlets to organize the timing of purchases and deliveries in order to meet consistent product demand (McCullough *et al.*, 2008). Secondly, high-value food products are

highly perishable and quality sensitive, and this implies safety and quality challenges for retailers (Gulati *et al.*, 2007). Ensuring the quality and safety standards demanded by consumers therefore requires shorter supply chains often involving direct sourcing from farmers. Moreover, demand for food safety and quality entails informational uncertainties for supply chain actors (Okello & Swinton, 2006). In order to maintain quality and safety standards, retailers therefore adopt tighter coordination that enables efficient flow of product information along the supply chain (McCullough *et al.*, 2008).

However, traditional food systems predominant in developing countries present major challenges for retailers seeking to meet demands of emerging consumers of high-value products. First, traditional food systems lack the coordinating capacity to ensure consistency in supply and quality attributes. Traditional food systems are also characterized by information asymmetries, which limit the flow of information necessary for assuring product quality and safety as demanded by consumers of high-value products. Additionally, traditional systems are also characterized by spot market trading, usually prone to uncertainty in quality, supply and prices (Grosh, 1994; Simmons, 2002). The structural weaknesses of traditional food systems have therefore necessitated the entry of modern retail outlets including super- and hypermarkets in domestic food chains (Dries & Swinnen, 2004; Reardon & Berdegue, 2002; Weatherspoon & Reardon, 2003).

The initial entry of supermarkets is often motivated by growth in income, which leads to increasing demand for processed food (Reardon *et al.*, 2008). The resulting growth in demand provides scale economies, which is a major incentive for operation of modern retail outlets. But as incomes rise and inspire dietary shifts, consumers also become conscious of food quality and safety, which can hardly be provided by the traditional food systems. Having already established

themselves in the sale of processed food and accustomed themselves to the needs of high-value consumers, supermarkets then enter the sale of FFVs to fill the gap created by the failures of traditional food systems. Given the sequence of these developments, supermarkets' share of fresh fruits and vegetables often lags behind their share in overall food retailing (Balsevich *et al.*, 2003; Neven & Reardon, 2004).

Encouraged by these emerging opportunities, supermarkets have therefore been spreading rapidly across the developing world in the last two decades. The degree of penetration varies across countries. In particular, supermarkets are more widespread in Latin America, Asia and Eastern Europe, where food systems are more structured with modern retailers assuming a sizeable proportion of food retailing (Traill, 2006). Latin America leads the pack with supermarkets accounting for 50 – 60% of the national food retail. This is followed by East Asian and South East Asian countries where supermarkets account for 33 – 63% of national food retailing (Reardon *et al.*, 2003). These developments reflect the income changes that have been evident in these countries and confirm the influence of income growth on the demand for high-value products. Figure 1.3 that is based on country-level data, illustrates the influence of per capita income on supermarket growth.

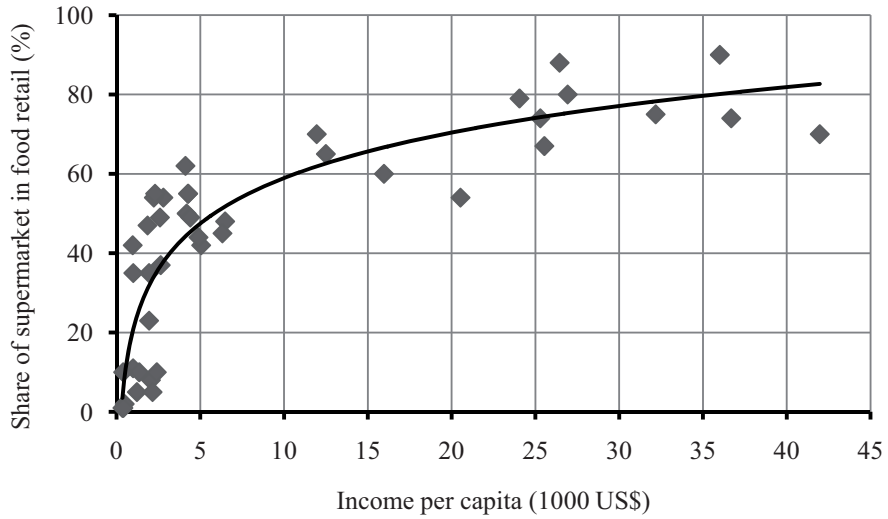


Figure 1.3: Influence of per capita income on supermarket growth

Source: Data from Traill (2006)

Despite their rapid expansion in Asia and Latin America, supermarket penetration is still relatively low in developing countries of Africa. In these countries, food systems are still characterized by a high degree of dualism with modern chains existing alongside traditional food systems (McCullough *et al.*, 2008). Nevertheless, food systems in these countries are also showing a transforming trend with modernized chains capturing a growing share of food markets (Neven *et al.*, 2006; Reardon *et al.*, 2003; Reardon *et al.*, 2008).

These developments present significant opportunities for farmers to integrate into high-value markets, which in the case of exports have shown greater benefits to smallholder farmers (Asfaw *et al.*, 2009; Maertens & Swinnen, 2009). Despite lagging behind the demand for processed food, the share of supermarkets in the sales of FFVs in developing countries has shown an upward trend and is already rivaling exports of fresh produces in these countries. In Latin America, supermarkets already buy more than twice the amount of fresh produce exported to industrialized

countries (Balsevich *et al.*, 2003; Berdegue *et al.*, 2005). Similarly, Kenyan supermarkets already buy about half the volume of FFVs exported to Europe (Neven & Reardon, 2004). Expansion of supermarkets in developing countries is therefore expected to widen the benefits of high-value markets that have so far largely been restricted to exports.

1.3. Problem statement

The transformation of food systems and the increasing role of modern retailers in domestic agri-food supply chains offers new opportunities and challenges for smallholder farmers and the rural poor (Hernandez *et al.*, 2007; McCullough *et al.*, 2008; Neven *et al.*, 2009; Reardon *et al.*, 2008). These opportunities and challenges are due to changing procurement systems adopted by modern retail outlets. Among approaches used by supermarkets are centralized procurement systems, use of specialized/dedicated wholesalers, and imposition of quality and safety standards (Neven & Reardon, 2004). Centralized procurement systems are aimed at reducing transaction costs and maintaining product quality and standards demanded by high-value consumers. Supermarkets in developing countries are also moving away from traditional wholesalers to specialized/dedicated suppliers. The overall goal is to have shorter supply chains, which enables them to impose private standards. This in turn enables retailers to meet demand by consumers of high-value products. The need for shorter supply chains sometimes implies that farmers are directly listed as preferred suppliers.

These procurement practices affect farmers in various ways (Balsevich *et al.*, 2003; Berdegue *et al.*, 2005). While shorter chains that sometimes involve direct sourcing from farmers is a welcome move, studies have shown that delivery requirements by supermarkets often favor

larger and wealthier farmers. Maintaining year-round supplies, as required by supermarkets for instance, poses a major challenge for smallholder farmers without access to irrigation technology. Quality and safety standards imposed by supermarkets are also a challenge for smallholder farmers, who are often faced with incomplete information and limited technical knowledge (Balsevich *et al.*, 2003). This implies that asset-poor smallholder farmers may be excluded from emerging high-value markets.

Despite these challenges, there is substantial scope for improvement in farm productivity and welfare gains by farmers who have access to these markets. Farm productivity is often enhanced by supermarket requirements that often involve transformation in production systems (McCullough *et al.*, 2008). Consistent supply of high-value products, for instance, entails off-season production, which requires use of irrigation technology. Production of quality products may also require adoption of certified seeds and changes in input mix. These changes could immensely improve farm productivity and lead to higher economic returns for farmers.

Besides improvement in farm productivity, higher returns from supplying supermarkets also provide an important source of household income, which could lead to significant reduction in poverty. Additionally, high-value crops are often labor intensive, so that increasing demand from supermarkets could entail substantial employment spillovers for rural landless laborers. Given the concentration of wage laborers among the poorer segments of the rural population, such employment spillovers could again have crucial effects on rural poverty. Expansion of high-value markets in developing countries therefore presents considerable scope for rural development with important welfare implications.

The increasing role of high-value markets and spread of supermarkets have attracted a lot of research attention. Most studies have focused on determinants of supermarket expansion in developing countries as well as determinants of farmer participation in these channels (Hernandez *et al.*, 2007; Neven *et al.*, 2009; Neven & Reardon, 2004; Reardon & Berdegue, 2002; Reardon *et al.*, 2003). Studies by Hernandez *et al.* (2007) and Neven *et al.* (2009) also look at potential impacts of supermarket participation on input use and farm incomes. These studies, however, do not address the overall gains in farm productivity that can result from supplying supermarket channels.

We hypothesize that farm reorganization and changes in input mix, which may accompany the decision to supply supermarkets, could induce changes in production technology. This could have important effects on farm productivity. We also hypothesize that income effects of supermarkets go beyond the farm income that has so far been analyzed, to affect household incomes. Finally, we hypothesize that producing crops for supermarkets could have important employment spillovers for rural landless laborers. A comparison of labor use across market channels by Neven *et al.* (2009) has shown that supermarket farmers use more hired labor. Yet no study has studied these employment spillovers in a more comprehensive manner. There is therefore need for comprehensive analysis that can determine if the observed intensity in labor use can be attributed to farmer participation in supermarket channels.

1.4. Objectives of the study

In light of the identified gap in the existing literature, this study seeks to analyze the impact of high-value agriculture on rural development. We do so by focusing on production of vegetables

in Kenya and evaluating farm and household level effects of supermarket access by vegetable farmers. Our analyses also address some of the methodological gaps inherent in existing studies. In order to cast our analyses beyond direct effects to farmers, we also analyze potential employment spillovers to rural landless laborers. The specific objectives of this study are as follows:

1. To analyze productivity gains and technical efficiency effects of farmer participation in supermarket channels.
2. To estimate income effects of supermarket participation and simulate potential poverty outcomes.
3. To analyze employment spillovers of farmer participation in supermarkets for rural agricultural laborers.

1.5. Outline of the dissertation

The study is organized as follows. Chapter 2 presents the theoretical framework guiding the study. The chapter opens with a look at the transaction costs implications of emerging high-value markets and presents the rise of supermarkets as an institutional response to transaction costs. The chapter also outlines market access implications of the supermarket spread and highlights how institutional innovations can address exclusion of certain segments of farming households from high-value markets. The chapter concludes with identification of potential welfare effects of supermarket access by farmers.

Chapter 3 describes the area of study and the research design. The chapter presents the overall role of agriculture in the Kenyan economy before exploring the development of supermarket

channels in the country. The final part of this chapter presents the sampling procedure and data collection methods employed in the study.

Chapter 4 undertakes the analysis with respect to the first objective of this study. The chapter analyses and discusses the impact of farmer participation in supermarkets on farm productivity and technical efficiency. The analytical approach adopted in this section accounts for differences in technology between supermarket suppliers and farmers in traditional channels.

Chapter 5 presents the analysis on welfare effects of participation in supermarket channels (second objective). The analysis in this chapter goes beyond simple gross margin analysis to look at effects of supermarket channels on household income and potential effects on poverty. The analysis takes into account structural differences between farmers in the two market channels and also accounts for potential selection bias.

Chapter 6 focuses on the third objective of this study that deals with employment spillovers of farmer participation in supermarket channels. The focus of analysis in this section is on demand for hired labor and the analytical framework allows for separation between the decision to hire labor and the decision on intensity in use of hired labor.

Finally, chapter 7 concludes the study by discussing the results and related policy implications.

2. Theoretical framework

The analyses carried out in this study are built on the theory of transaction costs, institutions and institutional innovation. Human interactions involving economic exchange are subject to uncertainty arising from incomplete and asymmetric information (North, 1990). Addressing these uncertainties requires verification/measuring the valued attributes of the product to be exchanged and this involves costs. Furthermore, since information on product quality is asymmetric, participating in an exchange requires that one has to screen and supervise trading partners. The costliness of verifying information is therefore central to the cost of transacting (North, 1990). Imperfect and asymmetric information also mean that parties to an exchange have to incur costs in searching for a satisfactory trading partner and additional cost in bargaining and negotiation of trading agreements (Key *et al.*, 2000). Trading parties may also have to incur legal enforcement costs due to uncertainty associated with behavior of parties to an exchange. All these add to the cost of transacting.[1] To reduce uncertainties, human beings device institutions, which are a set of rules that provide structure to human interactions. The role of institutions is therefore to facilitate human interaction by reducing uncertainty and thereby establishing a stable structure to these interactions.

However, in the process of simplifying human interaction, institutions impose constraints on the choices that are available to agents. These constraints have varied implications for the respective parties involved in a transaction. In this chapter we develop a theoretical understanding of the

[1] In the context of smallholder farmers, additional sources of transaction cost include cost of transport and lack of access to assets (Arega *et al.*, 2008; Omamo, 1998).

institutional framework within which high-value markets in developing countries emerge and operate. In particular, we outline institutional adaptation undertaken by players in high-value chains in response to transaction costs associated with demand for high-value products. We also introduce important implications of these institutional changes, which we analyze in later chapters. First, however, we explore the transaction cost implications of demand for high-value products.

2.1. Demand for high-value products and implications for transaction costs

Exchange of products generally entails an exchange of multiple attributes inherent in respective products that are valued by the exchange partners (North, 1990). The transfer that occurs with an exchange therefore involves the cost of both parties attempting to verify/measure these valued attributes. For fresh food products that are highly perishable and therefore susceptible to quality and safety concerns, meeting consumer demands for these attributes requires that retailers have to measure/verify quality and safety attributes valued by consumers. However, measuring these attributes is often difficult and may require excessive resources (Hoff *et al.*, 1993; North, 1990; Stiglitz, 2000). This implies considerable cost that may in some cases preclude the possibility of exchange.

In order to overcome such potentially prohibitive costs, parties in an exchange devote more resources to exchanging information about product attributes. Yet information is subject to substantial asymmetries (Stiglitz, 2000). For high-value fresh produces in particular, suppliers tend to know more about the quality and safety attributes of the products than retailers. Such asymmetry in information provides scope for opportunistic behavior leading to substantial

uncertainty. To reduce the uncertainty without resorting to the more costly measurement of product attributes, resources have to be devoted to making information publicly available. Retailers seeking to provide quality and safety attributes demanded by high-value consumers therefore commit resources to obtain complete information on products they source from suppliers. To achieve this, retailers either integrate vertically to engage in their own production or adopt tighter coordination to facilitate the flow of information (McCullough *et al.*, 2008; Williamson, 1999). Exchange of commodities therefore entails costly resources in terms of information gathering, which is central to the costliness of transacting (North, 1990; Stiglitz, 2000).

Besides asymmetry in product information, economic exchanges are also subject to asymmetry in price information, which provides incentives for suppliers to renege on supply agreements. This is of particular concern for modern retailers seeking to ensure year-round supply of products as demanded by consumers of high-value products. The challenge is particularly enormous for modern retailers operating in environments characterized by uncertainty in product supply, as is the case in most developing countries. The trading environment as presented by traditional food systems in developing countries is characterized by asymmetric information and spot market trading with little guarantee for repeated transaction (Dorward, 2001; Reardon *et al.*, 2008). Under such circumstances, modern retailers are uncertain that suppliers will find it in their interest to live up to agreements. The resulting uncertainty associated with product delivery represents further transaction costs for retailers (Okello & Swinton, 2006; Pingali *et al.*, 2007).

Finally, since product attributes are unknown and because costly resources are devoted in measuring them, there is need for enforcement mechanisms to ensure individuals live up to their commitment. This may involve negotiating a contract with suppliers. In the case of fresh

produces traded in high-value chains, retailers have to monitor and supervise suppliers to ensure that the required and agreed quality is supplied (Hueth *et al.*, 1999). However, monitoring involves costs, which increase for retailers if they have to source products from multiple suppliers (Gulati *et al.*, 2007). These costs of negotiating contracts and more fundamentally, of monitoring and enforcing agreements are additional sources of transaction costs (North, 1990).

Demand for high-value products therefore presents significant transaction cost challenges for retailers. In order to lower these costs, norms and informal rules emerge that govern interaction between actors in the supply chain (Narrod *et al.*, 2009). The mechanism adopted ensures that the desired products are supplied while the associated transaction costs for retailers are also reduced (Simmons *et al.*, 2005; Williamson, 1991). For modern retailers in high-value chains, the coordinating mechanism is implemented through procurement practices that are a reflection of the underlying transaction costs. These practices form the institutional arrangements that define the interactions between modern retailers and suppliers in developing countries. By defining interactions, institutions help retailers and suppliers to form expectations about the behavior of each other - expectations that will reasonably hold.

2.2. Modern retailers and their procurement systems: an institutional construct

In the previous section, we have outlined the transaction cost implications of demand for high-value products. We have also seen that the associated transaction costs define the coordination mechanisms adopted by retailers, that is, supermarkets and high-end groceries use these mechanisms to reduce transactions costs (McCullough *et al.*, 2008). The adopted practices are

aimed at addressing the weaknesses in the existing institutional framework of traditional food systems.

It is nevertheless, important to first understand the theoretical basis for modern retail growth in developing countries. Supermarkets and other modern supply chains are economic organizations, and organizations are created to respond to opportunity sets resulting from the existing institutional framework and economic constraints (North, 1990). The existing institutions in a society interact with economic constraints to produce opportunity sets that give incentives for emergence of specific exchange organizations. In the evolution of exchange organizations, institutions therefore play an important role. Indeed the types of organization that come into existence and how they evolve over time are fundamental consequences of the institutional framework (North, 1990). The resulting organizations in turn depend on the existing institutional framework for profitability of their activities. There is therefore a symbiotic relationship between institutions and organizations.

In light of the outlined theory of organizational evolution, the rise of supermarkets in developing countries can be viewed as organizational consequences of the existing institutional environment. Increasing demand for high-value products in an economic environment pervaded by institutions of traditional food systems for instance, provides "opportunity sets" for the emergence of supermarket chains. First, the institutional limitations of traditional food systems in handling large volumes of demand occasioned by increasing demand for processed food is what provides incentives for initial entry of supermarkets (Reardon *et al.*, 2008). The gap between large volumes of demand and limitations on the supply side provides opportunity sets for the operation of supermarkets. Indeed, supermarkets thrive on the incapability of traditional food systems to handle large volumes of demand by the emerging urban middle class. Thus, they depend on the

existing opportunities created by the weaker institutional framework of traditional food systems and exploit scale economies for their profitability. As incomes increase and demand for high-value products sets in, the incapability of traditional food systems in providing attributes demanded by consumers provide further incentives for supermarkets to enter the fresh produce markets.

Organizations, however, evolve over time and in the process adopt new practices to address existing challenges. The evolution may involve setting new rules or adjusting existing ones to address new constraints, and this leads to institutional change. This change arises from the perception of entrepreneurs that their organizations would benefit from altering the existing institutional framework (North, 1990). The evolution of supermarket procurement practices can therefore be seen in this context. In order to meet the needs of their clients and also to sustain their profits, supermarkets seek coordination mechanisms that minimize associated transaction costs. Transaction costs therefore play an important role in the evolution of rules guiding interaction between suppliers and retailers (Reardon *et al.*, 2008; Ruben *et al.*, 2007). Williamson (1991) identifies three factors that influence the choice of a cost-reducing coordinating mechanism, namely uncertainty that affects quality or price, asset specificity, and frequency with which transactions occur. These factors constitute the transaction characteristics that influence firms' risk exposure and define the coordination mechanism chosen to reduce the transaction costs.

For fresh produces in particular, the institutional framework guiding interaction between agents in the supply chains is influenced by uncertainty and hence the need to exercise control (Poole *et al.*, 1998). In order to address the apparent uncertainty and reduce the transaction costs associated with sourcing of high-value food products, modern retails in developing countries

adopt specific procurement systems. These procurement practices include centralized sourcing, use of preferred or dedicated suppliers and imposition of private standards (McCullough *et al.*, 2008; Neven & Reardon, 2004). The choice of coordination mechanism depends on retailers' perception of transaction risk exposure, but all these practices have implications for market access by farm households. We present these implications in the following section and highlight some of the institutional innovations aimed at addressing these institutional consequences.

2.3. Modern retailers, market access and institutional innovation

The procurement practices adopted by modern supply chains have several implications for suppliers and growers in general. These practices not only determine who is able to access high-value markets but they also define the benefits that accrue to participating farmers as well as to other rural non-farm households. Of foremost concern is the imposition of standards with regards to quality, safety and product delivery. The effect of standards imposed by modern high-value chains on market access by smallholder farmers has been widely explored in the existing literature (McCullough *et al.*, 2008; Moustier *et al.*, 2010; Narrod *et al.*, 2009; Neven *et al.*, 2009). These studies show that the capacity of smallholder farmers to meet supermarket standards is hampered by resource constraints of these asset-poor farmers. Meeting these standards often requires lumpy capital investments and high level of information processing. Yet many smallholder farmers are subsistence households with limited technical knowledge and limited access to capital, which are both necessary for meeting supermarket requirements. Their scale of production and the dispersed nature of their geographical location also compromise their ability to meet the volume and consistent supply requirements by modern supply chains. As a

result of these limitations, smallholder farmers face the risk of being excluded from high-value markets (Balsevich *et al.*, 2003; Boselie *et al.*, 2003; McCullough *et al.*, 2008; Reardon & Barrett, 2000).

The increasing role of specialized/dedicated wholesalers also has implications for market access by farmers. Relying on specialized wholesalers often involves sidestepping fragmented traditional wholesale markets. The specialized/dedicated wholesalers are specialized in specific product lines and are wholesomely dedicated to supermarkets as their main clients (Reardon *et al.*, 2008). By outsourcing their procurement activities to another intermediary, supermarket chains are able to cut transaction and search costs. These intermediaries assemble, grade and sort produces, thus bridging the scale gap between growers and modern retailers. This affords retailers better quality products and helps them reduce costs associated with spoilage that can be pervasive in traditional wholesale markets (Reardon *et al.*, 2008; Schwentesius & Manuel, 2002). It also ensures consistency in supply and enhances standardization of products as required by supermarkets (Boselie, 2002; Reardon *et al.*, 2008). Through these mechanisms, retailers transfer monitoring and enforcement roles to the intermediaries and in the process lower their costs.

The use of specialized traders may have positive consequences for disadvantaged farmers originally excluded from direct participation in high-value chains. Resource poor-farmers selling to the specialized wholesalers may have an alternative path for integrating into high-value chains if specialized wholesalers are indiscriminate in their procurement. These benefits could be enhanced by price advantages; there are indications that specialized wholesalers often offer higher prices than traditional wholesalers (Schwentesius & Manuel, 2002). Nevertheless, there are possibilities that smallholder farmers can still be excluded if specialized wholesalers impose similarly stringent standards as supermarkets.

The third procurement practice often adopted by modern retailers involves the use of preferred suppliers. This often involves informal contracts characterized by listing of growers or some wholesalers as supplier. The contracts, though informal, are meant to encourage farmers not to renege on supply agreements with modern retailers. Retailers, however, prefer larger farmers due to transaction costs involved in handling more smallholder suppliers (Pingali *et al.*, 2007). Nonetheless, there are reasons for and evidence of modern retailers sourcing from smallholder farmers (Boselie *et al.*, 2003). These farmers are preferred due to their use of labor-intensive techniques that enables them to supply high quality products. Additionally, there may not be enough large farmers to supply an ever growing high-value market.

The development of supermarkets and their associated procurement practices therefore has significant implications for market access by various categories of farmers. There are existing indications that these procurement practices exclude smallholder farmers and work in favor of larger and more specialized farmers (Kirsten & Sartorius, 2002; Reardon & Barrett, 2000; Reardon *et al.*, 2003). The possibility of smallholder farmers being by-passed by high-value chains has prompted institutional innovation from development partners. These innovations are aimed at enhancing participation by smallholder farmers through reduction in transaction costs that could exclude smallholders from accessing modern supply chains.

Major innovations that have so far been employed by various development partners have taken the form of collective action and public-private partnership. In particular, institutional and technological support offered through producer groups have proven to be effective tools for enhancing smallholder access to high-value markets (Boselie *et al.*, 2003; Minten *et al.*, 2009). High-value markets are usually information intensive and rely on contract negotiation and enforcement, which implies substantial transaction costs, as outlined in section 2.1. Some of

these costs can be addressed through collective action. Producer groups yield significant economies of scale that lowers the arising transaction costs, which would otherwise be borne by individual farmers (Markelova *et al.*, 2009; Moustier *et al.*, 2010; Narrod *et al.*, 2009). Additionally, the information pool that can be accessed by farmers is enhanced by the diversity in the characteristics of group members. More importantly, collective action also enables farmers to meet supermarket volume requirements and the need for consistent product supply. In the absence of collective action, individual smallholder farmers may not have enough output to meet supermarket requirements. Producer groups can therefore help farmers overcome institutional constraints and lack of scale economies that inhibit their access to high-value markets.

Limited access to high-value markets can also be addressed through public-private partnership that often complements collective action (Kaganzi *et al.*, 2009; Narrod *et al.*, 2009). This involves a cooperative venture between public and private sector based on the expertise of each partner that best meet clearly defined goals (Bettignies & Ross, 2004). Kaganzi *et al.* (2009) illustrates how a national research organization in Uganda (NARO) and CIAT (International Centre for Tropical Agriculture) collaborated to facilitate participation in a high-value market by a farmer group in Uganda. NARO provided extension services while CIAT provided training on market chain analysis, business planning and market linkage for the group. While extension ensures production of quality products, training by CIAT enhanced the business orientation of group and made farmers more reliable partners of modern retailers. The intermediation by CIAT also involved carrying out market analysis on behalf of groups and facilitating contract negotiation with buyers (Kaganzi *et al.*, 2009). Information from market analyses was communicated back to NARO so that the extension services could improve farmers' technical capacity to meet stringent requirements in modern supply chains. By providing extension,

carrying out market analysis and mediating between producer groups and buyers, the collaboration between NARO and CIAT addressed the information gap faced by smallholder farmers seeking to supply high-value markets. More importantly, these services were offered for the group as a whole. This reduced the transaction costs per farmer associated with acquiring market information and negotiating contracts.

These interventions have greatly enhanced access by smallholder farmers to emerging high-value markets in developing countries (Kaganzi *et al.*, 2009; Markelova *et al.*, 2009; Moustier *et al.*, 2010; Narrod *et al.*, 2009). The resulting participation by farmers in modern retail chains in turn provides important welfare gains for farming households and other rural non-farm households. In the next section, we illustrate the avenues through which some of these welfare gains are realized.

2.4. Supermarkets, farm productivity, farm household welfare, and labor market spillovers

Participation in supermarket channels presents opportunities for farmers to integrate in high-value chains that are potentially associated with important welfare effects. Among the possible direct benefits that accrue to farmers is the potential for yield improvement. Meeting demand for high-value products implies a transformation towards more commercially oriented production (McCullough *et al.*, 2008). This often supports the use of more labor and other inputs that could lead to important yield effects (Hernandez *et al.*, 2007; Neven *et al.*, 2009). The effects could even be more substantial if supplying supermarkets results in a movement away from semi-subsistence production structures characterized by low input use. More importantly, supplying supermarkets could induce better crop management and changes in production technology. This

could lead to productivity gains, issues that have hardly been analyzed comprehensively in the available literature. We explore these questions in details in chapter 4.

Supplying high-value markets could also enhance possibilities for improvement in farm income. Supermarkets often offer higher and more stable prices, which – when combined with stability in demand – may lead to higher net farm incomes for supermarket suppliers (Neven *et al.*, 2009). The expected gains in farm income can potentially be further boosted by the outlined productivity effects of supplying supermarkets. Gains in farm income can also have positive implications for total household income, an aspect that has also not been widely studied in the available literature; many existing studies take a more partial perspective by focusing on crop enterprise budgets and farm profits only. On the other hand, the income status of households may also determine farmer participation in high-value chains, complicating the analysis of causality. This interplay presents significant challenges in attempting to understand the effect of supermarket participation on household income. We address these issues in chapter 5 where we analyze the effect of supermarket participation on household income and poverty, controlling for potential endogeneity bias.

Beyond the welfare effects for farm households, there are possible spillover effects of high-value market participation for other rural farm households. A notable one is the potential increase in demand for labor that could benefit rural landless households; high-value crops were shown to be more labor intensive (Weinberger & Lumpkin, 2007; World Bank, 2007). Indeed, first empirical studies confirm that farmers supplying supermarkets sometimes use more hired labor than their counterparts in traditional marketing channels (Neven *et al.*, 2009). However, there is a dearth of analyses that establish whether the observed differences in labor use are really attributable to participation in supermarket channels. We explore this link in greater detail in chapter 6.

3. Description of research area and research design

This study was conducted in Kiambu District which lies in Central Province of Kenya. Kenya is a low income country located in East Africa and the country has a population of about 40 million people (2007). The population is largely rural, even though the share of urban population has shown an increasing trend over time, as can be seen from Figure 3.1. The income per capita for the country is about US$ 1,432 (PPP rate); close to 47% of the population lives below the national poverty line, with the majority of the poor residing in rural areas (World Bank, 2008). About 50% of the rural population lives below the poverty line, compared to about 34% in urban areas. Similar to other countries in Sub-Saharan Africa, poverty in Kenya is therefore predominantly a rural phenomenon (Thurlow *et al.*, 2007).

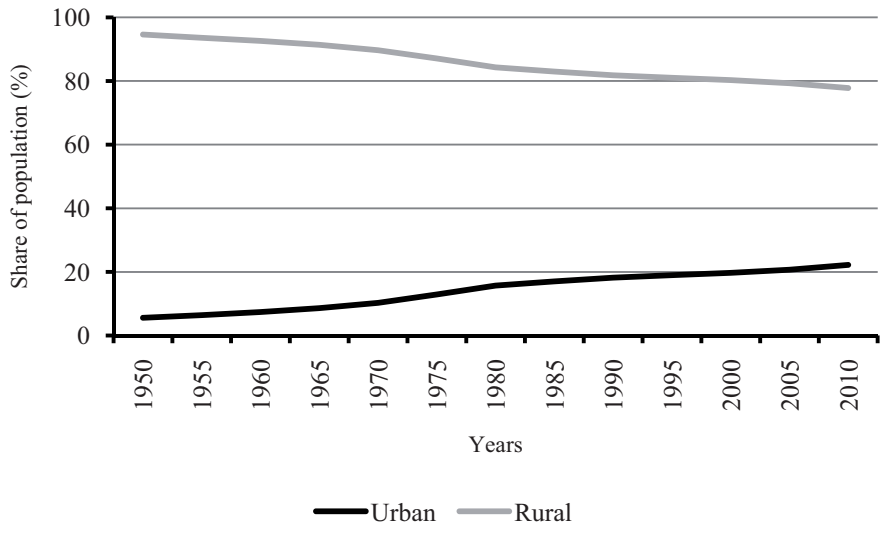


Figure 3.1: Kenyan urban and rural population trend, 1950-2010

Source: Data from UN Population Division (2007)

About 85% of the rural population are smallholder farmers with land holdings of less than 2 hectares (Omiti *et al.*, 2008). Most of these smallholder farmers engage in mixed crop/livestock production systems. The country consists of seven agro-ecological zones which vary in altitude, rainfall and temperatures and with varied potential for agriculture. Close to 20% of the country's land is suitable for crop cultivation, 26% of which fall within the areas considered to be of high to medium agricultural potential (Government of Kenya, 2007). These regions support the bulk of the Kenyan population, the majority of which is engaged in mixed crop/livestock production. The low potential areas, covering 74% of the arable land, are largely suitable for pastoralist activities; these areas support about 20% of the population. The major commodities produced by smallholder farmers in Kenya are maize, dairy and horticulture and a bit of cash crops such as tea and coffee.

3.1. Role of agriculture in the Kenyan economy

Similar to other countries in Sub-Saharan Africa, agriculture plays an important role in Kenya's economy. The sector accounts for 27% of the gross domestic product (GDP) in comparison to 19% accounted for by industry and 54% by services (World Bank, 2008). The sector is also a source of livelihood for a sizeable proportion of the Kenyan population. About 79% of the country's population is rural (FAO, 2009), where agriculture is the predominant activity. Indeed, 80% of the rural population in the country depends on agriculture for their livelihood, with the sector employing 70% of the national labor force (Omiti *et al.*, 2008). Since the majority of the poor in Kenya lives in rural areas, agriculture holds great potential for poverty reduction in the country.

The Kenyan agricultural sector is relatively diverse with cereals and other staples playing important roles alongside other cash crops like tea, coffee and horticultural crops as well as livestock production (Thurlow *et al.*, 2007). Production of cereals is particularly important for the Kenyan economy in as far as food security is concerned, since it contributes significantly to overall food supply to the Kenyan population. Indeed, cereals contribute about 80% of Kenyan food supply, accounting for 50% in total caloric consumption (FAO, 2009). Food crop production is dominated by maize with half of the country's wheat and rice consumption relying on imports.

Agriculture is also a major foreign exchange earner for the Kenyan economy, thanks to the substantial role of agricultural exports. The agricultural sector accounts for 55.8% of total exports from Kenya (WTO, 2009) with the leading export commodities being tea, coffee and horticulture commodities such as fresh fruits and vegetables and cut flowers (FAO, 2009). Declining world prices of coffee have seen horticultural exports assuming a significant role in Kenyan exports. With reference to overall foreign exchange earnings, horticulture is the third most important foreign exchange earner after tea and tourism (Omiti *et al.*, 2008). The horticultural sector also employs more than one million people in production, processing and marketing (Omiti *et al.*, 2008). Furthermore, the sector is also an important one for smallholder farmers who account for 70% of production in the sub-sector (McCulloch & Ota, 2002). The horticultural sub-sector is therefore an important one for the Kenyan economy both in terms of employment generation and contribution to national income. Besides exports, horticulture is also a major source of fresh fruits and vegetables consumed locally.

3.2. The Kenyan food system and emerging supermarket chains

The Kenyan food system is largely dominated by demand for staples with maize, rice and wheat among the major cereals consumed in large quantities (Ayieko *et al.*, 2008; FAO, 2009). Diets are, however, quite diversified with fresh fruits and vegetables also assuming a sizeable share of household food expenditure. This is especially so for richer urban households with an expenditure share of 40% for fresh fruits and vegetables, compared to a mere 5% among low income earners (Neven *et al.*, 2006). It is estimated that demand for fresh produces will accelerate as urbanization increases and income growth peaks. Kenya is therefore already showing signs of shifts in food demand patterns that usually accompany rapid urbanization and increasing incomes in many developing countries.

Despite the emerging shifts in food demand patterns, food supply chains in Kenya are still largely traditional, with small retail outlets such as over the counter shops, kiosks, and butcheries accounting for the largest share of purchases (Ayieko *et al.*, 2008). The type of retail outlet chosen by consumers, however, depends on the food items to be purchased. Consequently, consumer households tend to use more than one retail outlet. In spite of the dominance by traditional retail outlets, there is an increasing share of consumers purchasing food items from modern retail outlets such as super- and hypermarkets (Neven & Reardon, 2004; Neven *et al.*, 2006). Supermarkets tend to dominate purchases of staples as compared to fresh produces, as can be seen from table 3.1 (Ayieko *et al.*, 2008). These developments are similar to trends in other developing countries, where supermarkets usually penetrate the processed food sector before venturing into the fresh produce market (Neven *et al.*, 2006). This is because processed foods are easier to procure and manage as compared to fresh perishables.

Table 3.1: Share of food groups by retail outlets in Nairobi, 2003

Retail outlet type	Staples	Dairy	Meat	Fresh fruits & vegetables
	Share of total value of household purchase in outlet type (%)			
Supermarket chains	60.0	22.4	8.2	9.3
Small supermarkets	88.3	8.1	2.2	1.4
Dukas	56.1	35.7	7.6	0.6
Green grocers	14.8	0.0	0.0	85.2
Open air markets	11.2	0.0	15.2	73.7
Hawkers	4.1	71.5	6.8	17.6
Kiosks	18.5	13.9	6.6	60.9

Source: Ayieko *et al.* (2008)

Similar to supermarket development in other developing countries, the increasing role of modern retailers in Kenya is driven by rapid urbanization (Neven *et al.*, 2006). As already shown in figure 3.1, Kenya has experienced an increase in the urban population in the last decades; the urban population has been increasing twice as fast as the total population (UN Population Division, 2009). The dynamics in urban population are also accompanied by changing lifestyles, occasioned by women entering the workforce and westernization of diets (Neven *et al.*, 2006). Courtesy of changes in urban population and increasing incomes, supermarkets have been growing rapidly in Kenya to meet the demand patterns of an emerging urban middle class population. By the year 2003, there were about 209 supermarkets[2] and 16 hypermarkets in Kenya, which together accounted for 20% of food retail in urban areas (Neven & Reardon, 2004). Supermarket growth has also been enhanced by liberalization of the domestic market, which led to an increase in product variety – an incentive for operation of large stores. Figure 3.2

[2] This figure does not take into account an estimated 900 to 1,400 mini-supermarkets and convenience stores, which are non-traditional retail formats that have emerged in recent years in urban Kenya.

shows the overall growth in supermarkets in Kenya and how the trend has tended to follow growth in urbanization. The main supermarkets were initially mostly located in Nairobi, but stiff competition in the last decade has prompted the spread of supermarket stores to other regional cities in the country (Neven & Reardon, 2004).

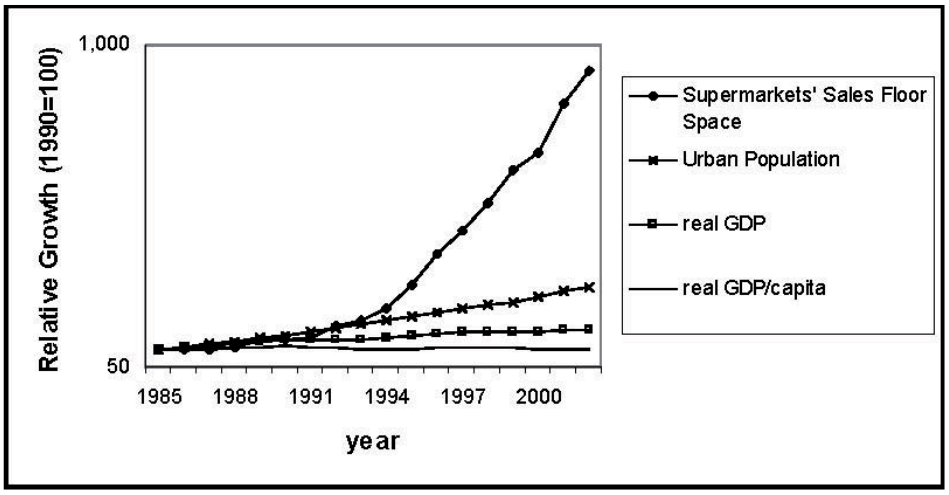


Figure 3.2: Growth of supermarkets in the broader macro context in Kenya, 1985-2003
Source: Neven and Reardon (2004)

Despite the rapid growth of supermarkets in the last decade, the supermarket share in fresh produce sales is still generally low. As can be seen from table 3.2, the supermarket sector accounted for 4% of fresh fruits and vegetables (FFV) sales in urban areas in general by the year 2003. This figure was slightly higher (7% to about 10%) for Nairobi, the capital city of Kenya (Ayieko *et al.*, 2008; Neven *et al.*, 2006). This is relatively low in comparison to the supermarket share in total food retail of 20%, as can be seen from table 3.2. It is, however, expected that the share will rise with changes in consumer habits and supermarket procurement systems.

Table 3.2: Food and FFV retailing in urban Kenya by type of outlet, 2003

Retail outlet type	No. of outlets	Food Sales		Fresh fruits & vegetables	
		US$ m.	Market share (%)	US$ m.	Market share (%)
Kiosks, shops, greengrocers	27,000	600	32	131	36
Market stalls and street hawkers	na	590	31	211	58
Supermarkets and hypermarkets	225	390	20	15	4
Smaller self-service shops	1,200	310	17	7	2
All types	na	1,890	100	364	100

Source: Neven and Reardon (2004)

Given the growth trends, supermarkets will play an increasing role in the Kenyan food system and will in turn influence the structure, conditions and performance of agri-food systems in the country (Neven & Reardon, 2008). With their increasing urban dominance, supermarkets will determine conditions and potential for small farms to sell agri-food products to the urban population which forms an important market for smallholder farmers in Kenya. Supermarket growth is therefore likely to have significant implications for rural households, especially given the role of the horticultural sector in the Kenyan economy. Horticulture is a major source of income and employment for many rural farm and non-farm households and therefore an important avenue for household to escape poverty (Omiti *et al.*, 2008). Besides domestic demand, exports form a major market for horticultural producers in Kenya with significant welfare effects for smallholder farmers (Asfaw *et al.*, 2009; Dolan, 2004). Since supermarkets in Kenya already buy more than half the volume of FFVs exported (Neven & Reardon, 2008), modern retailers are likely to have significant impact on rural households. Much of the potential impact will be due to procurement systems adopted by supermarkets, which differ substantially from traditional procurement practices predominant in Kenyan food systems.

Unlike traditional FFV supply chains that are characterized by fragmentation at both wholesale and retail level, the supermarket supply chains in Kenya are more tightly coordinated (Neven & Reardon, 2004; Neven & Reardon, 2008). These modern retailers increasingly adopt coordination mechanisms aimed at ensuring quality control and consistent delivery, attributes that are generally lacking in traditional food supply chains in Kenya. Supermarkets in Kenya initially relied on traditional wholesale markets, but they are gradually shifting to direct supplies from farmers as a major source of their fresh produce (Neven & Reardon, 2004). To achieve product diversity, quality control and consistent delivery, these supermarkets increasingly impose standards and use some form of contracts. Under this new arrangement, listed suppliers are expected to deliver agreed volumes according to certain pre-arranged supply calendars (Neven & Reardon, 2008). Farmers who are listed as suppliers of FFV to supermarkets therefore supply vegetables on order and are thus certain before harvesting that sale will take place (Neven *et al.*, 2009).

Supermarkets in Kenya also use centralized procurement systems and preferred/specialized suppliers to ensure product standardization and to reduce transaction costs associated with buying from multiple sources (Neven & Reardon, 2008). Other delivery conditions include washing, grading and packaging of products. Prices paid by supermarkets also remain stable for longer periods of time relative to prices in traditional channels. Furthermore, supermarkets order bigger volumes, which results into significant reduction in transaction costs for farmers (Neven *et al.*, 2009). These changes present great hope for vegetable farmers plagued by inefficiencies and low returns inherent in traditional channels. In subsequent chapters, we explore these impacts for vegetable producers in Kenya.

3.3. Institutional innovation for supermarket access in Kenya

The procurement system adopted by supermarkets in Kenya presents opportunities for vegetable farmers to integrate into high-value markets. The shorter chains, in combination with market assurance and stable prices, present potential for greater benefits for vegetable farmers. Nonetheless, as mentioned in chapter 2, these procurement practices also have implication for market access by certain segments of producers. Requirements for consistent delivery of large volumes of vegetables could potentially exclude smallholder vegetable farmers with low production capacity. Limited information regarding quality and delivery requirements of supermarkets could also limit the potential of poor farmers to access and benefit from modern supply chains. In response to these challenges, there are development agencies presently working on market linkage initiatives aimed at enhancing smallholder participation in supermarket channels. One such organization is Farm Concern International (FCI), a non-governmental organization (NGO) linking vegetable farmers in Kiambu District to supermarkets.

FCI market linkage initiatives are undertaken through farmer groups and involve training of farmers in the production of African Indigenous Vegetables (AIV) (Moore & Raymond, 2006; Ngugi *et al.*, 2007). AIV have recently attracted attention among consumers for their potential health benefits (Shiundu & Oniang'o, 2007). Besides training farmers on production techniques, FCI also trains farmers on group management, and business skills. Furthermore, FCI mediates between farmer groups and supermarkets by negotiating market access and training farmer groups on supermarket delivery requirements. Through the training and market mediation, FCI lowers transaction costs of searching trading partners, screening them, and negotiating agreements for both farmers and supermarkets. Such transaction costs could otherwise constitute an entry barrier for small-scale producers. Furthermore, collective action promoted by FCI

through group training, helps farmers to meet the strict delivery standards imposed by supermarkets.

Another service provided by the NGO is invoice discounting, that is, FCI pays farmers directly upon delivery of produce, recovering its funds when supermarkets process payment after one or two weeks. These initiatives therefore constitute an institutional innovation that facilitates market access by farmers who might otherwise have been excluded from high-value markets. FCI currently has 80 vegetable farmers involved in this project in Kiambu District. Out of these, more than half were already supplying supermarkets at the time of our survey.

3.4. Study area: Kiambu District

Data for this study was collected in Kiambu District of Central province in Kenya. The district is divided into five administrative divisions namely: Githunguri, Limuru, Kikuyu, Kiambaa and Lari (Republic of Kenya, 2005). The district covers an area of 1,324 square kilometers with 90% being high potential agricultural land. Rainfall ranges from 1,500 mm in the highlands to 500 mm in the semi-arid areas of Ndeiya and Karai in Lari division (Republic of Kenya, 2002). The district is one of the most densely populated areas in Kenya, with an estimated population of 806, 790 and a population density of 660 individuals per square kilometer. High population density has exerted pressure on available resources resulting into intense land fragmentation and landlessness affecting close to 50% of the population (Republic of Kenya, 2002). The average land holding is 0.8 hectare, and land sub-division has also led to uneconomical land sizes and/or highly intensive farming systems.

Kiambu District is predominantly agricultural with nearly 70% of the population engaged in agriculture. About 90% of farmers are smallholders, engaging in subsistence production of maize, beans and potatoes in a mixed intensive cultivation system (Republic of Kenya, 2002). Tea, coffee and horticultural crops (flowers, vegetables and potatoes) are the main cash crops. While tea and coffee have traditionally been the major income earners, proximity to urban markets of Nairobi and Kiambu town have increasingly created a shift to livestock and high-value horticultural enterprises. The district therefore provides an important source of vegetables both for traditional channels and emerging high-value channels. Furthermore, year-round production of horticultural produce is also sustained through irrigation, thus making the horticultural sector of strategic importance both for food provision and income generation in the region (Republic of Kenya, 2002). Income from livestock comprises a significant 30% of household income, and milk markets are relatively stable and well-streamlined with substantial government intervention. Farming in the district is hampered by use of uncertified seeds, shortage and high-high costs of farm inputs and poor farming skills among others (Republic of Kenya, 2002).

Kiambu District is considered one of the regions with low levels of poverty in Kenya. In total, about one-fifth of the district population lives below the national poverty line, with poverty being more prevalent in the urban (48%) than in the rural areas (22%) (Ndeng'e *et al.*, 2003). Indeed, compared with other rural areas, rural Kiambu has the lowest levels of poverty. Poverty levels are generally attributed to poor marketing systems, inaccessibility to credit and landlessness among others (Republic of Kenya, 2001).

3.5. Sampling methods

Kiambu District was chosen for this study since it is a major supplier of vegetables to the urban population in Nairobi (Neven *et al.*, 2009). Especially for supermarkets, most vegetables are produced within a 100 km band around the city. For Nairobi markets, production of kale, one of the most popular vegetables in Kenya, is concentrated around Lari and Kikuyu divisions of Kiambu District.

Since there were no lists or censuses of vegetable farmers in the region, we relied on information from the District Agricultural Office (DAO) in Kiambu District. Out of the five divisions of Kiambu District, four were selected for the study, as these were the areas suggested by the DAO as predominant vegetable production areas. These included; Kikuyu, Lari, Githunguri, and Limuru divisions. In the next step, 31 locations were selected from these divisions again based on relative predominance of vegetable production as suggested by the DAO. Within each location, vegetable farmers supplying traditional channels were then randomly selected resulting into a sample of 269 farmers supplying traditional channels.

For selection of supermarket suppliers we relied on information from supermarkets and supermarket traders. Since there are relatively few farmers presently supplying supermarkets, all farmers listed by supermarkets and supermarket traders were purposively selected, yielding a sample of 133 supermarket suppliers. In total therefore, our sample consists of 402 vegetable farm households.

3.6. Data collection: farm household survey

Data for this study was collected between June and October 2008. A structured questionnaire was developed and used to collect information from individual households by interviewing the household member in charge of vegetable production. The interviews were conducted by 3 trained enumerators who were recent graduates from University with undergraduate degrees in agricultural economics, food science and statistics respectively. Interviews were conducted in local language known to farmers (Kikuyu) or Swahili – the national language for Kenya, whichever was preferred by respective respondents. The enumerators were trained for two weeks and the questionnaire pre-tested and updated before the start of actual survey. The information gathered through the face-to-face interviews included general farming information such as land ownership and crop portfolios. Information was also collected regarding revenues from all crop and livestock enterprises and operational costs in order to derive farm income that is used in the analysis. More detailed information regarding vegetable market participation was also collected. Included under this section of the interview were details regarding determinants of market choice and access to market information. Farmers were also asked to list all their market outlets and to rank them in the order of importance.

Detailed production data was also collected at plot level. Production data included input and output data, output and input prices, quantity and frequency of input application and detailed labor use per operation. Data from this section of the questionnaire is used to conduct gross margin and productivity analyses.

Furthermore, information regarding participation in off-farm employment and income derived from the same was collected. For each household member, income earned from various

occupations (formal and informal) was collected. These income details, together with income from off-farm enterprises and farm income (including the value of subsistence consumption) provided information for the household income analysis. The original questionnaire is included in appendix B.

4. Supermarket channels, production technology, and technical efficiency

We begin our analysis by looking at effects of supermarket access by farmers on production technology and farm technical efficiency. While recent research has attempted productivity analysis, existing studies in this area focus on partial productivity measures that may not be fully informative. Furthermore, potential effects of supermarket participation on technical efficiency have not been analyzed. In this chapter we look at total factor productivity, which enables us to compare overall performance of farms in the two market channels. We use a meta-frontier approach and combine this with propensity score matching techniques to estimate unbiased treatment effects among vegetable farmers in Kenya.

4.1. Introduction

Domestic agri-food systems in many developing countries are experiencing increasing demand for high-value food products and a tendency towards supply chain modernization (Swinnen, 2007). In addition to market liberalization, these changes are largely motivated by rapid urbanization and rising living standards. The growing number of urban, middle-class consumers has preferences for higher levels of food quality, food safety, diversity, and convenience (Mergenthaler *et al.*, 2009b; Pingali *et al.*, 2007). To meet these emerging preference structures, modern supply chains often adopt tighter vertical coordination, with super- and hypermarkets rapidly gaining importance (Boselie *et al.*, 2003; Neven & Reardon, 2004; Reardon *et al.*, 2003).

Participation in modern supply chains can provide new income opportunities for farmers (Neven *et al.*, 2009). Yet, there are also new challenges. Food quality and safety can be associated with informational uncertainties and high transaction costs (Okello & Swinton, 2006; Pingali *et al.*, 2007). To minimize such costs, modern retailers often impose strict standards, which might potentially exclude resource-poor agricultural producers (Balsevich *et al.*, 2003). Recent studies have analyzed the determinants of farmer participation in modern supply chains, including supermarket and export channels, and impacts on farm and household incomes (Hernandez *et al.*, 2007; Neven *et al.*, 2005; Wollni & Zeller, 2007). There are also studies that have looked into effects for more traditional markets and spillovers on land use and rural employment (Maertens & Swinnen, 2009; Minten *et al.*, 2007; Schipmann & Qaim, 2010). However, restructuring supply chains might also have impacts on technical efficiency and farm productivity, aspects which have not been sufficiently analyzed so far.

Compared to traditional farming, producing for modern supply chains often entails more sophisticated planning and timing of input application, which could positively influence technical efficiency. Moreover, fulfilling supermarket standards for consistent supply may require use of new production technology, such as modern irrigation equipment. Similarly, investment in fixed capital is often encouraged by market assurance (Jayne *et al.*, 1997), which is often provided by supermarkets. Participation in high-value chains may also involve special extension and improved access to better quality seeds and other modern inputs (Masakure & Henson, 2005). We hypothesize that such changes in production technology are relevant and could contribute to improvements in farm productivity. If this is the case, modern supply chains could contribute to much needed agricultural productivity gains in Africa, with important

positive effects for poverty reduction and rural development (Irz *et al.*, 2001; World Bank, 2007).

While some studies have analyzed impacts of modern supply chains on farm productivity (Hernandez *et al.*, 2007; Minten *et al.*, 2007), the focus was mostly on partial rather than total factor productivity. Moreover, previous studies have employed approaches that do not measure productivity with respect to a common frontier, so that technical efficiency effects could not be separated. Here, we extend the literature by developing a decomposition approach. In addition to separate group frontiers for supermarket and traditional channel farmers, we estimate a meta-production frontier to derive technical efficiency scores and productivity ratios with respect to a common frontier. Propensity score matching techniques are then used to account for self-selection.

The empirical analysis builds on a comprehensive cross-section survey of vegetable farmers in central Kenya. Overall, the expansion of supermarkets in Sub-Saharan Africa is not yet as strong as in Asia and Latin America (Gulati *et al.*, 2007; Reardon *et al.*, 2003), but in Kenya supermarkets already account for 20% of food retailing in urban areas (Neven & Reardon, 2004; Nyoro *et al.*, 2007). While the focus of supermarkets is largely on processed foods, they are also gaining shares in fresh product markets. In Kenya, supermarkets accounted for about 4% of urban retailing in fresh fruits and vegetables in 2002, with a rapidly rising trend (Neven & Reardon, 2004). Supermarket procurement strategies have already influenced the horticultural sector around the city of Nairobi, and this phenomenon is likely to spread geographically as market shares are growing. Hence, understanding the wider implications is of crucial relevance for rural development research and policy.

The rest of this chapter is organized as follows. The next section presents the analytical framework and details of the econometric procedure. This is followed by presentation of the survey data and sample descriptive statistics. Subsequently, we show and discuss the estimation results, before making some concluding remarks.

4.2. Analytical framework

Our analytical approach follows the concept of a meta-production function as an envelope of neoclassical production functions (Hayami & Ruttan, 1985). The concept assumes that all producers in an industry have potential access to the same technology despite operating under different group-specific production technologies. Following this, Battese (2004) and O'Donnell (2008) have developed a meta-frontier (MF) model for estimating productivity differences between groups of producers and comparable technical efficiency scores.

4.2.1. Group-specific frontiers and technical effects

We define separate stochastic production frontiers (SPFs) for farmers in supermarket and traditional channels as follows:

$$Y_{ij} = f\left(\boldsymbol{x}_{ij}, \boldsymbol{\beta}_j\right) e^{v_{ij} - u_{ij}}; \quad i = 1, 2, \ldots N; j = 1,2 \tag{4.1}$$

where Y_{ij} denotes vegetable output of the *i*th farm for the *j*th group; $\boldsymbol{x}_{ij}$ denotes a vector of values of inputs used; $\boldsymbol{\beta}_j$ denotes the parameter vector associated with the *x*-variables for the stochastic frontier; v_{ij} is a random variable that is identically and independently distributed and

independent of u_{ij}, which is a non-negative unobservable random error associated with technical efficiency. If we assume a log-linear functional form (e.g., Cobb-Douglas or Translog) as in Battese *et al.* (2004), the SPF can be written as:

$$Y_{ij} = f\left(\boldsymbol{x}_{ij}, \boldsymbol{\beta}_j\right) e^{v_{ij} - u_{ij}} \equiv e^{\boldsymbol{x}_{ij}\beta_j + v_{ij} - u_{ij}} \tag{4.2}$$

Based on suitable distributional assumptions for the error terms *u* and *v*, input and output data for farms in the *j*th group can be used to obtain maximum-likelihood (ML) estimates of the unknown parameters of the frontier defined by equation (4.2). Output-oriented technical efficiency (TE) estimates with respect to the group *j* frontier for the *i*th farm can be computed as:

$$TE_{ij} = \frac{Y_{ij}}{Y_{ij}^{max}} = \frac{e^{\boldsymbol{x}_{ij}\boldsymbol{\beta}_j - u_{ij} + v_{ij}}}{e^{\boldsymbol{x}_{ij}\boldsymbol{\beta}_j + v_{ij}}} = e^{-u_{ij}} \tag{4.3}$$

In order to model the relationship between TE and those variables that might exert an impact on the level of TE, we follow Wang and Schmidt (2002) and Alvarez *et al.* (2006) by specifying a model for the *u* random variables which fulfills the scaling property, i.e., where the fundamental shape of the distribution remains constant for all observations. Specifically, we apply a heteroscedastic frontier model, which assumes heteroscedasticity of the one-sided error term. This error term reflects factors under the farmer's control, and since large farms have more factors under their control, the one-sided error term is likely subject to size-related heteroscedasticity (Caudill & Ford, 1993). We therefore model inefficiency as follows: [3]

$$\sigma_{ui} = \exp\left(\boldsymbol{w_i}\boldsymbol{\delta_j}\right) \tag{4.4}$$

[3] An alternative functional form; $\sigma_{ui} = \sigma \exp\left(\boldsymbol{z_i}\boldsymbol{\delta_j}\right)$ assumes no intercept, so that the overall scale is set by a constant σ. Equivalently, we can eliminate the overall constant (σ) if we add an intercept to $\boldsymbol{w_i}\boldsymbol{\delta_j}$ (Wang & Schmidt, 2002). We use this latter option.

In (4.4), $\boldsymbol{w_i}$ is a vector of farm-specific variables and size-related input use (including a constant), where $\boldsymbol{w_i}$ and $\boldsymbol{x_i}$ are allowed to overlap (Alvarez *et al.*, 2006; Wang & Schmidt, 2002). Besides allowing for functions of inputs in the inefficiency model, the scaling property of the heteroscedastic model enables direct interpretation of inefficiency coefficients as semi-elasticities (Wang & Schmidt, 2002). After estimating the group frontiers in equation (4.2), we perform a likelihood ratio (LR) test to verify if the technologies in the two market channels can be represented by a common technology. If the null hypothesis of a common technology is rejected, the estimation proceeds following the MF framework (Battese *et al.*, 2004).

4.2.2. Meta-frontier analysis

Battese *et al.* (2004) define the MF as a deterministic parametric frontier of a specified functional form such that its values are no less than the deterministic part of the group-specific SPFs. Furthermore, the MF is assumed to be a smooth function and not a segmented envelope of group frontiers. The deterministic MF model for all farms in the supermarket and traditional channels can therefore be expressed as follows:

$$Y_i^* = f(\boldsymbol{x}_i, \boldsymbol{\beta}^*) = e^{\boldsymbol{x}_i\boldsymbol{\beta}^*}; i = 1, 2, \ldots . N, N = \sum_{j=1}^{2} N_j \quad (4.5)$$

where $\boldsymbol{\beta}^*$denotes the vector of parameters of the MF function such that $\boldsymbol{x}_i\boldsymbol{\beta}^* \geq \boldsymbol{x}_i\boldsymbol{\beta}_j$. for all *i* observations. These parameters can be obtained by minimizing the sum of absolute deviations (MAD) or the sum of the squared deviations of the distance between the MF and the *j*th group frontier evaluated at the observed input vector for a farm in the *j*th group. Estimating MF parameters therefore involves solving the following optimization problems:

$$\min \text{L1} \equiv \sum_{i=1}^{N} \left| \left(\ln f(\boldsymbol{x}_i, \boldsymbol{\beta}^*) - \ln f\left(\boldsymbol{x}_i, \widehat{\boldsymbol{\beta}}_j\right) \right) \right| \; or \tag{4.6a}$$

$$\min \text{L2} \equiv \sum_{i=1}^{N} \left(\ln f(\boldsymbol{x}_i, \boldsymbol{\beta}^{\sim}) - \ln f\left(\boldsymbol{x}_i, \widehat{\boldsymbol{\beta}}_j\right) \right)^2 \tag{4.6b}$$

$$s.t. \;\; \ln f(\boldsymbol{x}_i, \boldsymbol{\beta}^*) \geq \ln f\left(\boldsymbol{x}_i, \widehat{\boldsymbol{\beta}}_j\right) \text{ for all } i \text{ observations.}$$

For these optimization problems, the $\widehat{\boldsymbol{\beta}}_j$ are treated as fixed so that the second term in the summation is constant with respect to the minimization. Hence, (4.6a) can be equivalently solved by minimizing the objective function $L^* \equiv \overline{\boldsymbol{x}}\boldsymbol{\beta}^*$, subject to the linear restriction as shown, where $\overline{\boldsymbol{x}}$ is the row vector of means of elements of the *x*-vector for all observations in the dataset. Standard errors for the MF parameters can be derived by simulation as outlined in Battese *et al.* (2004).

In terms of the estimated MF, the observed output of the *i*th farm, defined by the SPF for the *j*th group in equation (2) can alternatively be expressed as follows:

$$Y_i = e^{-u_{ij}} \times \frac{e^{\boldsymbol{x}_i\boldsymbol{\beta}_j}}{e^{\boldsymbol{x}_i\boldsymbol{\beta}^{*/\sim}}} \times e^{\boldsymbol{x}_i\boldsymbol{\beta}^{*/\sim} + v_{ij}} \tag{4.7}$$

where the first term on the right hand side is the technical efficiency with respect to group frontiers (TE), and the second term is the meta-technology ratio (MTR) for the particular sample farm involved:

$$MTR = \frac{e^{\boldsymbol{x}_i\boldsymbol{\beta}_j}}{e^{\boldsymbol{x}_i\boldsymbol{\beta}^{*/\sim}}} = \frac{Y_i}{e^{\boldsymbol{x}_i\boldsymbol{\beta}^{*/\sim}}} \Big/ \frac{Y_i}{e^{\boldsymbol{x}_i\boldsymbol{\beta}_j}} \tag{4.8}$$

MTR is a ratio of output for the frontier production function for the *j*th group relative to the potential output defined by the MF function, given the observed inputs (O'Donnell, Rao, and Battese 2008), or as the second equality in equation (4.8) illustrates, the ratio between the

efficiency estimate against the group frontier and the efficiency estimate against the MF (TE_i^*). It lies between zero and one and captures productivity differences between the two technologies. Alternatively, equation (4.7) can be rearranged to decompose TE_i^* into the group TE estimate and MTR:

$$TE_i^* = TE_{ij} \times MTR \tag{4.9}$$

4.2.3. Potential selection bias

The MF approach can reveal productivity and efficiency differences between farmers in supermarket and traditional channels. However, we cannot simply attribute these differences to participation in supermarket channels due to potential for selection bias – some of the factors determining participation in supermarket channels may also influence farm efficiency and productivity. If participation were randomized, the counterfactual would be observable, making it possible to derive causal inference. Unfortunately, this is not the case in our example. The cross-sectional nature of our data also rules out the possibility of addressing selection bias through panel data approaches. A conventional approach is to use the two-step estimation procedure developed by Heckman (1976), for which recent examples include Sipiläinen and Lansink (2005) and Solis *et al.* (2007). However, this approach is less suitable for non-linear functions such as the stochastic frontier. To address selection bias, we therefore use matching techniques, which have also been used in the context of stochastic frontier analysis by Mayen *et al.* (2010). Unlike their study, however, we conduct matching after estimation to avoid losing information useful for construction of the frontiers – thus improving the precision of our TE_i^* and MTR estimates.

Matching involves pairing farmers in supermarket and traditional channels who are similar in terms of their observable characteristics (Dehejia & Wahba, 2002). The impact variable of interest in the matching model is the expected treatment effect for the treated population, which can be expressed as follows:

$$\tau_{I=1} = E(\tau I = 1) = E(R_1|I = 1) - E(R_0|I = 1) \quad (4.10)$$

where τ is the average treatment effect for the treated (ATT), R_1 denotes the value of outcome for supermarket suppliers, and R_0 denotes the value of outcome for traditional channel suppliers. Since the counterfactual $[E(R_0|I = 1)]$ is not observable, we use matching techniques to estimate this magnitude. Normally, matching would be done on covariates that are correlated with selection into treatment and/or with the outcome variable. However, this can be challenging in the presence of a large set of covariates. Rosenbaum and Rubin (1983) therefore suggest matching on propensity scores to overcome the curse of "multidimensionality". Our matching approach is based on predicted propensity scores (PS).

The PS is defined as the conditional probability that a producer participates in supermarket channels given covariates, Z $[PS = \hat{p}(I = 1|Z)]$; this is estimated using probit or logit functions. The predicted PS is then used to estimate ATT through a matching process as follows:

$$\tau = E\{R_1 - R_0|I = 1\} = E\big\{E\{R_1 - R_0|I = 1, PS\}\big\}$$

$$= E\big\{E\{R_1|I = 1, PS\} - E\{R_0|I = 0, PS\}|I = 0\big\} \quad (4.11)$$

There are various matching techniques, but the most common ones include nearest neighbor matching (NNM), kernel-based matching (KBM), stratified radius matching, and Mahalanobis matching methods. In this study, we apply the KBM and the NNM methods.

NNM involves pairing farmers in supermarket and traditional channels who are closest in terms of PS as matching partners. KBM, on the other hand, uses a weighted average of the outcome variable for all individuals in the control group (traditional channel suppliers) to construct a counterfactual outcome. Observations that provide better matches are given more weight. The weighted average is compared to the outcome for the supermarket suppliers, and the difference provides an estimate of the treatment effect for the treated. A sample average over all supermarket suppliers then provides an estimate of ATT. In both the NNM and the KBM, only observations in the common support region, where the PS of the treated unit is not higher than the maximum or less than the minimum PS of the control units, are used in the calculation. We adopt matching "with replacement" in the NNM method.

To mimic the conditions of a randomized experiment, propensity score matching (PSM) assumes unconfoundedness or conditional independence. This implies that – once determinants of participation in supermarket channels are controlled for – supermarket participation is random and uncorrelated with the outcome variables (Wooldridge, 2002). This is a relatively strong assumption, because systematic differences between farmers in the two channels may exits even after conditioning, if selection is based on unmeasured characteristics (Smith & Todd, 2005). Rosenbaum (2002) therefore suggests a bounding approach that evaluates how strongly unmeasured variables must influence the selection process to invalidate the implications of the matching process; this provides a standard test for unconfoundedness that we also use.

4.3. Data and descriptive statistics

As outlined in chapter 3, data for this study was collected in 2008 in Kiambu District, Central Province of Kenya. Kiambu is located in relative proximity to Nairobi; even before the spread of supermarkets, this district has been one of the main vegetable-supplying regions for the capital city. Based on information from the District Agricultural Office, four of the main vegetable-producing divisions were chosen. In these four divisions, 31 administrative locations were purposively selected, again using statistical information on vegetable production. Within the locations, vegetable farmers were sampled randomly. Since farmers who participate in supermarket channels are still the minority, we oversampled them using complete lists obtained from supermarkets and supermarket traders. In total, our sample comprises 402 farmers – 133 supermarket suppliers and 269 traditional channel suppliers. Using a structured questionnaire, these farmers were interviewed on vegetable production and marketing details, other farm and non-farm economic activities, as well as household and contextual characteristics.

Both types of farmers produce vegetables in addition to maize, bananas, and a number of other crops. The main vegetables produced are leafy vegetables, including exotic ones such as spinach and kale, and indigenous ones such as *amaranthus* and black nightshade, among others.[4] Figure 4.1 shows the different marketing channels for vegetables used by sample farmers. Some supermarket suppliers also sell vegetables in traditional spot markets when they have excess supply. However, for analytical purposes, farmers that supply at least part of their vegetables to supermarkets are classified as supermarket suppliers.

[4] Recently, African indigenous vegetables have received renewed attention from upper and middle income consumers in Kenya (Ngugi *et al.*, 2007).

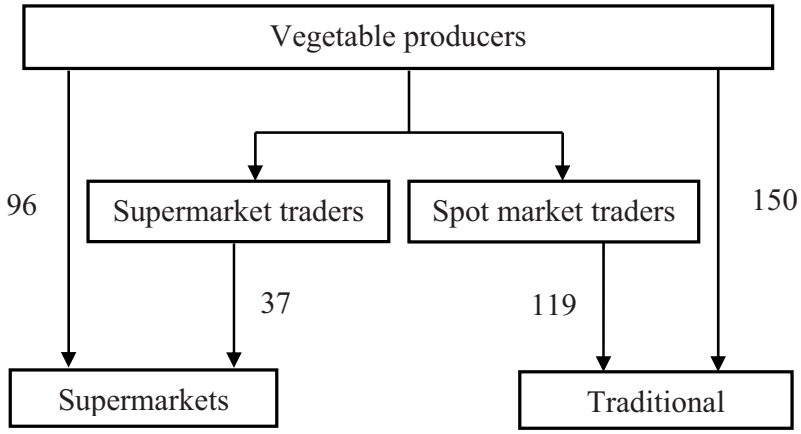


Figure 4.1: Vegetable marketing channels among Kenyan sample farmers

Source: Author's own representation

Traditional market sales are one-off transactions between farmers and wholesalers or consumers with neither promise for repeated transactions nor prior agreements on product delivery or price. Depending on the demand and supply situation, prices are subject to wide fluctuation. Farmers who are unable to supply directly to wholesale or retail markets sell their produce to traditional market traders who act as intermediaries. Such traders collect vegetables at the farm gate without any prior agreement. In contrast, supermarkets do have agreements with vegetable farmers regarding product price, physical quality and hygiene, and consistency in supply (Ngugi *et al.*, 2007). Price agreements are made before delivery, and prices are relatively stable. Payments are usually only once a week or every two weeks. All agreements are verbal with no written contract. Some farmers also supply supermarkets through special traders. Based on similar verbal agreements, these traders again maintain regular contacts with farmers, in order to be able to supply supermarkets in a timely and consistent way. Strict supply requirements by supermarkets

have led to specialization among traders. Consequently, supermarket traders tend to exclusively supply modern retail outlets.[5]

Table 4.1 compares selected variables between supermarket and traditional channel suppliers in our sample. On average, farmers supplying supermarkets own more land.[6] They are also better educated and have significantly higher farm, non-farm, and per capita household incomes. While supermarket suppliers have an annual mean per capita income of 167 thousand Kenyan shillings (Ksh) (2230 US dollars), average per capita incomes among spot market suppliers are only around 77 thousand Ksh (1025 US dollars). Supermarket farmers have a larger share of their land under vegetables, which is an indication of their higher degree of specialization. In addition, significantly larger proportions of supermarket suppliers use advanced irrigation technology such as drip irrigation and sprinklers, and have their own means of transportation. This gives them an advantage in terms of meeting supermarket requirements for consistency and regularity in supply. Yet there are no significant differences between the two groups in terms of access to a reliable water source, the share of the vegetable area under irrigation, and experience in vegetable farming.

[5] Initially, supermarkets in Kenya purchased fresh vegetables in traditional wholesale markets, which can partly still be observed today. However, meanwhile supermarkets have diversified their procurement to include contracted farmers and traders, in order to ensure price stability and consistency in quality and supply.

[6] The mean farm size in Kenya is 6.7 acres (Jayne *et al.*, 2003), but this also includes large plantations. In terms of per capita incomes, households in Kiambu are slightly richer than those in most other rural districts of the country. The rural poverty rate in Kiambu was 22% in the early 2000s (Ndeng'e *et al.*, 2003).

Table 4.1: Summary statistics

Variables	Supermarket (n = 133)		Traditional (n = 269)	
	Mean	SD	Mean	SD
Household and farm characteristics				
Total area owned *(acres)*	2.692**	5.607	1.870	2.485
Total vegetable area cultivated *(acres)*	1.168***	1.457	0.697	0.992
Share of vegetable area *(%)*	68.8*	31.9	62.8	32.5
Access to reliable water source *(%)*	19.5	39.8	21.6	41.2
Use of advanced irrigation technology *(%)*	52.6***	50.1	35.3	47.9
Share of vegetable area irrigated *(%)*	76.7	38.7	77.0	39.1
Age of operator *(years)*	47	12	49	15
Education of operator *(years of schooling)*	10.3***	3.14	8.72	4.05
Vegetable farming experience *(years)*	14.01	11.73	15.18	12.14
Own means of transportation *(%)*	24.06***	42.91	8.92	28.56
Total farm income *(Ksh)*	283,944***	379,823	156,022	189,333
Non-farm income *(Ksh)*	151,589***	235,460	59,115	134,945
Household income per capita *(Ksh)*	167,155***	251,363	76,839	93,710
Plot level variables for vegetables				
Sales revenue per acre *(Ksh/acre)*	499,005***	400,508	370,865	335,877
Dummy for farming of exotic vegetables *(%)*	76***	43	88	32
Seed cost *(Ksh/acre)*	6,823.60*	9,485.90	5,490.80	6,105.70
Seed from formal channels *(%)*	65***	48	45	50
Chemical fertilizer use *(kg/acre)*	362.56**	548.76	494.21	640.19
Pesticide use *(ml/acre)*	2,251.22	4,083.44	2,745.51	4,382.22
Purchased manure use *(kg/acre)*	15,926**	28,107	11,108	19,329
Own manure use *(kg/acre)*	5,550	15,693	6,107	14,473
Hired labor use *(labor days/acre)*	215.36**	296.29	164.28	276.98
Family labor use *(labor days/acre)*	307***	395	489	632
Total labor use *(labor days/acre)*	522**	472	653	734

*, **, *** Mean differences between supermarket and traditional channel suppliers are significant at the 10%, 5%, and 1% levels, respectively.

Note: 1 US dollar = 75 Ksh.

Source: Own data

In the lower part of table 4.1 we present plot level variables related to vegetable production. The two groups show significant differences in the value of output per acre: vegetable farmers in supermarket channels have significantly higher sales revenues, which is due to both higher yields and higher prices. With respect to inputs, the groups differ in terms of chemical fertilizer,

farmyard manure, and labor use. Famers in supermarket channels use significantly more purchased farmyard manure and hired labor. However, they use significantly less chemical fertilizer and family labor. The two groups also show significant differences in terms of source and cost of seeds, indicating a distinction in seed quality. These comparisons suggest that production practices and technologies differ. Whether these differences also affect productivity and technical efficiency, as hypothesized, will be analyzed in the following.

4.4. Results and discussion

We begin our analysis with the estimation of technical effects using group-specific SPFs. Our dependent variable in the frontier analysis is the value of vegetable production, which is preferred due to non-comparability of quantity measures across different vegetable species. Furthermore, we expect quality differences, which are better captured using value of output. Before discussing the estimation results, we carry out standard tests for choice of functional form and justification of the inefficiency approach. These test results are shown in table 4.2. In both supermarket and traditional channel sub-samples, the likelihood ratio test rejects the more restrictive Cobb-Douglas functional form in favor of the more flexible translog model. Additional tests confirm the presence of inefficiency effects in both sub-samples.

Table 4.2: Hypothesis testing for stochastic production frontier model

Null hypothesis H_0	χ^2 Statistics	χ^2 Critical	Conclusion
Choice of functional form: $\beta_{ij} = 0$			
Supermarket model	84.34	32.67	Translog is appropriate
Traditional channel model	39.18	32.67	Translog is appropriate
No inefficiency [a]: $\gamma = 0$			
Supermarket model	83.73	14.07	Stochastic frontier appropriate
Traditional channel model	15.91	14.07	Stochastic frontier appropriate
No technical effects: $\delta_1 = \ldots\ldots = \delta_8 = 0$			
Supermarket model	23.48	15.51	Inefficiency model appropriate
Traditional channel model	15.96	15.51	Inefficiency model appropriate
Test for same technology	149.12	48.60	MF is appropriate

[a] This test is subject to 9 restrictions; $\sigma_u = 0$ and $\delta_1 = \ldots\ldots = \delta_8 = 0$. This results into a mixed χ^2 distribution with an upper bound of 16.27 at $\alpha = 0.05$ or 14.07 at $\alpha = 0.1$ for 9 restrictions (Kodde & Palm, 1986).

Source: Own data

Results for the group frontiers are shown in table 4.3. Following Battese (1997), we correct for zero values of inputs by including dummies for input use and interactions between these dummies and the continuous input variables. Furthermore, the continuous input variables are mean corrected ($\log x_i - \log \bar{x}$), so that the estimated coefficients of the first order terms can be interpreted directly as production elasticities at the sample mean.

Table 4.3: Parameter estimates of the stochastic production frontier (Translog Models)

Variables	Supermarket		Traditional	
	Coefficient	SE	Coefficient	SE
Production frontier model: Dependent variable is log value of output				
Dummy for use of chemical fertilizer	-0.101	0.083	-0.264**	0.134
Dummy for use of pesticide	0.371***	0.075	-0.295*	0.169
Dummy for use of manure	-0.584	0.366	-0.394**	0.198
log seed cost	0.116***	0.033	0.004	0.065
log chemical fertilizer	0.066	0.050	0.333***	0.069
log pesticide	0.164***	0.043	0.055	0.073
log manure	0.101***	0.022	0.299**	0.146
log labor	0.311***	0.058	0.009	0.114
log plot size	0.165**	0.073	0.256***	0.074
0.5 × (*log* seed cost)^2	0.129***	0.022	-0.037	0.080
0.5 × (*log* chemical fertilizer)^2	0.153***	0.054	0.151	0.098
0.5 × (*log* pesticide)^2	0.140**	0.068	0.075	0.062
0.5 × (*log* manure)^2	-0.282***	0.023	0.105	0.094
0.5 × (*log* labor)^2	-0.507***	0.054	0.215	0.147
0.5 × (*log* plot size)^2	0.023	0.060	-0.025	0.127
Advanced irrigation technology *(dummy)*	-0.027	0.033	0.176*	0.094
Githunguri & Lower Lari region[a] (*dummy*)	-0.361***	0.138	-0.359*	0.194
Kikuyu/Westland region[a] (*dummy*)	0.710***	0.199	-0.174	0.180
Limuru region[a] (*dummy*)	0.402	0.299	-0.346*	0.183
Exotic vegetable *(dummy)*	0.520***	0.057	0.290**	0.144
Constant	0.036	0.178	0.143	0.231
Inefficiency model				
Experience in vegetable farming (*years*)	0.004	0.005	-0.014**	0.007
Gender of operator (*male dummy*)	0.896***	0.301	-0.230	0.222
Education of operator (*years*)	-0.014	0.019	-0.030	0.021
Access to agricultural extension (*dummy*)	-0.055	0.159	0.230	0.167
Share of vegetable area	0.210	0.245	-0.222	0.234
log manure	-0.298**	0.117	0.272	0.171
log labor	0.379**	0.153	-0.517***	0.115
Share of family labor	0.522***	0.163	0.133	0.200
Constant	-1.320***	0.343	-0.155	0.366
Number of observations	*133*		*265*	
Log likelihood	*-71.527*		*-237.470*	

*, **, *** Significant at the 10%, 5%, and 1% levels, respectively.

[a] *The reference region is Lari.*

Note: Interaction terms were included in estimation, but are not shown here for reasons of space.

Source: Own data

The value of vegetable output for supermarket suppliers is significantly affected by pesticides, farmyard manure, labor, and plot size. Labor has the highest elasticity of 0.31, indicating that a 1% increase in labor quantity would lead to a 0.31% increase in value of vegetable output. Value of vegetable output for traditional channels is, however, insignificantly affected by labor input. This is likely due to higher use of family labor, some of which may be redundant. Farmyard manure has a significant effect in both models, but the effect is bigger among traditional channel suppliers. This is consistent with table 4.1, which showed that traditional channel farmers use significantly less farmyard manure. Similarly, plot size has differential impacts on the value of output, suggesting that economies of scale are somewhat more important for farmers in traditional channels. Expenditure on seeds affects vegetable output significantly only for supermarket suppliers. This is probably due to use of better quality seeds, as discussed above. Interestingly, chemical fertilizer and advanced irrigation technology have significant effects only for traditional channel suppliers. Overall, the differences between the two models are indicative of potential differences in technology, which we explore later.

With regards to efficiency effects, farmyard manure, labor, gender differences, and experience in vegetable farming play significant roles. Use of farmyard manure by supermarket suppliers increases technical efficiency (reduces inefficiency). On the other hand, use of labor as well as increasing share of family labor reduces their technical efficiency. Vegetable producers in supermarket channels would therefore benefit from reduced use of labor, especially family labor. Strikingly, female suppliers of supermarket channels are more technically efficient than male suppliers. For farmers in traditional channels, increasing use of labor improves efficiency, while share of family labor is insignificant. Technical efficiency improvements due to labor use by these farmers are therefore likely to come from increasing hired labor use; table 1 showed that

hired labor use is significantly lower among traditional channel farmers. Experience in vegetable farming also increases efficiency of traditional channel suppliers.

4.4.1. Meta-frontier estimates

Differential effects of variables exhibited by group frontiers are indicative of differences in production technology by farmers in the two market channels. These differences are confirmed by results of the likelihood ratio test shown in the last row of table 2. Test results confirm our earlier hypothesis of technological differences between farmers in the two channels. The next task is therefore to investigate if these differences could lead to productivity differences. We therefore proceed with the MF analysis, as outlined in the analytical framework.

Using parameter estimates from the group frontiers, both a linear and a quadratic programming optimization model (see equations 4.6a and 4.6b) are solved for the entire sample. Since the group frontiers favor the use of a translog model, the meta-frontier is also specified as a translog function. Estimation of group frontiers and the meta-frontier were done using Ox version 6.10 (Doornik, 2007). Parameter estimates for the two meta-frontiers (L1 and L2) and the simulated standard errors are shown in table 4.4. Since we find only minor differences between the two meta-frontiers, the following discussion is based on the L1 coefficients, i.e., results obtained by minimizing the absolute sum of deviations as in equation (4.6a).

Table 4.4: Parameter estimates for the Meta-Frontier

Variable	Coefficient (L1)	SE	Coefficient (L2)	SE
Dependent variable is log value of output				
Dummy for use of chemical fertilizer	-0.186	0.094	-0.198	0.086
Dummy for use of pesticide	0.289**	0.114	0.249**	0.100
Dummy for use of farmyard manure	-0.447	0.193	-0.485	0.175
log seed cost	0.064	0.064	0.080	0.061
log chemical fertilizer	0.189***	0.070	0.160***	0.056
log pesticide	0.031	0.063	0.032	0.057
log manure	0.316***	0.082	0.290***	0.079
log labor	0.114	0.093	0.142*	0.085
log plot size	0.230***	0.080	0.218***	0.076
0.5 × (*log* seed cost)^2	0.217***	0.060	0.216***	0.053
0.5 × (*log* chemical fertilizer)^2	0.176**	0.079	0.144**	0.063
0.5 × (*log* pesticide)^2	0.122*	0.070	0.088	0.066
0.5 × (*log* manure)^2	0.140*	0.081	0.091	0.070
0.5 × (*log* labor)^2	0.052	0.146	0.013	0.140
0.5 × (*log* plot size)^2	0.004	0.091	-0.037	0.081
log seed cost × *log* chemical fertilizer	0.157**	0.076	0.139**	0.071
log seed cost × *log* pesticides	-0.128	0.043	-0.115	0.038
log seed cost × *log* manure	-0.012	0.055	-0.007	0.051
log seed cost × *log* labor	-0.065	0.068	-0.061	0.064
log seed cost × *log* plot size	-0.157	0.062	-0.136	0.054
log chemical fertilizer × *log* pesticide	-0.033	0.051	-0.017	0.039
log chemical fertilizer × *log* manure	-0.118	0.054	-0.131	0.047
log chemical fertilizer × *log* labor	0.046	0.064	0.070	0.057
log chemical fertilizer × *log* plot size	-0.146	0.064	-0.147	0.058
log pesticide × *log* manure	0.011	0.066	0.023	0.060
log pesticide × *log* labor	0.028	0.068	0.028	0.060
log pesticide × *log* plot size	-0.010	0.064	-0.017	0.053
log manure × *log* labor	-0.112	0.094	-0.092	0.088
log manure × *log* plot size	0.133*	0.070	0.133**	0.062
log labor × *log* plot size	0.051	0.086	0.055	0.078
Advanced irrigation technology (*dummy*)	0.092	0.057	0.113*	0.058
Githunguri & Lower Lari region [a] (*dummy*)	-0.265	0.183	-0.276	0.185
Kikuyu/Westland region [a] (*dummy*)	0.619***	0.201	0.51**	0.204
Limuru region [a] (*dummy*)	-0.238	0.219	-0.291	0.222
Exotic vegetable	0.378***	0.093	0.358***	0.083
Constant	0.372	0.233	0.517**	0.233
Number of observations		*398*		

*, **, *** Significant at the 10%, 5%, and 1% levels, respectively; [a] *the reference region is Lari.*
Source: Own data

Results show positive and significant effects of chemical fertilizer, farmyard manure, and plot size on the value of vegetable output. Use of advanced irrigation technology also leads to an increase in the value of output, although the L1 coefficient is not significant. The parameters of the MF are used in the estimation of MTR and technical efficiency, as shown in equations (4.8) and (4.9), respectively. A summary of these two measures is shown in table 4.5, alongside scores for technical efficiency with respect to the group frontiers. However, the group-specific scores cannot be compared across groups since they are estimated with respect to different frontiers. Comparisons across groups should therefore only be based on the common MF.

Table 4.5: Meta-Technology Ratio (MTR) and technical efficiency for group SPFs and Meta-Frontier

	Supermarket suppliers			Traditional channel suppliers		
	Group TE	MTR	Meta-frontier TE	Group TE	MTR	Meta-frontier TE
Mean	0.61	0.72***	0.42*	0.70	0.54	0.37
Minimum	0.09	0.16	0.07	0.12	0.07	0.01
Maximum	0.99	1.00	0.99	0.91	1.00	0.86
Std. deviation	0.30	0.24	0.19	0.17	0.24	0.24

*, **, *** Mean values for supermarket suppliers are significantly different from mean values for traditional channel suppliers at the 10%, 5%, and 1% levels, respectively.

Source: Own data

As can be seen from table 4.5, farmers in supermarket and traditional channels show significant differences in MTR and technical efficiency with respect to the MF. On average, supermarket farmers exhibit a productivity level that is 18 percentage points (33%) higher than farmers in traditional channels. Given the technology potentially available to all vegetable farms in Kiambu District, supermarket farmers produce 72% of potential output, whereas traditional channel

farmers only produce 54% of potential output on average. In both cases, the group frontiers are tangent to the meta-frontier since the maximum value of the MTR is achieved. Yet, as figure 4.2(a) illustrates, more supermarket than traditional channel famers achieve the maximum MTR. Supermarket farmers also have higher technical efficiency on average. Figure 4.2(b) shows that a larger percentage of supermarket farmers scores technical efficiency levels of above 80%.

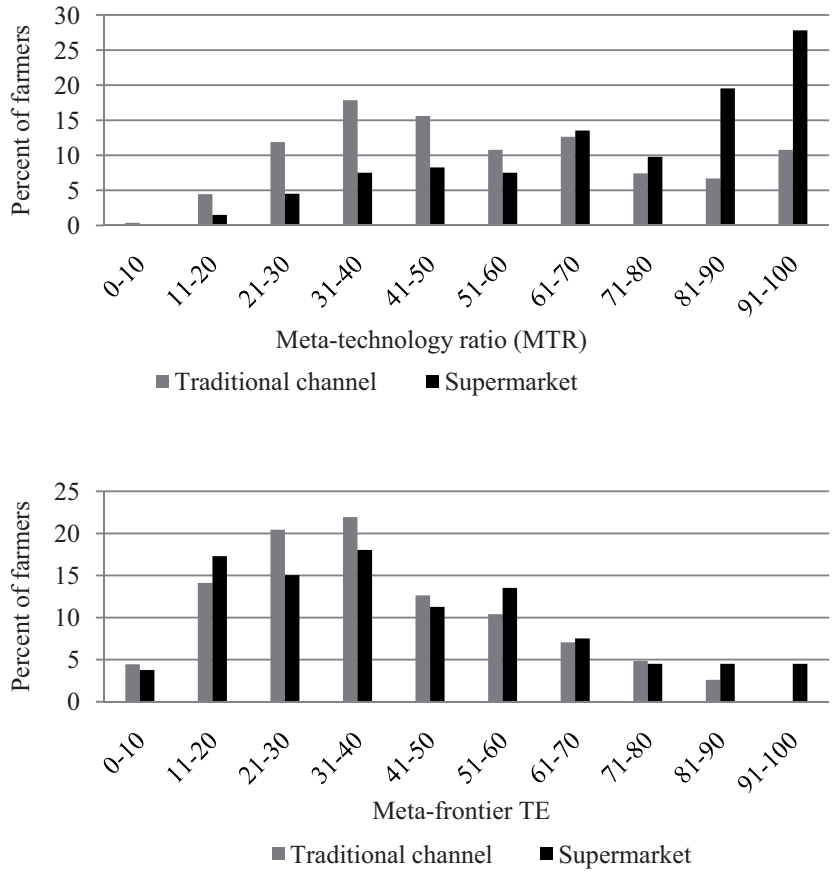


Figure 4.2: Distribution of meta-technology ratios and meta-frontier technical efficiency by market channel

Source: Own data

4.4.2. Treatment effect analysis

In order to establish if the estimated differences in MTR and TE can be attributed to farmer participation in supermarket channels, we carry out treatment effect analysis using PSM, as outlined in the analytical framework. The matching process begins by estimation of PS using a probit model. Results of this model indicate that the age of the farmer, education level, own means of transportation, and use of advanced irrigation technology positively determines participation in supermarket channels (table 4.6).

Table 4.6: Propensity score for participation in supermarket channels (Probit estimates)

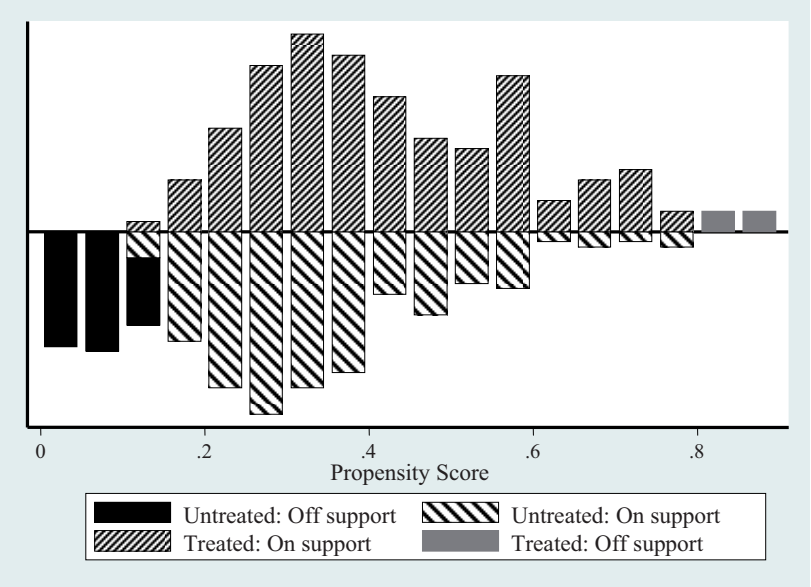
	Coefficient	SE
Variables		
Education of operator (years)	0.180**	0.075
Education of operator squared *(years)*	-0.008*	0.010
Own means of transportation *(dummy)*	0.433**	0.201
Age of operator *(years)*	-0.008	0.006
Household labor endowment *(no. of people)*	-0.035	0.062
Share of family labor	-0.515**	0.210
Off-farm employment *(dummy)*	0.276*	0.142
Use of advanced irrigation technology *(dummy)*	0.296**	0.148
Household access to electricity *(dummy)*	0.196	0.185
Lari region *(dummy)*	-0.738*	0.424
Githunguri and Lower Lari region *(dummy)*	0.584***	0.188
Constant	-1.151**	0.539
Number of observations		*398*
Pseudo R^2		*0.126*
Log likelihood		*-221.532*

*, **, *** Significant at the 10%, 5%, and 1% levels, respectively.

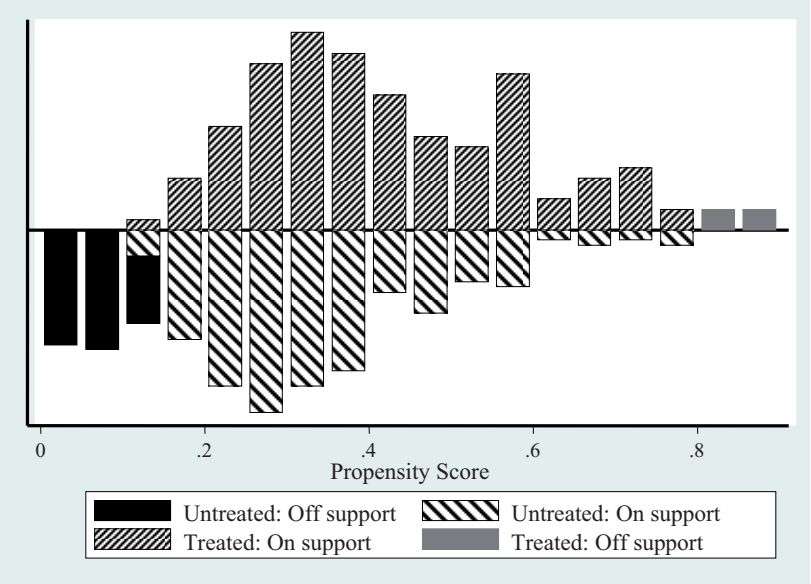
Source: Own data

Predicted PS are employed in subsequent steps to estimate productivity and efficiency effects of supermarket participation. We use the KBM and NNM methods and impose the common support condition on the matching process to ensure proper matching. The matching procedure was

conducted in STATA software, following steps by Leuven and Sianesi (2003). Distributions of PS and the region of common support are shown in figure 4.3. The distributions reveal the significance of proper matching and the need for imposing the common support condition to avoid bad matches.



a) Effects on meta-technology ratio (MTR)



b) Effects on meta-frontier TE

Note: On support refers to observations in respective categories that find suitable matches, while off support indicates observations that do not find suitable matches.

Figure 4.3: Propensity score distribution and common support for propensity score estimation

Source: Own data

In table 4.7, we present the average treatment effects estimated by KBM and NNM methods. Both methods reveal significant effects of supermarket participation on MTR. The results suggest that participation in supermarket channels leads to a 19-20 percentage point (35-38%) improvement in productivity, thus confirming our main research hypothesis. These effects are highest for farmers in the middle range of productivity scores, as can be seen from figure 4. The supermarket impact on technical efficiency is not statistically significant.

Table 4.7: Average treatment effects and results of sensitivity analysis

Matching algorithm	Outcome	ATT	Critical level of hidden bias (Γ)	Number of treated	Number of control
Kernel-based matching	Meta-technology ratio	0.19*** (6.75)	4.15 – 4.20	129	207
	Meta-frontier TE	0.04 (1.62)		129	207
Nearest neighbor matching	Meta-technology ratio	0.20*** (5.70)	3.05 – 3.10	129	207
	Meta-frontier TE	0.05 (1.64)		129	207

*, **, *** Significant at the 10%, 5%, and 1% levels, respectively.

Source: Own data

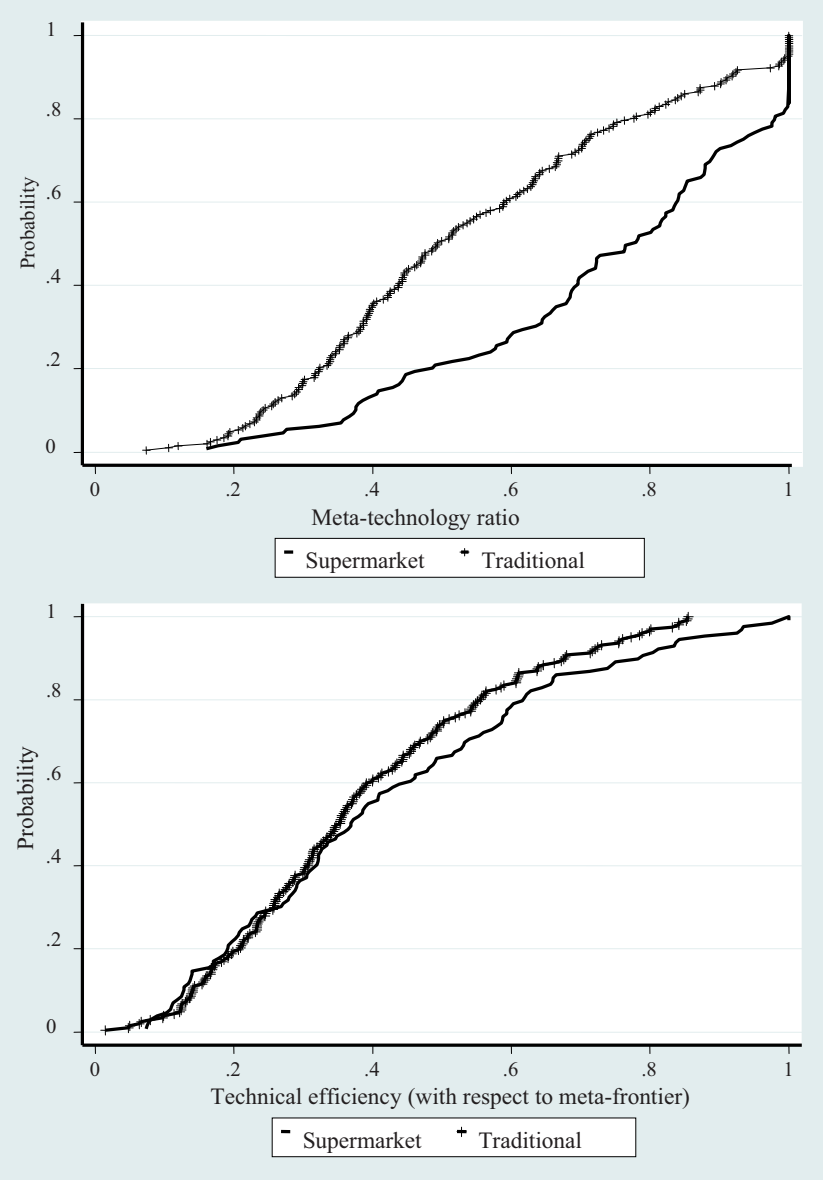


Figure 4.4: Cumulative distribution of meta-technology ratio (MTR) and meta-frontier TE by market channel (adjusted for selection bias)

Source: Own data

4.4.3. Validity of the matching assumptions

Despite the general ability of matching techniques to control for selection bias, the estimates are only valid subject to two conditions – balancing in covariates and unconfoundedness (Caliendo & Kopeinig, 2008; Dehejia & Wahba, 2002). The objective of estimating the PS used in matching is to balance the distribution of variables relevant to the matching process rather than obtaining precise selection into treatment. Balancing tests are therefore necessary after matching to determine if the matching process has reduced the bias by eliminating differences in covariates. We evaluate the balancing condition and bias reduction following Rosenbaum and Rubin (1985). Table 4.8 shows indicators of covariate balancing for the matching model. The results reveal substantial reduction of bias through matching: above 87% reduction in the KBM and 76% in the NNM. The pseudo R^2 and *p-values* of the likelihood ratio tests before and after matching are also presented in table 4.8. The joint significance of regressors is rejected after matching, while it is not rejected before matching. This is evidence of a non-systematic difference in the distribution of covariates between farmers in supermarket and traditional channels after matching.

Table 4.8: Indicators of covariate balancing, before and after matching

Matching algorithm	Outcome	Median absolute bias		% bias reduction	Pseudo R^2		*p*-value of LR	
		Before matching	After matching		Unmatched	Matched	Unmatched	Matched
Kernel-based matching	Meta-technology ratio	34.18	4.26	87.54	0.126	0.027	0.000	0.354
	Meta-frontier TE	34.18	4.26	87.54	0.126	0.027	0.000	0.354
Nearest neighbor matching	Meta-technology ratio	34.13	8.20	75.97	0.114	0.031	0.000	0.142
	Meta-frontier TE	34.13	8.20	75.97	0.114	0.031	0.000	0.142

Source: Own data

We test for unconfoundedness by evaluating the sensitivity of ATT estimates to hidden bias, the results of which are presented in table 4.7. Since sensitivity of insignificant effects is not meaningful, Rosenbaum bounds are only calculated for MTR treatment effects, which are significantly different from zero (Hujer *et al.*, 2004). The critical values of Γ for MTR is 4.15 – 4.20 (KBM) and 3.05 – 3.10 (NNM). These values imply that at the level of Γ=4.2, the causal inference of significant impact of supermarket participation on productivity would have to be viewed critically. In other words, if individuals that have the same **Z**-vector differ in their odds of participation in supermarket channels by 320% or 210%, the significance of supermarket effect on farm productivity may be questionable. Our results on productivity effects of supermarket participation are therefore quite robust to unobserved heterogeneity.

4.5. Conclusion

Agri-food systems in many developing countries are currently undergoing a transformation towards modern high-value supply chains, with supermarkets and their new procurement systems gaining in importance. Recent research has studied what types of farmers participate in such high-value supply chains and what the impacts are in terms of farm and household income. Our research contributes to this literature through analysis of productivity and technical efficiency effects.

Using primary survey data of vegetable growers in Kenya, we have shown that participation in supermarket channels has a positive impact on farm productivity. First, we have revealed differences in technology between farmers in supermarket and traditional channels. Then, we have used meta-frontier analysis to estimate comparable productivity and efficiency scores. Finally, controlling for self-selection through propensity score matching we have shown that participation in supermarket channels improves farm productivity by 35-38%. Effects on technical efficiency are positive but not statistically significant. Beyond the empirical findings, we have extended the efficiency and productivity literature by using the meta-frontier framework for impact analysis, combining it with statistical matching techniques to address problems of selection bias. We are not aware of any previous study using such an approach.

Kenya is only one example where supermarkets and other high-value market developments are transforming agricultural supply chains in developing countries. Therefore, this research has wider policy implications. Understanding the repercussions of the agri-food system transformation is crucial, as supermarket developments gradually spread to a wider geographical area. Our results suggest that high-value supply chains can contribute to technological

innovations, leading to productivity gains in smallholder agriculture, which are so important for poverty reduction and rural development in Africa. This does not preclude the possibility that particularly disadvantaged farmers are bypassed or that transforming agri-food systems may also entail problems associated with increasing industry concentration. Since modernization in supply chains and a growing role of supermarkets in food retailing will happen anyway, it is important to understand the development potentials and implement policies to harness these potentials while avoiding undesirable social consequences.

5. Supermarkets, farm household income, and poverty

Beyond productivity effects analyzed in chapter 4, the expansion of supermarkets in developing countries may have far-reaching consequences for poverty and rural development. The productivity effects shown in chapter 4 can yield even greater benefits for households due to stable and often higher prices offered by supermarkets. These dynamics could lead to higher incomes for farm households and significant reduction in poverty. While previous studies have compared farm profits between participants and non-participants in supermarket channels, wider household welfare effects have hardly been analyzed. Moreover, structural differences between the two groups have been ignored. In this chapter, we address these issues by using endogenous switching regression approach. Participation in supermarket channels shows significant effect on per capita household income, leading to significant poverty reduction.

5.1. Introduction

The share of supermarkets in developing country food retailing has increased significantly in the recent past (e.g., Mergenthaler *et al.*, 2009b; Neven *et al.*, 2006; Reardon *et al.*, 2003). This is affecting food consumers, but it also has far-reaching consequences for agricultural producers, because supermarket procurement channels are more integrated than traditional supply chains and have higher requirements in terms of product quality and consistency. Especially for perishable products, supermarket procurement often involves contractual arrangements with farmers. From a development policy perspective, it is particularly important to understand how

poor rural households are affected. For farmers, participation in supermarket channels might be associated with market assurance as well as stability in volumes and prices, potentially entailing rising incomes. However, technical constraints and market imperfections might also lead to smallholder exclusion, which could result in increasing disparities and marginalization.

There is a growing body of literature analyzing such aspects in various developing countries (e.g., Neven & Reardon, 2004; Pingali *et al.*, 2007; Reardon *et al.*, 2009). Different studies have examined determinants of farmer participation in supermarket channels (Hernandez *et al.*, 2007; Moustier *et al.*, 2010; Neven *et al.*, 2009). There are also a few studies that have tried to assess economic effects by comparing gross margins for specific crops that are either supplied to supermarkets or traditional channels (Hernandez *et al.*, 2007; Neven *et al.*, 2009). While such comparisons may provide an indication of income effects, differences cannot be interpreted as net impacts of supermarket participation, because there may be other factors influencing the outcome that are not controlled for. Furthermore, simple gross margin analysis does not account for possible resource reallocation between different economic activities within the household occasioned by supermarket participation. To our knowledge, there are no previous studies that have looked more comprehensively into the impacts of supermarkets on household income and implications for poverty, as we do in this article.

A related strain of literature focuses on modernizing export supply chains for high-value foods and the increasing role of standards in international trade (Asfaw *et al.*, 2009; Asfaw *et al.*, 2010; Bolwig *et al.*, 2009; Maertens & Swinnen, 2009; Minten *et al.*, 2009; Miyata *et al.*, 2009; Warning & Key, 2002; Wollni & Zeller, 2007). Some of these studies also look at income and poverty effects in the small farm sector, mostly building on standard treatment models that account for non-random sample selection. This strain of literature is very relevant for our work,

because the conditions in high-value export chains are often similar to those in supermarket channels. However, standard treatment models assume uniform impacts across different groups, whereas recent evidence suggests that there may be systematic differences between farmers supplying supermarkets and their counterparts in traditional channels (Hernandez *et al.*, 2007; Neven *et al.*, 2009). Household income structures are therefore likely to differ systematically, especially if participation in supermarket channels is determined by the same factors that affect income. In that case, assuming uniform impacts conceals inherent interaction between market channel choice and other factors influencing income, potentially leading to spurious conclusions.

We address these issues by using an endogenous switching regression model that treats marketing channels as regimes and thus allows for structural differences in income functions between farmers supplying supermarkets and traditional channels. Similar models have been used in other studies related to agriculture (e.g., Fuglie & Bosch, 1995), including for production function estimates in the context of supermarket developments (Hernandez *et al.*, 2007). We refine and extend the approach such that net household income and poverty effects of supermarket participation can be estimated. The empirical research builds on primary household level data from a survey of vegetable farmers in central Kenya. Even though the overall share of supermarkets in vegetable retailing is still relatively small in Kenya, it is increasing rapidly (Neven & Reardon, 2004). Similar trends are also observed in other countries of Africa. Since many African smallholders are involved in horticultural production, there may be important effects for rural welfare and poverty.

The chapter proceeds as follows. In the next section, we present the analytical framework and estimation procedure. In section 5.3, we describe the data and undertake some descriptive

analyses, while in section 5.4 we present and discuss the estimation results. Section 5.5 provides some concluding remarks regarding analysis of this chapter.

5.2. Analytical framework and estimation procedure

Participation in supermarket channels can be viewed as a binary choice decision problem by farm households that try to maximize utility or net returns.[7] Utility is determined by a set of variables *Z*, which influence the ability and the cost of adjusting to a market option with new requirements (such as acquiring information and implementing new market standards). Variables in *Z* also determine the relative returns that a farmer can earn from supermarket and traditional market channels. Thus, *Z* can include farm, household, and contextual characteristics such as assets, measures of human capital, income sources, credit access, and other variables capturing farmers' risk attitudes. Specific determinants of transaction costs, such as physical infrastructure and transportation costs, can also affect household marketing preferences and opportunities (Dorward, 2001).

The probability that farmers participate in supermarket channels is therefore determined by a comparison of the expected utility of participation, I_s^*, against the expected utility of supplying traditional markets, I_t^*. In making this comparison farmers evaluate both the benefits and costs of adjustment. Farmers will participate in supermarket channels only if $I_s^* > I_t^*$, implying that the potential benefits outweigh the constraints. However, I_s^* and I_t^* are latent variables; what is

[7] The term "binary choice" does not imply that participation is solely determined by farmers' preferences. Supermarkets prefer to work with producers who can supply reliably and efficiently, so that farmers' access and institutional constraints also play important roles. As access is also determined by socioeconomic variables, this is captured in the model.

observed is actual participation in supermarket channels, I, with $I = 1$ if $I_s^* > I_t^*$ and $I = 0$ if $I_s^* \leq I_t^*$. Participation in supermarket channels can therefore be represented as follows:

$$I = Z\alpha - v \tag{5.1}$$

where α is a vector of parameters, and v is an error term with zero mean and variance σ^2. Since farmers are heterogeneous in their characteristics, not all of them will participate in supermarket channels. For those who do, participation is expected to result in higher farm returns and household incomes.

5.2.1. Modeling income effects

Household income is determined by various socioeconomic factors. For farm households, income is usually influenced by returns from agricultural production, which depend on asset ownership and capacity to produce and market efficiently. Hence, participation in certain market channels may directly influence household income. We hypothesize that supermarket channel participation has an important positive effect on household income, due to market assurance, higher and more stable output prices, and better access to inputs and technologies. In order to evaluate income effects, we build on a model commonly used in the impact assessment literature:

$$y = X\beta + \gamma I + u \tag{5.2}$$

where y is household income, X is a vector of farm, household, and contextual characteristics, and I is the participation dummy. Thus, the coefficient γ captures the impact of supermarket participation on household income. However, because farmers self-select into the group of

participants, this coefficient may be biased. Especially when more efficient farmers, whose incomes are higher anyway, are more likely to participate in supermarket channels, the income effect would be overestimated. In order to correct for such bias, Heckman selection or instrumental variable approaches could be used. Yet, these approaches still assume that the income functions would differ only by a constant term between participants and non-participants. In reality, differences between the groups may be more systematic, that is, there may be interactions between marketing channel choice and the other income determinants captured in *X*. Maertens & Swinnen (2009) have used propensity score matching, which can deal with structural differences, but only to the extent that these differences are based on observables. When there are unobserved factors that simultaneously influence farmers' marketing decisions and household incomes, such as individual skills, ability, or motivation, then propensity score matching may still result in biased estimates.

An approach that can account for systematic differences across groups is switching regression (Maddala, 1983). A switching regression model treats market channels as regime shifters; this can be represented as follows:

$$\begin{aligned} y_s &= X\beta_s + u_s \\ y_t &= X\beta_t + u_t \\ I^* &= Z\alpha - v \end{aligned} \tag{5.3}$$

where y_s and y_t represent household income for supermarket and traditional channel suppliers, respectively, and I^* is a latent variable determining which regime applies. β_s and β_t are sets of parameters to be estimated. While the variable sets X and Z are allowed to overlap, proper identification requires that at least one variable in Z does not appear in X. Note that in a cross-section sample y_s and y_t are only partially observed: y_s is only observed for the subsample of

supermarket suppliers, and y_t for the subsample of farmers supplying traditional channels. What is totally observed is a single variable y_i defined as follows:

$$y_i = \begin{cases} y_s & \text{if } I^* > 0 \\ y_t & \text{if } I^* \leq 0 \end{cases} \text{ and } I = \begin{cases} 1 & \text{if } I^* > 0 \\ 0 & \text{if } I^* \leq 0 \end{cases} \tag{5.4}$$

In equation (5.3), u_s, u_t, and v are residuals that are only contemporaneously correlated; they are assumed to be jointly normally distributed with a mean vector 0, and covariance matrix as follows:

$$\Sigma = \begin{pmatrix} \sigma_s^2 & \sigma_{st} & \sigma_{sv} \\ \sigma_{st} & \sigma_t^2 & \sigma_{tv} \\ \sigma_{sv} & \sigma_{tv} & \sigma^2 \end{pmatrix} \tag{5.5}$$

where $var(u_s) = \sigma_s^2$, $var(u_t) = \sigma_t^2$, $var(v) = \sigma^2$, $cov(u_s, u_t) = \sigma_{st}$, $cov(u_s, v) = \sigma_{sv}$, and $cov(u_t, v) = \sigma_{tv}$. The variance of v is set to one, since α is estimable only up to a scale factor (Greene, 2008; Maddala, 1986). In addition, $\sigma_{st} = 0$, since y_s and y_t are never observed together.

The switching model outlined so far accounts for observed systematic differences between farmers in the two market channels. When there are unobserved factors that matter, there will be correlation between the error terms of the regime equations and the selection equation. Estimates of the covariance terms can therefore provide a test for endogeneity. If $\sigma_{sv} = \sigma_{tv} = 0$, there is exogenous switching, but if either σ_{sv} or σ_{tv} is non-zero, then we have a model with endogenous switching (Maddala, 1986). The test is achieved by testing for significance of the correlation coefficients between u_s and v (ρ_{sv}) computed as $\sigma_{sv}/\sigma_s\sigma_v$, and between u_t and v (ρ_{tv}) computed as $\sigma_{tv}/\sigma_t\sigma_v$ (Lokshin & Sajaia, 2004). Using these correlations, the expected values of the truncated error terms can be expressed as follows:

$$E(u_s|I=1) = E(u_s|v > Z\alpha) = -\sigma_{sv}\frac{\emptyset(Z\alpha/\sigma)}{\phi(Z\alpha/\sigma)} = -\sigma_{sv}\lambda_s \quad (5.6)$$

$$E(u_t|I=0) = E(u_t|v \leq Z\alpha) = \sigma_{tv}\frac{\emptyset(Z\alpha/\sigma)}{1-\phi(Z\alpha/\sigma)} = \sigma_{tv}\lambda_t \quad (5.7)$$

where $\emptyset$ and Φ are the probability density and cumulative distribution function of the standard normal distribution, respectively. Hence, λ_s and λ_t are the Inverse Mills Ratios (IMRs) evaluated at $Z\alpha$ (Greene, 2008).

Besides providing a test for endogeneity, the signs of ρ_{sv} and ρ_{tv} have economic interpretation. If ρ_{sv} and ρ_{tv} have alternate signs, then farmers choose supermarket channels based on their comparative advantage (Fuglie & Bosch, 1995; Maddala, 1983). Thus, if $\rho_{sv} < 0$, farmers with above average incomes in supermarket channels have a higher likelihood of participating in these channels. Similarly, if $\rho_{tv} > 0$, farmers with above average incomes in traditional channels have a lower likelihood of participating in supermarket channels. Alternatively, if ρ_{sv} and ρ_{tv} have the same sign, then there is evidence of "hierarchical sorting" (Fuglie & Bosch, 1995), implying that supermarket suppliers have above average incomes in both channels but are better off in supermarket channels. Similarly, traditional market suppliers have below average incomes in both channels but are better off in traditional channels. Interpretation of the covariance terms also provides proof of model consistency, which requires that $\rho_{sv} < \rho_{tv}$ (Trost, 1981). This condition also implies that supermarket suppliers earn higher incomes than they would earn if they supplied traditional channels.

5.2.2. Estimation procedure

When there is correlation between the error terms in equations (5.6) and (5.7), a two-stage method can be used to estimate the model. A first-stage probit provides estimates of α , based on

which the IMRs can be calculated. The IMRs are then included in estimating the regime equations in (5.3) in the second stage, and the resulting IMR coefficients provide estimates of σ_{sv} and σ_{tv}. However, since the IMRs are estimated, u_s and u_t cannot be used to calculate standard errors of the second-stage estimates (Fuglie & Bosch, 1995; Maddala, 1983).[8] A more efficient approach is the full information maximum likelihood (FIML) method for endogenous switching regression, which jointly estimates the selection and regime equations (Greene, 2008; Lokshin & Sajaia, 2004). The FIML approach is followed here.

Note that the coefficients β_s and β_t in equation (5.3) measure the marginal effects of the independent variables on household income *unconditional* on farmers' actual market choice, i.e. the effect of *X* on the respective subsample. Yet, if there are variables that appear both in *X* and *Z*, the coefficients can be used to estimate conditional effects as follows:

$$\frac{\partial E(y_s|I=1)}{\partial X_j} = \beta_{sj} - \alpha_j \sigma_{sv} \frac{\emptyset(Z\alpha/\sigma)}{\phi(Z\alpha/\sigma)} \left[Z\alpha/\sigma + \frac{\emptyset(Z\alpha/\sigma)}{\phi(Z\alpha/\sigma)} \right] \quad (5.8)$$

Equation (5.8) decomposes the effect of change in X_j into two parts: β_{sj} is the direct effect on the mean of y_s ; the second part is the indirect effect from market choice that appears as a result of correlation between the unobserved component of y_s and *I*.

5.2.3. Estimating the income effect of supermarket participation

In order to evaluate the income effect of participation in supermarket channels, we need to estimate the conditional expectation of income that participants would have without participation

[8] A procedure for deriving consistent standard errors is provided by Maddala (1983, pp. 223-228), but the adjustment is cumbersome because the correct variance-covariance matrix of the estimates is complicated (Lee, 1978).

in supermarket channels (Maddala, 1983). The evaluation proceeds as follows. First, for a farmer with characteristics *X* and *Z* who participates in supermarket channels, the expected value of income is:

$$E(y_s|I = 1) = X\beta_s - \sigma_{sv}\lambda_s \quad (5.9)$$

where the last term ($\sigma_{sv}\lambda_s$) takes into account sample selectivity, i.e. that a farmer who supplies supermarkets may be different from an average farmer with characteristics *X* and *Z* due to unobserved factors (Fuglie & Bosch, 1995). For the same supermarket farmer, the expected income had he chosen to supply traditional channels would be (Maddala, 1983, pp. 257-260):

$$E(y_t|I = 1) = X\beta_t - \sigma_{tv}\lambda_s \quad (5.10)$$

The change in income due to participation in supermarket channels can then be calculated as (Fuglie & Bosch, 1995; Maddala, 1983):

$$E(y_s|I = 1) - E(y_t|I = 1) = X(\beta_s - \beta_t) + (\sigma_{tv} - \sigma_{sv})\lambda_s \quad (5.11)$$

In the impact assessment literature, this is called the average treatment effect on the treated, which controls for all other possible causes of income differences.[9] This treatment effect on the treated is due to the differences in the coefficients in equations (5.9) and (5.10). If self-selection is based on comparative advantage, $\sigma_{tv} - \sigma_{sv}$ would be greater than zero, and supplying supermarkets would produce bigger benefits under self-selection than under random assignment (Maddala, 1983). In that case, simple comparison of mean income of farmers in the two

[9] Note that the unobserved factors are not ignored since λ_s remains in both equations (5.9) and (5.10). The procedure simply implies that the unobserved factors have different effects depending on which regime applies. By holding λ_s constant and taking the differences in effects ($\sigma_{tv} - \sigma_{sv}$), we cancel out effects of unobserved factors, so that the estimated income difference is purely due to market channels, devoid of any unobserved effects.

channels, i.e. $E(y_s|I=1)$ versus $E(y_t|I=0)$, would lead to an upward bias of the treatment effect, which is controlled for in equation (5.11).

5.3. Descriptive analysis

Data for this study was collected in 2008 through a survey of vegetable farmers in Kiambu District, Central Province of Kenya. Kiambu is relatively close to Nairobi, where most of the country's supermarkets can be found. But also before the spread of supermarkets, this district was one of the main vegetable-supplying areas for the capital city. Based on information from the District Agricultural Office (DAO), four of the main vegetable-producing divisions were chosen. In these four divisions, 31 administrative locations were purposively selected, again using statistical information on vegetable production. Within the locations, vegetable farmers were sampled randomly. Since farmers who participate in supermarket channels are still the minority, we oversampled them using complete lists obtained from supermarkets and supermarket traders. In total, our sample comprises 402 farmers – 133 supermarket suppliers and 269 traditional channels suppliers.

Using a structured questionnaire, these farmers were interviewed eliciting information on vegetable production and marketing, other farm and non-farm economic activities, as well as household and contextual characteristics. Both types of farmers produce vegetables in addition to maize, bananas, and other cash crops. The main vegetables produced are leafy types, including exotic ones such as spinach and kale, and indigenous ones such as *amaranthus* and black nightshade, among others.[10] Farmers were asked to list all market channels for vegetables that

[10] Recently, African indigenous vegetables have received renewed attention from upper and middle income consumers (Ngugi *et al.*, 2007).

they participate in, and rank them by individual sales proportions. The channels reported can be categorized into traditional channels on the one hand, and supermarket channels on the other.[11] Traditional channels include direct sales to consumers, spot market sales to wholesalers, and sales to traditional traders at the farm gate, whereas supermarket channels involve either direct sales to modern retailers or sales through specialized supermarket traders. While some farmers sell vegetables in both categories, all supermarket suppliers ranked supermarkets as their major market channel. For analytical purposes, farmers are therefore classified into supermarket and traditional channel suppliers.

In traditional channels, spot market trading often involves one-off transactions between farmers and wholesalers/traders with neither promise for repeated transactions nor prior agreements on product delivery or price. Depending on the demand and supply situation, prices are subject to wide fluctuation. In contrast, supermarkets have agreements with vegetable farmers regarding product price, physical quality and hygiene, and consistency and regularity in supply (Ngugi *et al.*, 2007). Price agreements are made before delivery, and prices are relatively stable. Payments are usually only once a week or every two weeks. All agreements are verbal with no written contract.[12] Supermarket traders have similar verbal agreements and regular contacts with farmers, in order to be able to supply supermarkets in a timely and consistent way. Strict supply

[11] While in some other parts of Kenya, high-value vegetable exports are important (Asfaw *et al.*, 2009), this is not the case in Kiambu district. In fact, none of our sample farmers reported producing vegetables for export.

[12] The supermarkets have lists of farmers from whom they buy, and they also keep written records of the transactions made. But there is usually no written contract that farmers have to sign.

requirements by supermarkets have led to specialization among traders. Consequently supermarket traders tend to exclusively supply modern retail outlets.[13]

Given the risk of exclusion from emerging modern supply chains, there are various organizations in Kenya trying to link smallholders to supermarket and export channels. One such organization active in Kiambu is the NGO Farm Concern International (FCI). FCI trains farmers and farmer groups on production of indigenous vegetables before linking them to various supermarkets in Nairobi (Ngugi *et al.*, 2007). FCI also promotes collective action and – through training efforts – helps farmers to meet the strict delivery standards imposed by supermarkets. Our sample covers 80 vegetable farmers currently involved in the FCI project. Out of these, more than half were already supplying supermarkets at the time of our survey.

5.3.1. Descriptive analysis

Table 5.1 shows descriptive statistics for the two groups of farmers. There are significant differences with respect to some of the variables. On average, supermarket suppliers own more land and cultivate larger areas of vegetables. They also tend to be somewhat more specialized on vegetable production and have a higher tendency to use advanced irrigation technology such as sprinklers or drip irrigation. There are also significant differences with respect to education levels and participation in off-farm employment. Better educated vegetable growers and those that have off-farm employment are more likely to supply supermarkets. Significantly more of the

[13] Initially, supermarkets in Kenya purchased fresh vegetables in traditional wholesale markets, which can still be observed today. However, supermarkets have diversified their procurement to include contracted farmers and traders, in order to ensure price stability and consistency in quality and supply.

supermarket suppliers also have own means of transportation and access to public transportation. This gives them an advantage in supplying supermarkets that demand stricter delivery schedules.

Table 5.1: General differences between supermarket and spot market suppliers

	Supermarket (n=133)		Traditional market (n=269)	
Variables	Mean	SD	Mean	SD
Gender of operator *(male dummy) (%)*	93.2	25.2	88.1	32.4
Total area owned *(acres)*	2.692**	5.607	1.870	2.485
Total vegetable area cultivated *(acres)*	1.168***	1.457	0.697	0.992
Ownership of livestock *(%)*	83.4	37.2	80.7	48.1
Share of vegetable area *(%)*	68.8*	31.9	62.8	32.5
Use of advanced irrigation technology *(%)*	87.9***	32.7	71.4	45.3
Age of operator *(years)*	47	12	49	15
Education of operator *(years of schooling)*	10.3***	3.14	8.72	4.05
Household size *(number of people)*	4	2	3	2
Household access to public piped water *(%)*	29	46	38	49
Own means of transportation *(%)*	24.1**	42.9	8.9	28.6
Availability of public transport in village *(%)*	88.7**	31.8	79.9	40.1
Proximity to tarmac road *(%)*	48.9	50.2	52.4	50.0
Credit accessed in the last 12 months *(%)*	10.5	30.8	9.7	29.6
General farming experience *(years)*	16.16**	11.60	17.89	13.33
Participation in FCI market linkage *(%)*	34.6***	47.7	12.6	33.3
Off-farm employment of farmer (%)	61***	47	43	50

*, **, *** Mean values are significantly different at 10%, 5%, and 1% level, respectively

Source: Own data

In table 5.2 we compare vegetable gross margins between farmers in the two market channels. There are significant differences both in revenues and production costs. Revenue differences are due to higher yields obtained by supermarket suppliers and also higher mean prices. In terms of costs, supermarket suppliers spend significantly more on hired labor. Part of the additional labor demand is due to the fact that supermarkets often require farmers to pack or bundle the vegetables into certain units (Neven *et al.*, 2009). Hence, supermarket procurement channels are employment generating in rural areas. On the other hand, farmers supplying supermarkets use

slightly less inorganic fertilizer. Instead, they use more farmyard manure, which adds organic matter to the soil and – according to their own statements – entails a quicker regeneration of the leaves after harvest. This is important, because in supermarket channels vegetables have to be supplied on a regular basis.

Table 5.2: Gross margin differences between supermarket and spot market suppliers

	Supermarket (n=133)		Traditional market (n=269)	
	Mean	SD	Mean	SD
Gross revenue *(Ksh/acre)*	116,636***	129,370	73,179	60,136
Seed cost *(Ksh/acre)*	2,175	5,428	1,660	3,021
Hired labor cost *(Ksh/acre)*	6,330**	10,019	4,722	7,481
Fertilizer cost *(Ksh/acre)*	4,846*	7,485	5,781	6,379
Purchased manure cost *(Ksh/acre)*	8,666***	14,099	5,712	8,751
Pesticide cost *(Ksh/acre)*	1,104	1,922	1,179	1,835
Other cost *(Ksh/acre)*	1,271**	4,723	623	2,167
Gross margin *(Ksh/acre)*	**92,244*** **	**114,202**	**53,502**	**54,677**
Value of family labor *(Ksh/acre)*	9,775**	21,297	13,951	16,570
Value of own manure *(Ksh/acre)*	2,520	7,253	2,687	7,575
Gross margin less value of own resources *(Ksh/acre)*	**79,950*** **	**112,246**	**36,865**	**54,004**

*, **, *** Mean values are significantly different at 10%, 5%, and 1% level, respectively.

Note: 1US dollar = 75

Source: Own data

The differences in revenues and costs result in significantly higher gross margins for supermarket suppliers. This picture also remains when additionally subtracting the imputed value of household own resources such as family labor and own farmyard manure. Positive gross margin differences occur across the entire distribution, as can be seen in figure 5.1. The gross margin cumulative distribution function (CDF) for supermarket suppliers significantly dominates the CDF for traditional market suppliers.

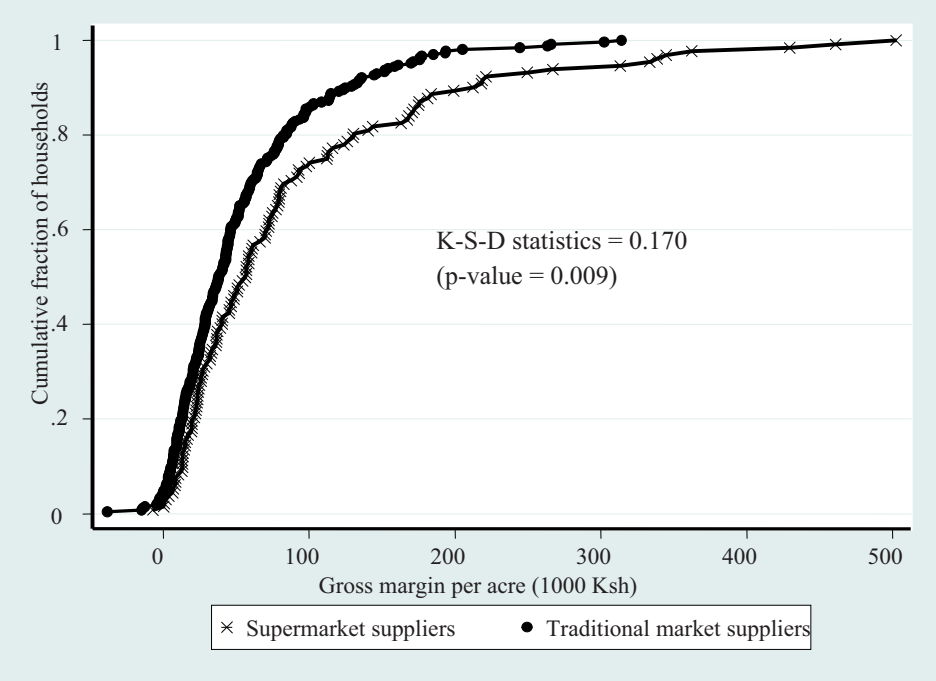


Figure 5.1: Cumulative distribution of gross margin by market channel

Note: The Kolmogorov-Smirnov test statistic indicates statistical difference between two distributions.

Source: Own data

Yet, gross margins for one particular farm enterprise can only provide a partial picture of income effects. For instance, higher vegetable gross margins may be realized by reallocating resources from other important economic activities, so that the focus on vegetables alone may be misleading. We therefore also look at total household income, which includes farm income (total revenue from all farm enterprises less operational costs) and off-farm income (salaries, wages, profits from off-farm enterprises and transfers for all household members). As can be seen in figure 5.2, farm, off-farm, and total incomes expressed in *per capita* terms are notably higher for supermarket suppliers than for households supplying vegetables to traditional channels. Figure 5.3 shows that the income CDF of supermarket suppliers clearly dominates that of traditional market suppliers, both in terms of total and *per capita* household incomes. While these

differences cannot be interpreted as impacts, they provide an indication that there may indeed be structural differences in household incomes between supermarket and traditional channel suppliers.

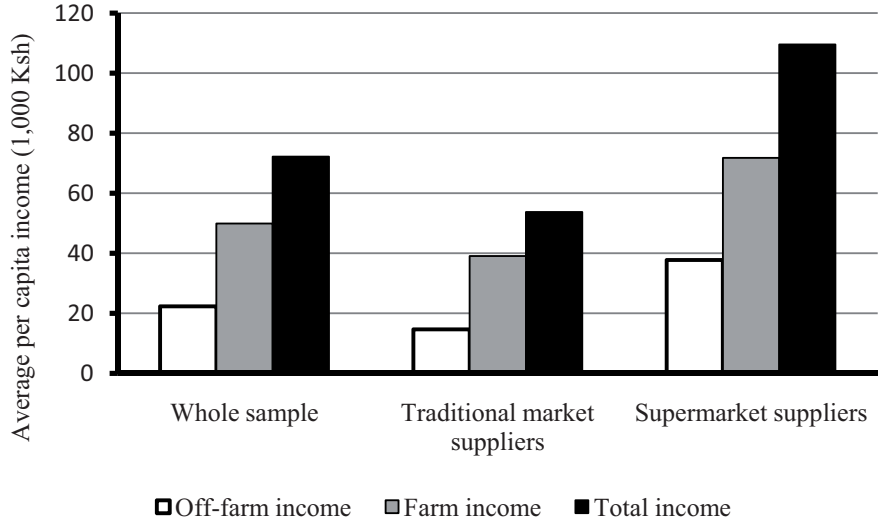


Figure 5.2: Average annual per capita income by market channel

Source: Own data

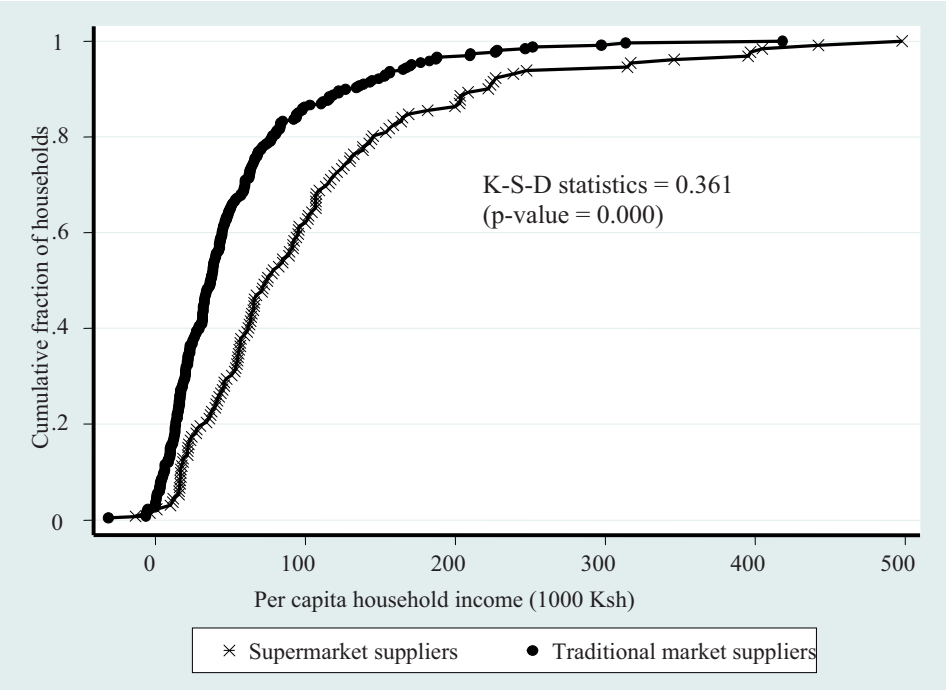


Figure 5.3: Cumulative distribution of household income by market channel

Note: The Kolmogorow-Smirnov test statistic indicates statistical difference between two distributions.

Source: Own data

Superior incomes also translate into lower poverty rates among supermarket suppliers, as can be seen in figure 5.4. Poverty incidences were calculated based on 1.25 dollar and 2 dollar a day poverty lines for extreme and moderate poverty, respectively. These poverty lines were converted to local currency equivalents using purchasing power parity (PPP) exchange rates. The PPP exchange rate was 1 dollar to 29.52 Kenyan shillings in 2005 (IBRD, 2008). This was updated to current rates using the consumer price index. Compared to the rest of the country, poverty rates in Kiambu are relatively low; in fact, Kiambu District is one of the least poor rural districts in Kenya.

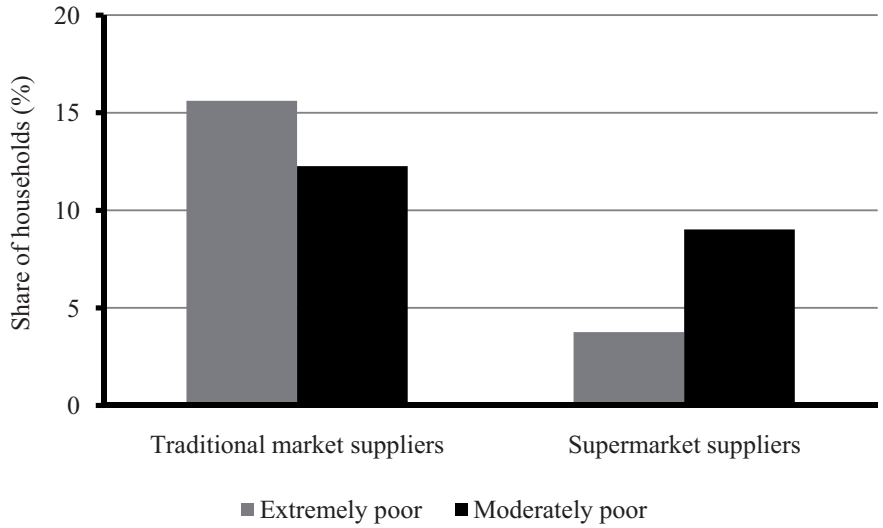


Figure 5.4: Incidence of poverty by market channel

Source: Own data

5.4. Econometric analysis

The descriptive analyses in the previous section revealed significant differences in vegetable gross margins and household incomes between supermarket and traditional channel suppliers. Yet, to properly analyze impacts we need econometric approaches. As outlined in section 5.2, we apply an endogenous switching regression model to estimate income effects of participation in supermarket channels. The income equations are estimated jointly with the selection equation that explains farmers' participation in supermarket channels. Since supermarket farmers were purposely oversampled, we used sampling weights for all estimates, building on information from the DAO regarding the share of supermarket farmers in Kiambu District. In the following, we first discuss the results on the determinants of participation, before focusing on income and poverty effects.

5.4.1. Determinants of participation in supermarket channels

Alongside typical farm, household, and contextual characteristics we hypothesize that institutional support through FCI influences farmers' access to supermarket channels. Therefore, we include participation in the FCI market linkage program as an additional explanatory variable – defined as a dummy. Yet, participation in that program might potentially be endogenous, which would lead to a bias in the coefficient estimate. We test for endogeneity of the FCI dummy employing a two-stage approach developed by Rivers and Vuong (1988) and detailed in Wooldridge (2002). In the first stage, we run a probit regression with the FCI dummy as dependent variable, using membership in a farmer group, as an instrument. As FCI prefers to work with farmer groups, group membership is correlated with the FCI dummy, although there are also some farmers in the FCI program who do not belong to a farmer group. On the other hand, group membership is not correlated with supermarket channel participation.[14] In the second stage, we run a probit with supermarket participation as dependent variable, including predicted residuals from the first-stage probit as an additional explanatory variable. The *t*-statistics for the coefficient of this residual term provides a valid test for the null hypothesis that the FCI variable is exogenous (Wooldridge, 2002, p. 474). The test fails to reject the null hypothesis (see table A1 in Appendix A for details).

The first column of table 5.3 shows results of a normal probit, estimated independently, while the second column shows the probit model that is jointly estimated with the income equations using the FIML method, as detailed above. Participation in supermarket channels significantly depends

[14] The correlation coefficient between group membership and FCI is $\rho = 0.474$ ($p = 0.000$), while between group membership and supermarket channel participation it is $\rho = 0.062$ ($p = 0.219$).

on the farmer's education and age. Better educated farmers are more likely to participate in supermarket channels. This is plausible, because education helps farmers to better adjust to the new production and market requirements. In general, better educated farmers tend to be more innovative and therefore more likely to participate in emerging supply chains. Older farmers are also more likely to participate in supermarket channels, which may be related to longer experience. Yet the negative and significant coefficient for the square term of age indicates that there is an inverse U-shaped relationship, implying that beyond a certain age farmers become less innovative again.

Table 5.3: Probit model for determinants of participation in supermarket channel

	Independent probit		Jointly estimated probit [a]	
Variables	Coefficient	SE	Coefficient	SE
Gender of operator *(male dummy)*	0.353	0.282	0.278	0.285
Education of operator *(years)*	0.067***	0.023	0.070***	0.024
Age of operator *(years)*	0.152***	0.037	0.196***	0.048
Age of operator squared *(years)*	-0.002***	0.000	-0.002***	0.001
Household size *(number of people)*	-0.185***	0.045	-0.207***	0.056
Off-farm employment *(dummy)*	0.378***	0.138	0.340**	0.137
Total area owned *(acres)*	0.079**	0.034	0.076**	0.037
Use of advanced irrigation technology *(dummy)*	0.112	0.200	0.178	0.186
Ownership of livestock *(dummy)*	0.010	0.180	0.135	0.196
Household access to electricity *(dummy)*	0.095	0.218	0.018	0.220
Own means of transportation *(dummy)*	0.811***	0.249	1.078**	0.488
Availability of public transportation in village *(dummy)*	0.418*	0.218	0.611**	0.264
Proximity to tarmac road *(dummy)*	-0.042	0.152	-0.058	0.153
Household access to public piped water *(dummy)*	-0.260*	0.145	-0.198	0.145
Credit accessed in the last 12 months *(dummy)*	0.026	0.313	0.171	0.332
Participation in FCI market linkage program *(dummy)*	1.020***	0.243	1.084***	0.282
Limuru region *(dummy)* [b]	-0.670	0.472	-0.824*	0.491
Kikuyu/Westland region *(dummy)* [b]	1.007**	0.442	0.924**	0.442
Githunguri and Lower Lari region *(dummy)* [b]	0.467	0.466	0.252	0.508
Constant	-3.382***	0.997	-4.401***	1.225
Number of observations		*402*		*402*

Note: This selection equation is jointly estimated with income regime model whose results are shown in table 5.4.

*, **, *** Significant at the 10%, 5%, and 1% level, respectively.

[b] The reference region is Lari.

Source: Own data

Farmers who are engaged in off-farm employment are more likely to participate in supermarket channels. This could be due to certain capital investments necessary for participation, which are facilitated through off-farm earnings, especially when there are credit constraints. Furthermore, off-farm income helps to ensure short-term liquidity against the background of lagged supermarket payment schedules. Ownership of land also has a significantly positive, albeit relatively small, effect on the likelihood of supermarket participation. Obviously, larger farms are at a certain advantage, which may be due to fixed transaction costs in supermarket channels,

such as transportation and information search costs. In a similar fashion, ownership of a means of transportation and availability of public transportation in the village increase the likelihood of participation. This is plausible because – unless there are specialized traders – farmers have to deliver their produce themselves to the supermarket locations. These results underscore that infrastructure, which is key for linking farmers to markets in general, is equally important in the context of emerging modern supply chains.

Finally, institutional support by FCI has a positive and significant influence on supermarket participation. FCI negotiates with supermarkets on behalf of farmers. The NGO also facilitates farmer collective marketing approaches and offers training on production techniques and special supermarket requirements. These activities reduce transaction costs and contribute to making smallholder farmers more reliable trading partners for supermarkets. Equally important is the so-called invoice discounting service, that is, FCI anticipates payments to farmers when they present a supermarket delivery receipt; in that case, supermarkets later pay FCI instead of farmers directly. This mechanism enables even relatively poor households with immediate cash needs to participate in supermarket channels, despite the lagged payment schedule. These are important findings with a view to designing institutional support programs to better link smallholders to high-value markets.

5.4.2. Determinants of household income

As described in section 5.2, we explain household income in supermarket and traditional channels with the help of an endogenous switching model, results of which are presented in table 5.4. To properly identify the model, two variables in the probit model – namely the FCI dummy

and availability of public transportation in the village – are excluded from the income function. It was tested that these variables do not affect household income directly.[15] For comparison, we show results of the two-stage estimation approach in the Appendix A (table A2), with coefficient estimates in a similar range. However, we prefer the results in table 5.4, because the FIML approach provides more efficient estimates, as explained in section 5.2.

The results indicate that there are indeed structural differences across the two market channels. For instance, off-farm employment and ownership of a means of transportation have a positive and significant influence on household income in both market channels, but the effects are much bigger among supermarket suppliers. This suggests that supermarket suppliers use off-farm income and own vehicles in a more productive way than their colleagues in traditional market channels. It should be noted that these differences are not due to supermarket participation, since the coefficients shown in table 5.4 represent unconditional effects. Nonetheless, both variables also significantly affect the probability of supermarket participation, which is an indication of joint determination of income and market channel choice.[16]

[15] FCI is correlated with participation in supermarket channels (ρ = 0.259; p = 0.000) and uncorrelated with household income (ρ = -0.007; p = 0.897). Availability of public transportation in the village is correlated with participation in supermarket channels (ρ = 0.110; p = 0.028) and uncorrelated with household income (ρ = 0.041; p = 0.412).

[16] Off-farm employment and own means of transportation could potentially be endogenous in the income model. Unfortunately, we could not identify appropriate instruments for these variables. We also do not have lagged values, which could possibly help. We therefore estimated several additional models, in which we dropped potentially endogenous variables. These additional models did not lead to changes in the main findings, as we explain further below (also see Appendix A table 0.3).

Table 5.4: Full information maximum likelihood parameter estimates for household income

	Supermarket suppliers		Traditional market suppliers	
Variables	Coefficient	SE	Coefficient	SE
Gender of operator *(male dummy)*	14.031	25.542	11.775	10.163
Education of operator *(years)*	2.182	2.474	1.322	0.877
Age of operator *(years)*	0.749	0.754	-0.144	0.257
Household size *(number of people)*	-8.610	6.055	-1.789	1.798
Off-farm employment *(dummy)*	56.513***	19.413	25.437***	6.421
Total area owned *(acres)*	1.788	1.111	7.235***	2.543
Use of advanced irrigation technology *(dummy)*	14.532	18.008	17.984***	6.165
Ownership of livestock *(dummy)*	14.142	20.867	20.531***	7.614
Household access to electricity *(dummy)*	9.882	21.872	16.748***	5.095
Own means of transportation *(dummy)*	98.950***	33.442	34.481*	19.946
Proximity to tarmac road *(dummy)*	2.954	17.289	5.273	5.239
Household access to public piped water *(dummy)*	-46.028***	16.199	9.353	6.783
Credit accessed in the last 12 months *(dummy)*	-59.075***	20.354	-10.685*	5.848
Limuru region *(dummy)* [a]	112.152**	55.920	11.211	10.648
Kikuyu/Westland region *(dummy)* [a]	-9.395	38.388	5.696	11.718
Githunguri and Lower Lari region *(dummy)* [a]	-35.033	36.402	5.313	11.522
Constant	6.053	57.315	-37.045**	18.389
ln σ_s	4.607***	0.012		
ρ_{sv}	-0.439*	0.241		
ln σ_t			3.853***	0.002
ρ_{tv}			-0.006	0.093
Likelihood ratio test for independent equation χ^2				*3.330**
Number of observations				*402*
Log likelihood				*-2401.445*
F-statistics χ^2				*67.700****

Notes: The dependent variable is annual *per capita* income measured in thousand Ksh. These regime equations are jointly estimated with the selection equation shown in table 5.3.

*, **, *** Significant at the 10%, 5%, and 1% level, respectively.

[a] The reference region is Lari.

Source: Own data

Land ownership influences income positively and significantly only for traditional market suppliers, which is related to larger quantities of agricultural produce, particularly of cash crops, which are usually associated with larger landholdings. The fact that the impact of land is insignificant in the case of supermarket suppliers suggests that these farmers put greater

emphasis on product quality, which is required and more rewarded by supermarkets. Somewhat surprising is that use of advanced irrigation technology is also significant only for traditional channel suppliers. However, as pointed out above, most farmers in supermarket channels use advanced irrigation technology, which is almost a precondition for participation. Hence, the observed variability in this subsample is lower, entailing larger standard errors. Traditional channel farmers who use advanced irrigation technology benefit because they can supply vegetables also during the off-season when prices are generally higher.

Livestock ownership also has a positive and significant impact on household income of traditional channel farmers, while the effect is insignificant among supermarket suppliers. This suggests a higher degree of specialization in vegetable production among supermarket suppliers, which is consistent with the descriptive results presented above. Specialization is possible because of more stable and predictable prices in supermarket channels. Given high seasonal fluctuation in traditional markets for vegetables, many traditional market farmers diversify into dairy activities, because prices of milk remain relatively stable.[17]

The lower part of table 5.4 reports estimates for the covariance terms. The terms have the same sign, which indicates "hierarchical sorting". Hence, supermarket suppliers have above average incomes in both channels but are better off in supermarket channels. The significance of the correlation coefficient (ρ_{sv}) shows that self-selection would be an issue if not controlled for. In particular, farmers with incomes below average for supermarket suppliers have lower than expected chances of participating in supermarket channels. The fact that the covariance estimate for traditional market suppliers is insignificant indicates that, in the absence of supermarket

[17] Stability in milk prices is attributable to substantial government intervention in the milk market (Republic of Kenya, 2002).

participation, there would be no significant difference in average behavior of the two farmer categories caused by unobserved effects. The model fulfils the necessary condition for consistency, namely that $\rho_{sv} < \rho_{tv}$. Supermarket suppliers therefore earn higher incomes than they would earn if they supplied traditional channels. We also show the likelihood ratio test for joint independence of the three equations. The test statistic suggests that there is significant dependence between the selection and two income equations; this is further evidence of endogeneity, which is controlled for in our specification.

5.4.3. Income and poverty effects of supermarket channel participation

We now analyze net income effects of supermarket channel participation as illustrated in equation (5.11). As explained, we calculate the average treatment effect on the treated, that is, building on the results in table 5.4 we compare predicted *per capita* incomes for the subsample of participating households with and without supermarkets, holding all other factors constant. Results are presented in table 5.5, disaggregated for different categories of farmers. Significant positive net income effects can be observed. For the whole subsample of supermarket suppliers, participation produces a net gain of 48% in *per capita* incomes.

Table 5.5: Simulated impact of participation in supermarket channels on income and poverty

	No. of obs.	Without supermarket	With supermarket	Net change (%)
		Annual per capita income (1,000 Ksh)		
All supermarket suppliers	133	73.654	109.280	48***
By land holding				
Supermarket suppliers owning < 1 acre of land	62	52.762	87.963	67***
Supermarket suppliers owning 1-2 acres of land	29	71.001	100.150	41***
Supermarket suppliers owning >2 acres of land	42	106.328	147.046	38***
By poverty status				
Extremely and moderately poor	17	49.851	79.752	60**
Non-poor	116	77.143	113.605	47***
By supply category				
Direct suppliers	96	74.754	112.680	51***
Suppliers through specialized traders	37	70.802	100.451	42***
		Poverty incidence (%)		
Extremely and moderately poor		5	4	-20
Non-poor		95	96	1

*, **, *** The net change (difference between predicted income with and without supermarkets) is significant at the 10%, 5%, and 1% level, respectively.

Source: Own data

The disaggregated results suggest that supplying supermarkets can also lead to improvements in income distribution among the participants. With an average income gain of 67%, small-scale farmers owning less than one acre of land benefit over-proportionally. Likewise, poor households benefit more than non-poor households. These differences can partly be explained by the fact that small and poor farmers tend to engage mostly in subsistence farming; hence, the option to supply supermarkets at more stable prices provides new incentives to commercialize, leading to substantial gains in household income. Another type of disaggregation in table 5.5 shows that farmers who supply supermarkets directly gain more than their counterparts who supply through specialized traders. This is plausible: without intermediaries, a bigger share of the profits accrues to primary producers.

We also use the results to simulate the impact of supermarket participation on the incidence of poverty. For this purpose, the predicted poverty incidence among the supermarket suppliers is compared with and without participation. Results are shown in the lower part of table 5.5. They suggest that supermarket participation reduces the incidence of extreme and moderate poverty by 20%. Since the number of poor households in our supermarket subsample is small, the exact results should be interpreted with caution. Nevertheless, the findings show that supermarket participation can improve household incomes in the small farm sector and contribute to poverty reduction.

As some of the explanatory variables in the estimated models are potentially endogenous and suitable instruments could not be identified for all of them, we carried out a sensitivity analysis. Potentially endogenous variables include off-farm employment, own means of transportation, and credit accessed during the last 12 months. We re-estimated the FIML model by dropping these variables individually and used the alternative results to re-calculate net income effects of supermarket participation. The results of this sensitivity analysis are shown in table A3 in Appendix A. While the exact numerical outcomes vary, the general finding of large net income effects is very robust.

5.5. Conclusion

The expansion of supermarkets in developing countries and the establishment of more integrated procurement systems provide new opportunities for farmers to commercialize and participate in modern high-value supply chains. This offers potentials for income increases in rural areas. Yet there is still uncertainty related to the question whether smallholder farmers can benefit, too.

While recent studies have analyzed some of the implications in various settings, there is hardly any work that has looked at the impact of supermarkets on household income and poverty. In this chapter of our study, we have addressed this research gap by analyzing the situation of vegetable farmers in central Kenya. Building on recent farm household survey data, we have developed and used an endogenous switching regression model, which explains household income, taking account of sample selection and structural differences between participants and non-participants in supermarket channels.

The estimation results show that participation in supermarket channels produces gains in *per capita* household income in a magnitude of 48%. Smaller and poorer farms supplying supermarkets even benefit over-proportionally. Simulations demonstrate that poverty rates among supermarket suppliers are 20% lower than they would be were there no supermarkets. These results are in line with studies that have analyzed income and poverty effects of high-value exports in the vegetable sector of Kenya and other countries in Africa (e.g., Maertens & Swinnen, 2009; McCulloch & Ota, 2002). Our findings therefore suggest that increasing domestic demand for high-value products can expand the income effects that have so far been restricted to high-value exports.

It should be stressed, however, that the income effects analyzed here are average treatment effects on the treated, that is, we have looked at the gains that accrue to those households that participate in supermarket channels. We have not analyzed potential spillovers to households that do not or cannot supply vegetables to supermarkets. Such spillovers can be negative or positive. Negative effects would occur when smallholder farmers in traditional channels were driven out of the market through the expansion of supermarkets that would procure primarily from larger commercial producers. This might potentially also lead to further land concentration. On the

other hand, supermarket developments may entail broader technological and institutional innovation such that farmers in traditional channels could benefit as well, even when they do not supply supermarkets themselves (Schipmann & Qaim, 2010). Furthermore, there may be positive employment effects through commercial farms and processing enterprises in high-value markets hiring in additional labor (Neven *et al.*, 2009). This was also shown in the vegetable export sector (Humphrey *et al.*, 2004; Maertens & Swinnen, 2009; McCulloch & Ota, 2002). Capturing such broader rural development effects is beyond the scope of this study, but remains an important topic for further research.

Policy support can help to guide developments and avoid undesirable social outcomes. Disadvantaged households often face constraints in supplying vegetables to supermarkets. Our analysis has shown that better educated farmers and households with more assets are more likely to be involved in supermarket channels. Moreover, infrastructure and access to transportation are factors that facilitate participation significantly. The positive role of off-farm employment suggests that there may also be credit constraints. Such bottlenecks should be reduced through appropriate institutional innovation.

In the study region in central Kenya, there is an NGO that promotes collective action among farmers, provides training on production techniques and special supermarket requirements, and offers other institutional support. These targeted activities reduce transaction costs and contribute to making smallholder farmers more reliable trading partners for supermarkets. The estimation results confirm that farmers who obtain this NGO support are much more likely to participate in supermarket channels. Hence, such efforts should be scaled up to reach a larger number of farmers and achieve larger geographical coverage. This may involve both new incentives for private activities or also public interventions. In some cases, public-private partnerships have

also proven successful in terms of better linking farmers to high-value markets (Kaganzi *et al.*, 2009; Narrod *et al.*, 2009). For instance, the public sector may provide the physical infrastructure that supports extension and market linkage services offered by private agents.

Kenya is only one example in Africa where supermarkets are gradually transforming agricultural supply chains. Therefore, this research has wider implications. Understanding both the potentials and risks of emerging value chains is crucial, as developments gradually spread to a wider geographical area. Our results suggest that supermarkets can contribute to income growth and poverty reduction in the small farm sector. Yet to realize this potential on a larger scale will necessitate broader infrastructure development as well as targeted institutional support.

6. The supermarket revolution and impacts on agricultural labor markets

The previous two chapters have looked at effects of supermarket participation by farmers on farm productivity and household income. But given the labor intensity of high-value crops, expansion of high-value markets could have considerable implications for agricultural wage employment. However, these impacts have received little attention and even existing analyses apply restricted approaches. In the present study, we apply a flexible double hurdle model to show that farmer participation in supermarket channels not only increases the likelihood of hiring labor but also substantially increases the quantity of labor hired. Given that agricultural wage labor is primarily an activity of low-income households in rural areas, the poor benefit over-proportionally.

6.1. Introduction

Developing countries are experiencing increasing demand for high-value food products and agricultural supply chain modernization, spurred by rapid urbanization, rising incomes, and market liberalization (Mergenthaler *et al.*, 2009b; Reardon *et al.*, 2009). As a result, a supermarket revolution is ongoing, with new opportunities for farmers to integrate into high-value markets (Hernandez *et al.*, 2007; Reardon *et al.*, 2003). These developments may have important implications for agricultural and wider rural growth. There may be direct gains in income that accrue to farm households participating in high-value markets. Additionally, there may be indirect effects to households not directly participating. Negative indirect effects may

also occur if smallholder farmers are excluded and further marginalized through high-value market trends (Neven *et al.*, 2009). Yet there may also be positive indirect effects through innovation spillovers to traditional markets and employment-generating impacts (Neven *et al.*, 2009; Schipmann & Qaim, 2010). Due to their labor-intensive nature, employment-generating effects can be expected especially in high-value fruits and vegetables (Barrientos *et al.*, 2005; Maertens & Swinnen, 2009).

The importance of rural employment and off-farm income has been reviewed in a stream of literature covering various developing countries (e.g., Davis *et al.*, 2009; Maertens, 2009; Oseni & Winters, 2009). Overall, with increasing land and capital constraints, the role of off-farm income is increasing. While agricultural wage income constitutes a fairly small proportion of off-farm income in general, its relative role often increases with decreasing overall household incomes (Kijima *et al.*, 2006; Reardon, 1997). Agricultural employment opportunities arising from the expansion of supermarkets could therefore benefit the poor over-proportionally.

Previous studies on employment effects of high-value agriculture have largely focused on non-traditional exports (Dolan, 2004; Maertens & Swinnen, 2009). Yet, as Neven *et al*. (2009) and Simmons *et al*. (2005) suggest, increasing domestic demand for high-value products may entail new employment opportunities as well. Surprisingly, few studies have attempted to estimate and quantify employment effects of the supermarket revolution. Existing research compares labor demand between farmers in supermarket and traditional channels without controlling for other factors (Neven *et al.*, 2009). Here, we contribute to the literature by estimating labor use models, in order to derive net employment effects of farmers' participation in supermarket channels. To properly account for the decision-making process involved in hiring in labor, we use a double-hurdle model. Results are also disaggregated by gender.

Similar to the previous two chapters, the analysis is based on data from the survey of vegetable farmers in central Kenya – one of the countries experiencing rapid supermarket expansion. Supermarkets already accounted for 20% of food retailing in urban Kenya by 2002 (Neven & Reardon, 2004; Nyoro *et al.*, 2007). The share of fresh fruits and vegetables in supermarket retailing is still relatively low but has been rising rapidly (Neven & Reardon, 2004). These dynamics could produce substantial employment effects, especially when supermarkets gradually spread from the larger cities to smaller cities and towns, as is already observed in parts of Asia and Latin America.

This chapter proceeds as follows. The next section presents the analytical framework and estimation procedure. In section 6.3 we describe the data and show sample descriptive statistics. In section 6.4, we present and discuss the estimation results, before concluding in section 6.5.

6.2. Analytical framework and estimation procedure

Agricultural labor use models have been frequently estimated in the literature, either referring to individual cropping activities or to the farm as a whole (cf. Espey & Thilmany, 2000; Simmons *et al.*, 2005). However, available studies mostly restrict the decision to hire in labor and the decision on use intensity to a single process. Yet there is no *a priori* reason why this should be true, especially in a developing country smallholder context, where market failures are widespread and farm-household decisions are interconnected. Rather, observed demand for hired labor can be expressed as a two-stage decision, involving first the decision on whether or not to hire labor at all, followed by the decision on the exact quantity of labor to hire. The decision to hire labor can be represented as

$$d_i^* = \alpha x_i + u_i; \qquad u_i \sim N(0,1) \tag{6.1}$$

with

$$d_i = \begin{cases} 1 \; if \; d_i^* > 0 \\ 0 \; otherwise \end{cases} \tag{6.2}$$

while the decision on how much labor to hire can be described as

$$y_i^* = \beta z_i + v_i; \quad v_i \sim N(0, \sigma^2) \tag{6.3}$$

with

$$y_i = \begin{cases} y_i^* \; if \; y_i^* > 0 \; and \; d_i = 1 \\ 0 \; otherwise \end{cases} \tag{6.4}$$

Where d_i is a discrete variable measuring whether or not outside labor is hired, and d_i^* is a latent (unobserved) variable for d_i. y_i refers to the observed amount of labor hired, and y_i^* represents the latent variable for y_i. The decision to hire labor and the quantity of hired labor used are influenced by variables x_i and z_i respectively, which are allowed to overlap. Demand for agricultural inputs, including labor, is influenced by factors that can be broadly categorized into farm and household characteristics, market characteristics, and agro-ecological conditions (Xu *et al.*, 2009). We are particularly interested in the effect of supermarket participation on hired labor demand. Therefore, we include a dummy variable capturing supermarket participation in *x* and *z.*

Equation (6.4) shows that positive quantities of hired labor are observed only if $d_i = 1$ and $y_i^* > 0$. Due to this left-censoring of the dependent variable, the ordinary least squares estimator is inconsistent. Instead, such models are commonly estimated with the tobit estimator. However, the tobit model assumes that zero observations represent a corner solution in the sense that – if

relative prices (wages and/or output prices) changed, positive values of hired labor would be realized (Blaylock & Blisard, 1992). In reality, there may be cases of zero observations where even relatively large changes in relative prices would not induce positive outcomes. Zero observations may arise either because desired demand is non-positive (deliberate zeros) or because of inhibiting factors when desired demand is actually positive (censored). An example of a deliberate zero is when careful handling of some types of vegetables grown by farmers requires use of more diligent family labor. Under such circumstances, farmers may not hire in labor even though their economic characteristics would allow them to do so. Another limitation of the tobit model is that it restricts coefficients in the two decision stages to the same sign and magnitude (Wooldridge, 2002).

To account for these shortcomings, we use the double-hurdle (DH) model that acknowledges the two-stage decision while also allowing for the option of deliberate zero observations.[18] The DH model was originally developed by Cragg (1971), and its variants have recently been applied in studies of input demand and technology adoption (Langyintuo & Mungoma, 2008; Shiferaw *et al.*, 2008; Xu *et al.*, 2009). Following the specification in equations (6.1) through (6.4) and assuming independent error terms, the likelihood function for the DH model can be expressed as follows (Jones, 1989):

$$L(y_i|x_i,\theta) = \prod_{y_i=0}[1-\Phi(x_i\alpha/\sigma_u)]\,\Phi(z_i\beta/\sigma_v) * \prod_{y_i>0}\Phi(x_i\alpha/\sigma_u)\,\Phi(z_i\beta/\sigma_v)\,\frac{\phi[(y_i-z_i\beta)/\sigma_v]}{\sigma_v\Phi(z_i\beta/\sigma_v)} \quad (6.5)$$

[18]The two-step decision can also be handled by *heckit* models. However, *heckit* models assume that, once respondents have positive desired demand for hired labor, they cannot report zero values (Blaylock & Blisard, 1992).

Where ϕ and Φ are probability density and cumulative distribution functions of the normal distribution, σ_u is the standard deviation of u_i which is assumed to be one as shown in equation (6.1). σ_v is the standard deviation of v_i. Dividing by $1/\Phi(z_i\beta/\sigma_v)$ (included in the last term) ensures that the density integrates to unity over $y > 0$. Equation (6.5) can then be solved for α, β, and σ_v^2 through maximum likelihood estimation. For brevity, in the following we write σ instead of σ_v.

Since the tobit model is nested in the DH model, we can choose which of the two is more appropriate in a particular situation based on a likelihood ratio (LR) test. If we assume independent error terms, the log-likelihood of the DH model is equivalent to the sum of the log-likelihoods of the probit and the truncated regressions. An LR test of the tobit restriction can therefore be carried out as follows (Greene, 2008):

$$LR\ statistics = -2[\ln L_T - (\ln L_P + \ln L_{TR})] \tag{6.6}$$

Where: L_T is the likelihood for the tobit model; L_P is the likelihood for the probit model and; L_{TR} is the likelihood for the truncated regression model. The LR statistic has a χ^2 distribution.

Upon estimation of the DH model one can also estimate the expected effect of individual explanatory variables on the probability of hiring in labor and on the quantity of hired labor used. First, we estimate the probability of hiring in labor as

$$P(d_i^* > 0|x_i) = \Phi(x_i\alpha) \tag{6.7}$$

Conditional expected quantity of hired labor can then be estimated as follows:

$$E(y_i|y_i > 0, z_i) = z_i\beta + \sigma \times \lambda(z_i\beta/\sigma) \quad (6.8)$$

Similarly, unconditional expected quantity of hired labor can also be estimated as follows:

$$E(y_i|x_i, z_i) = \Phi(x_i\alpha)[z_i\beta + \sigma \times \lambda(z_i\beta/\sigma)] \quad (6.9)$$

The term $\lambda(z_i\beta/\sigma)$ in equations (6.8) and (6.9) is the inverse Mills ratio (IMR) expressed as:

$$\lambda(z_i\beta/\sigma) = \phi(z_i\beta/\sigma)/\Phi(z_i\beta/\sigma) \quad (6.10)$$

The marginal effect of each independent variable can then be estimated following procedures outlined in Burke (2009). For a given observation, the marginal effect of an independent variable, x_j, around the probability that $y > 0$ is

$$\frac{\partial P(y>0|x)}{\partial x_j} = \alpha_j \phi(x\alpha) \quad (6.11)$$

The marginal effect of the same independent variable, x_j, on the expected value of y, given that $y > 0$ (conditional average partial effect – CAPE) is

$$\frac{\partial E(y_i|y_i>0,z_i)}{\partial x_j} = \beta_j[1 - \lambda(z_i\beta/\sigma)\{z_i\beta/\sigma + \lambda(z_i\beta/\sigma)\}] \quad (6.12)$$

The marginal effect of the independent variables on the unconditional expected value of y (unconditional average partial effect – UAPE) is

$$\frac{\partial E(y_i|x_i,z_i)}{\partial x_j} = \alpha_j \phi(x\alpha) \times \{z_i\beta/\sigma + \lambda(z_i\beta/\sigma)\} + \Phi(x_i\alpha) \times \beta_j[1 - \lambda(z_i\beta/\sigma)\{z_i\beta/\sigma + \lambda(z_i\beta/\sigma)\}] \; if \; x_j \epsilon \, x, z \quad (6.13)$$

If x_j is only determining the probability equation, then $\beta_j = 0$, and the second term in equation (6.13) drops out. Alternatively if x_j is only in the second stage model, then $\alpha_j = 0$ and the first

term drops out. Either way, the marginal effect will still be a function of parameters and explanatory variables in both stages of the regression (Burke, 2009).

6.3. Data and descriptive statistics

Data used in this study were collected in 2008 through a survey of vegetable farmers in Kiambu District, Central Province of Kenya. This district is relatively close to Nairobi, where most of the country's supermarkets can be found. But even before supermarkets started their operation, Kiambu was one of the main vegetable-supplying areas for the capital city. Based on information from the District Agricultural Office, four of the main vegetable-producing divisions were chosen. In these four divisions, 31 administrative locations were purposively selected, again using statistical information on vegetable production. Within the locations, vegetable farmers were sampled randomly. Since farmers who participate in supermarket channels are still the minority, we purposely oversampled them using complete lists obtained from supermarkets and supermarket traders. In total, our sample comprises 402 farmers: 133 supermarket suppliers and 269 traditional channels suppliers.

A structured questionnaire was used to collect information from farmers regarding vegetable production and marketing. Furthermore, information on other farm and non-farm economic activities as well as on household and contextual characteristics was collected. Farmers produce vegetables in addition to maize, bananas, and other cash crops. The main vegetables produced are leafy types, including exotic ones such as spinach and kale, and indigenous ones such as *amaranthus* and black nightshade, among others. Even though some supermarket suppliers in our sample also sell parts of their produce in traditional channels, all of them reported supermarkets

to be their main marketing channel for vegetables. In contrast, none of the traditional channel farmers in our sample sells vegetables to supermarkets.[19]

Traditional channels consist of direct spot market trading and sales to middlemen/intermediaries at the farm gate. This mostly involves one-off transactions with neither promise for repeated transactions nor prior agreements on product delivery or price. In contrast, supermarkets do have agreements with vegetable farmers regarding product price, physical quality and hygiene, and consistency and regularity of supply. We hypothesize that these requirements may lead to higher demand for labor. All agreements are verbal with no written contracts. Some farmers also supply supermarkets through specialized traders, who then use similar verbal contracts in order to be able to supply supermarkets on stipulated terms.[20]

6.3.1. Descriptive analysis

Farmers in the two market channels differ with respect to some of the socioeconomic variables, as shown in table 6.1. In terms of farm and household characteristics, we observe significant differences in total land ownership, area cultivated with vegetables, education, occupational characteristics, and use of irrigation technology. On average, supermarket farmers have larger land holdings and more years of schooling. Moreover, even though the majority of farmers in both channels have own farming as their main occupation, 8% of the supermarket farmers

[19] While in some other parts of Kenya, high-value vegetable exports are important (Asfaw *et al.*, 2010), this is not the case in Kiambu District. In fact, none of our sample farmers reported producing vegetables for export.

[20] Initially, supermarkets in Kenya purchased fresh vegetables in traditional wholesale markets, which can still be observed today. However, supermarkets have diversified their procurement to include contracted farmers and specialized traders, in order to ensure price stability and consistency in quality and supply.

reported non-agricultural wage employment as their main occupation, compared to only 4% of the traditional channel farmers.

Table 6.1: Differences in socioeconomic and farm characteristics according to market channels

Variables	Whole sample (*n* = 402)	Supermarket (*n* = 133)	Traditional (*n* = 269)
Farm and household characteristics			
Total area owned (*acres*)	2.1 (3.8)	2.7** (5.6)	1.9 (2.5)
Area cultivated with vegetables (*acres*)	0.8 (1.2)	1.2*** (1.5)	0.7 (0.9)
Household size (*adult equivalents*)	4.0 (0.2)	4.0 (0.2)	4.0 (0.2)
Gender of operator (*male dummy*)	0.90 (0.30)	0.93* (0.25)	0.88 (0.32)
Age of operator (*years*)	49 (14)	47* (13)	49 (15)
Education of operator (*years*)	9.2 (3.8)	10.3*** (3.1)	8.7 (4.1)
Main occupation			
Working on own farm (*dummy*)	0.84 (0.37)	0.79** (0.41)	0.86 (0.35)
Non-agricultural employment (*dummy*)	0.05 (0.22)	0.08** (0.26)	0.04 (0.19)
Agricultural wage employment (*dummy*)	0.01 (0.09)	0.01 (0.09)	0.01 (0.09)
Self-employed outside farm (*dummy*)	0.10 (0.31)	0.13 (0.34)	0.09 (0.29)
Use of irrigation (*dummy*)	0.77 (0.42)	0.88*** (0.33)	0.71 (0.45)
Access to credit (*dummy*)	0.10 (0.30)	0.11 (0.31)	0.10 (0.30)
Size of main vegetable plot (*acres*)	0.08 (0.09)	0.09* (0.09)	0.08 (0.09)
Labor use in vegetables (*labor days per acre-months*)			
Total labor	95.1 (105.6)	91.4 (121.2)	96.9 (97.1)
Family labor	59.1 (87.2)	48.4** (109.7)	64.4 (73.2)
Hired labor	36.0 (57.3)	43.0** (62.0)	32.5 (54.6)
Hired labor by gender of laborers			
Hired female labor	19.1 (42.1)	23.9* (51.9)	16.7 (36.2)
Hired male labor	16.9 (37.1)	19.1 (30.2)	15.8 (40.1)
Hired labor by operation			
Land preparation	6.3 (20.6)	6.0 (11.4)	6.4 (23.9)
Planting	3.6 (10.6)	3.6 (5.7)	3.7 (12.3)
Gap filling	0.1 (0.7)	0.1 (0.6)	0.1 (0.7)
Weeding	14.7 (29.1)	18.8** (37.8)	12.6 (23.4)
Irrigation	2.3 (13.9)	2.7 (18.6)	2.0 (10.8)
Pesticide application	0.7 (4.6)	1.2* (6.9)	0.5 (2.7)
Application of fertilizer & manure	0.6 (3.4)	1.1** (4.4)	0.3 (2.7)
Harvesting	7.2 (18.7)	8.4 (19.4)	6.6 (18.3)
Packing	0.5 (3.7)	1.0** (5.5)	0.2 (2.3)

*, **, *** Significantly different at the 10%, 5%, and 1% levels, respectively;

In parentheses are standard deviations.

Source: Own data

Data about inputs used and outputs obtained in vegetable cultivation were elicited at the plot level. Since most farmers maintain several vegetable plots, we asked them to provide details for their main plot. Table 6.1 shows that an average vegetable plot has a size of only 0.08 acres. Depending on the types of vegetables grown and the farmers' individual cultivation patterns, cropping cycles for vegetables vary in length between two and twelve months. Labor use was reported by farmers for the last cropping cycle on their main plot. In order to have a common reference, in the lower part of table 6.1 we divided the reported labor days by plot size and cycle length, so that labor use is expressed per acre-months. On average, farmers in supermarket channels use more hired labor, whereas traditional channel farmers use more family labor. Substitution of hired for family labor among supermarket farmers may possibly be explained by higher degrees of commercialization and higher opportunity costs of family labor time. Interestingly, the difference in hired labor use is particularly pronounced for women workers. Dolan (2004) also showed for Kenya that substantially more female labor is employed in non-traditional export crops.

Hired labor use statistics in table 6.1 are also disaggregated by farm operation. The bulk of hired labor is used in land preparation, weeding, and harvesting, which holds true for farmers in both market channels. Yet, the two channels show significant differences in labor use for weeding, application of pesticides, fertilizer, and manure, as well as for packing of vegetables. These differences are partly due to supermarket quality and consistency requirements. For instance, pesticide applications help reduce pest damage and improve the product's outward appearance. Fertilizer and manure contribute to faster plant regeneration after harvesting, and supermarkets

also require some on-farm cleaning and bundling, in order to minimize labor costs in supermarket stores.

But beyond concrete requirements, changes in farmers' economic incentives probably also play a role in explaining differences in hired labor use. Higher and more stable output prices in supermarket channels tend to encourage higher input intensities. Moreover, higher returns may contribute to easing liquidity constraints often faced by smallholder producers. This increase in the use of hired labor could be beneficial especially for poor households in rural areas, for whom agricultural wage employment is an important source of off-farm income. Indeed, figure 6.1 shows that agricultural wage income is more important for poorer than for relatively richer households in our sample. In this connection, it should be noted that our sample is not representative of all rural households in Kiambu District or other regions of Kenya, because we only sampled vegetable farmers. Many of the poorest households do not grow vegetables commercially, and for them agricultural wage incomes are even more important on average.

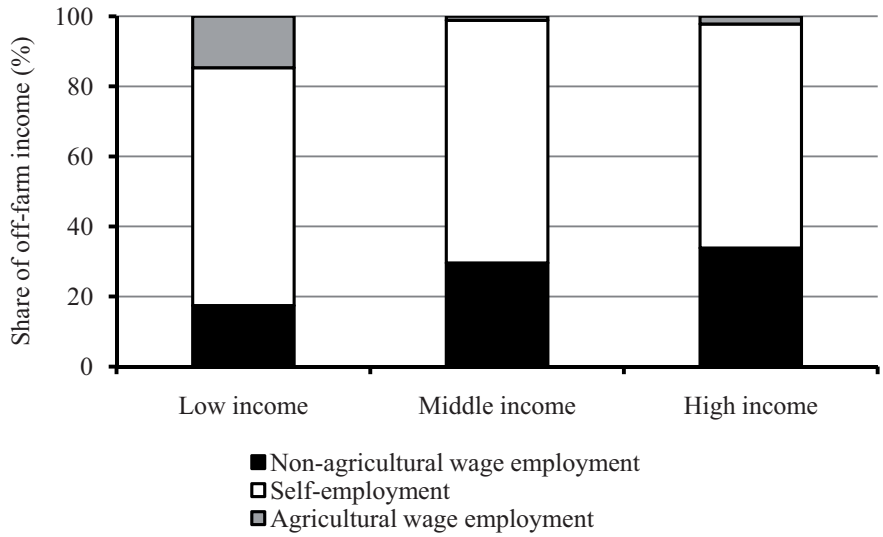


Figure 6.1: Diversification of off-farm income among vegetable farmers in Kiambu district.

Source: Own data

6.4. Econometric results and discussion

In this section, we discuss results of the DH model for labor use, as outlined in section 6.2. The dependent variable is the quantity of labor hired on the main vegetable plot for one cropping cycle. In order to control for differences in acreage and cycle length, "adjusted plot size" is introduced as an explanatory variable, which is plot size multiplied by cycle length. We estimate a model for total hired labor on the plot. In addition, since the descriptive analysis suggested that there may be gender differences, we estimate separate models for female and male hired labor.

6.4.1. Specification tests

Before discussing the estimation results, we conduct some tests in order to justify the specification of the DH models. As summarized above, the DH model is an alternative to the tobit specification; in fact, the tobit model is nested in the DH model. We therefore test for the appropriateness of the DH specification over the tobit alternative, following the steps outlined in equation (6.6). The test results are shown in the upper part of table 6.2. In all the three cases (total hired labor, female hired labor, and male hired labor), the tobit restriction is rejected, so that the DH model is preferred.

Table 6.2: Specification tests for the double hurdle models

Test against tobit specification (H_o: tobit specification is appropriate)				
		LR statistic (χ^2)	*Critical* χ^2_{19}	*Conclusion*
Total hired labor		223.06	30.14	H_0 rejected
Female hired labor		81.60	30.14	H_0 rejected
Male hired labor		226.56	30.14	H_0 rejected
Test for endogeneity of supermarket participation variable (H_o: variable is exogenous)				
		p-value		*Conclusion*
Total hired labor	First stage	0.972		H_0 not rejected
	Second stage	0.543		H_0 not rejected
Female hired labor	First stage	0.929		H_0 not rejected
	Second stage	0.657		H_0 not rejected
Male hired labor	First stage	0.360		H_0 not rejected
	Second stage	0.387		H_0 not rejected

Source: Own data

The main focus of our analysis is the potential impact of farmer participation in supermarket channels on demand for hired labor. Supermarket channel participation is expressed as a dummy variable. However, this variable may potentially be endogenous, because some unobserved factors could simultaneously influence the use of hired labor and participation in supermarket channels. We test for endogeneity following a two-step approach suggested by Rivers and Vuong (1988).

In the first step, we estimate a probit model of participation in supermarket channels. In this probit model, we include a variable capturing participation in a market linkage initiative by a locally active NGO as an instrument. Correlation analysis confirms that this NGO linkage variable is significantly correlated with supermarket participation but not with demand for hired labor. The NGO links farmers in the study area to supermarket channels through various

institutional support mechanisms.[21] In the second step, predicted residuals from this probit are included as an additional explanatory variable in (i) the probit explaining the decision to hire labor (first stage) and in (ii) the truncated regression explaining the quantity of labor hired (second stage). The *t*-statistic for the coefficient of this residual term provides a valid test for the null hypothesis that the supermarket participation variable is exogenous (Wooldridge, 2002). As the test results in the lower part of table 6.2 show, this null hypothesis cannot be rejected in any of the models, so that we proceed with the DH model without instrumentation.

6.4.2. Double-hurdle model results for total hired labor

Results of the DH model are presented in table 6.3. We first refer to the model for total hired labor. The estimates show that supermarket farmers are more likely to hire labor than their counterparts in traditional channels. Farmers with more land and those who use irrigation are also more likely to hire labor. Conditional on the first-stage decision being positive, supermarket participation, land size, and being a male farmer positively and significantly influence the quantity of labor demand. These findings confirm that participation in supermarket channels influences both the likelihood of hiring in labor and the intensity of hired labor used.

Self-employment outside the farm, use of irrigation, access to credit, and adjusted plot size also positively influence the intensity of hired labor use, conditional on farmers hiring labor. These results are as expected. Strikingly, the agricultural wage rate has no statistically significant impact on labor demand, and the price of purchased manure has a negative effect. The latter may

[21] Since the NGO linkage variable may itself be endogenous, we tested for this option through the use of additional instruments, including variables for household assets, infrastructure, and group membership. The hypothesis of exogeneity could not be rejected.

be due to the fact that manure application is fairly labor-intensive. Thus, higher manure prices discourage manure application, leading to lower hired labor demand.

Table 6.3: Maximum likelihood estimate for the double hurdle model

	Total hired labor		Female hired labor		Male hired labor	
Variables	Decision to hire	Labor quantity	Decision to hire	Labor quantity	Decision to hire	Labor quantity
Participation in supermarket channels	0.303*	24.322*	0.295*	28.499**	0.138	22.382
	(0.182)	(12.576)	(0.155)	(12.982)	(0.165)	(37.621)
Total area owned *(acres)*	0.073*	4.848**	0.079**	1.593	0.102**	11.402
	(0.042)	(2.366)	(0.037)	(2.056)	(0.041)	(11.601)
Household size *(adult equivalent)*	-0.100	31.041	0.414	-19.806	-0.067	150.784
	(0.395)	(28.219)	(0.355)	(28.789)	(0.369)	(154.319)
Gender of operator *(male dummy)*	0.227	78.079**	0.003	72.247*	0.484**	114.837
	(0.242)	(36.426)	(0.228)	(38.232)	(0.231)	(139.518)
Age of operator *(years)*	-0.003	0.091	0.003	-0.477	-0.001	-1.597
	(0.007)	(0.489)	(0.006)	(0.516)	(0.006)	(2.001)
Education of operator *(years)*	-0.036	-2.799	-0.012	-1.094	-0.015	-12.599
	(0.023)	(1.714)	(0.020)	(1.572)	(0.021)	(11.564)
Self employed outside farm [a] *(dummy)*	0.280	90.179**	0.379	43.238	-0.207	325.084
	(0.392)	(36.506)	(0.354)	(30.336)	(0.376)	(293.940)
Working on own farm [a] *(dummy)*	0.261	42.377	0.114	8.050	0.039	240.071
	(0.329)	(30.182)	(0.298)	(25.710)	(0.323)	(236.052)
Agricultural wage employment [a] *(dummy)*	0.233	-419.650	1.002	-652.099	-0.381	-621.204
	(0.832)	(435.276)	(0.837)	(587.134)	(0.837)	(1,352.771)
Use of irrigation *(dummy)*	0.319*	31.249*	0.174	13.103	0.272	57.692
	(0.177)	(18.438)	(0.170)	(16.844)	(0.171)	(80.406)
Access to credit *(dummy)*	0.383	34.187**	0.343	33.229**	0.208	8.839
	(0.259)	(16.993)	(0.220)	(16.286)	(0.228)	(60.041)
Daily wage rate *(Ksh/day)*	0.000	-0.024	-0.000	-0.182	0.005*	-0.652
	(0.003)	(0.168)	(0.002)	(0.202)	(0.002)	(0.827)
Price of fertilizer *(ksh)*	0.001	-0.310	0.000	0.029	0.000	-1.077
	(0.003)	(0.227)	(0.003)	(0.233)	(0.003)	(1.107)
Price of pesticide *(ksh)*	0.015	-0.918	0.022	0.190	0.005	-23.531 (23.302)
	(0.021)	(1.690)	(0.018)	(1.325)	(0.019)	
Price of purchased farmyard manure *(ksh)*	0.075	-14.593**	-0.056	2.494	0.022	-44.088 (40.242)
	(0.088)	(6.806)	(0.077)	(6.013)	(0.080)	
Limuru region [b]	-0.097	45.600*	-0.394	7.759	0.172	609.257
	(0.329)	(26.022)	(0.317)	(20.445)	(0.311)	(589.286)

Githunguri/Lower Lari region [b]	-0.034	-57.031*	-0.642*	-53.205*	0.338	367.666
	(0.383)	(33.112)	(0.368)	(31.781)	(0.369)	(435.831)
Kikuyu/Westland region [b]	0.383	-13.332	-0.466	-29.175	0.689**	473.081
	(0.335)	(26.040)	(0.318)	(23.010)	(0.314)	(495.478)
Exotic vegetables *(dummy)*		-26.516*		-21.570		-104.595 (99.862)
		(15.604)		(15.449)		
Plot size *(acre/month)*		82.643***		57.188***		161.880
		(17.104)		(15.108)		(127.447)
Share of land under vegetable	0.186		0.327		0.307	
area	(0.223)		(0.203)		(0.210)	
Constant	0.033	-287.771**	-1.951	-60.037	-1.537	-1,297.135
	(1.682)	(146.658)	(1.517)	(134.076)	(1.575)	(1,251.864)
Sigma		35.025***		28.824***		49.276**
		(5.270)		(5.369)		(22.164)
Number of observations	*400*	*400*	*400*	*400*	*400*	*400*
Log-likelihood		*-1271.328*		*-922.108*		*-957.757*

*, **, *** Significant at the 10%, 5%, and 1% level, respectively.

Standard errors in parentheses

[a] the reference occupation is non-agricultural employment outside farm.

[b] the reference region is Lari

Source: Own data

Based on the DH model, conditional and unconditional marginal effects were calculated as explained in section 6.2; they are shown in table 6.4. The first column suggests that supermarket participation increases the likelihood of hiring labor by about 9 percentage points. Relative to a 70% mean likelihood of farmers in traditional channels to hire labor, this represents a 13% increase. The conditional average partial effect (CAPE) of supermarket participation can be interpreted as follows: when the first-stage decision is positive, then supermarket participation increases hired labor demand on the vegetable plot by 3.3 labor days. More interesting is the unconditional average partial effect (UAPE), as this can be interpreted as the combined effect of both decision stages and is therefore of higher practical relevance. The UAPE reveals that participation in supermarket channels increases hired labor use by 4.1 labor days. Compared to the mean hired labor use by farmers in traditional channels, which is 10.7 labor days per plot and cropping cycle, this implies a 38% increase. Land size, which is an indicator of farmers' wealth, also has a positive and significant net effect on the quantity of labor hired. Similarly, male farmers use significantly more hired labor than female farmers in vegetable production. This may potentially be due to cultural factors and gender differences in the opportunity cost of time.

Table 6.4: Marginal effects for the double hurdle model (total hired labor)

Variables	Decision to hire labor		Marginal effects for quantity of labor used			
	Marginal effects	SE	CAPE	SE [c]	UAPE	SE [c]
Participation in supermarket channels (*dummy*)	0.089*	0.051	3.261*	2.136	4.103**	1.931
Total area owned *(acres)*	0.022*	0.013	0.722*	0.415	0.872*	0.470
Household size *(adult equivalents)*	-0.031	0.121	4.622	5.291	3.170	4.453
Gender of operator *(male dummy)*	0.074	0.083	11.627*	6.416	10.004**	5.012
Age of operator *(years)*	-0.001	0.002	0.014	0.085	-0.001	0.070
Education of operator *(years)*	-0.011	0.007	-0.417	0.275	-0.478**	0.237
Working on own farm [a] *(dummy)*	0.085	0.112	6.310	5.935	6.014	4.993
Agr. wage employment [a] *(dummy)*	0.065	0.209	-62.490	41.345	-47.601	35.973
Self-employed outside farm [a] *(dummy)*	0.078	0.099	13.429**	6.600	11.629*	5.968
Use of irrigation *(dummy)*	0.103*	0.060	4.653*	2.616	4.972**	2.371
Access to credit *(dummy)*	0.103*	0.060	5.091*	2.975	5.584**	2.749
Daily wage rate *(Ksh/day)*	0.000	0.001	-0.004	0.025	-0.001	0.021
Price of fertilizer *(Ksh/kg)*	0.000	0.001	-0.046	0.035	-0.032	0.032
Price of pesticide *(Ksh/ml)*	0.005	0.006	-0.137	0.425	-0.043	0.350
Price of purchased manure *(Ksh/kg)*	0.023	0.027	-2.173**	1.031	-1.372	0.921
Limuru region [b]	-0.030	0.104	6.790	4.319	4.869	3.558
Githunguri/Lower Lari region [b]	-0.011	0.121	-8.493*	5.041	-6.749	4.138
Kikuyu/Westland region [b]	0.115	0.099	-1.985	4.186	0.081	4.004
Share of land under vegetables	0.130	0.081			0.791	1.031
Adjusted plot size *(acre-months)*			12.306***	2.503	9.569***	1.826
Exotic vegetables *(dummy)*			-3.948	2.705	-3.070	2.233
Number of observations	*400*		*400*		*400*	

*, **, *** Significantly different at the 10%, 5%, and 1% level, respectively.

[a] The reference occupation is non-agricultural employment.

[b] The reference region is Lari.

[c] These are bootstrapped standard errors.

Source: Own data

The results also provide some evidence of substitution between family and hired labor. Farmers whose main occupation is self-employment outside the farm use 11 hired labor days more on their vegetable plot than farmers whose main occupation is non-agricultural employment; they also use more hired labor than their colleagues whose primary occupation is farming. This is not surprising, because self-employed activities often belong to the most lucrative off-farm income

sources. It is also possible that income from self-employment lowers liquidity constraints faced by farmers, thus improving their ability to hire labor. Similar effects were found by Maertens (2009) in Senegal's export vegetable sector. That farmers often lack sufficient funds to employ hired labor is also supported by the positive and significant influence of credit access. Finally, as expected, larger adjusted plot sizes imply the use of more hired labor.

6.4.3. Double-hurdle model results for female and male hired labor

We now analyze demand for hired labor differentiating by gender of laborers. The descriptive analysis in table 6.1 revealed that supermarket farmers hire more female labor than their counterparts in traditional channels. We therefore estimate gender-specific DH models, using the same specification as above; the only difference is that – instead of total hired labor – we use female and male hired labor as dependent variables. The results of these additional models are shown on the right-hand side of table 6.3. Supermarket farmers are more likely to hire female labor than farmers in traditional channels. Furthermore, conditional on farmers hiring female labor, supermarket farmers hire more female labor than their counterparts supplying traditional channels. This makes sense, because women are mostly hired for weeding and vegetable packing operations, for which significant differences between supermarket and traditional channels can be observed. In contrast, in the male hired labor model we do not find a significant effect of supermarket participation, neither in the first nor in the second decision stage.

Many of the other variables that were shown to play a role for total hired labor are not statistically significant in the gender-specific models. This suggests that for many of the other operations the gender of laborers is considered less important. Interestingly, however, the gender

of the farm operator matters. Male farmers are more likely to hire male labor. Yet, if male farmers do hire female labor, then they hire more female labor than female farmers. This is potentially due to the general wealth status of male farmers relative to their female counterparts.

As above, we also use the coefficient estimates to calculate marginal effects for the gender-specific models. They are shown in table 6.5. Given that the supermarket effects are not statistically significant for male hired labor, we only show the results for female hired labor. The effect of supermarket participation on the likelihood of hiring labor is somewhat stronger for female labor than for total labor (see above). Supermarket participation increases the likelihood of hiring female labor by 11.7 percentage points. Given a 44% mean likelihood of hiring female labor among traditional channel farmers, this represents an increase of almost 27%.

The UAPE shown in the last column of table 6.5 reveals that supermarket participation increases demand for female hired labor by 3.8 labor days per plot. If we compare this to the 4.1 additional days for total hired labor, it becomes obvious that the positive farm employment effects of supermarkets are largely attributable to more female labor being hired. The 3.8 days imply an increase of almost 68% over the average amount of female labor hired by traditional channel farmers – 5.6 labor days. Other factors significantly influencing demand for female hired labor include gender of the farmer, access to credit, and adjusted vegetable plot size. Moreover, farmers who work as wage laborers on other farms hire much less female labor than the reference group consisting of farmers who have non-agricultural employment. This makes sense, because non-agricultural employment is often more remunerative than agricultural employment on own or other farms.

Table 6.5: Marginal effects for the double hurdle model (female hired labor)

Variables	Decision to hire labor		Marginal effects for quantity of labor used			
	Marginal effects	SE	CAPE	SE [c]	UAPE	SE [c]
Participation in supermarket channels (*dummy*)	0.117*	0.061	4.499**	2.285	3.811**	1.540
Total area owned *(acres)*	0.031**	0.015	0.252	0.600	0.517	0.383
Household size *(adult equivalents)*	0.165	0.141	-3.127	5.601	0.385	3.631
Gender of operator *(male dummy)*	0.001	0.091	11.405**	4.780	6.004**	2.865
Age of operator *(years)*	0.001	0.002	0.075	0.108	0.054	0.064
Education of operator *(years)*	-0.005	0.008	-0.173	0.272	-0.148	0.180
Working on own farm [a] *(dummy)*	0.045	0.118	1.271	6.612	1.228	4.042
Agr. wage employment [a] *(dummy)*	0.352	0.217	-102.943***	18.377	-49.167***	14.921
Self-employed outside farm [a] *(dummy)*	0.150	0.136	6.826	6.597	5.443	4.503
Use of irrigation *(dummy)*	0.069	0.067	2.069	2.489	1.941	1.703
Access to credit *(dummy)*	0.136	0.085	5.246**	2.545	4.437**	1.814
Daily wage rate *(Ksh/day)*	-0.000	0.001	0.029	0.033	-0.016	0.021
Price of fertilizer *(Ksh/kg)*	0.000	0.001	0.005	0.042	0.004	0.022
Price of pesticide *(Ksh/ml)*	0.009	0.007	0.030	0.445	0.124	0.232
Price of purchased manure *(Ksh/kg)*	-0.022	0.031	0.394	1.110	-0.066	0.645
Limuru region [b]	-0.154	0.121	1.225	3.760	-1.286	2.523
Githunguri/Lower Lari region [b]	-0.245*	0.130	-8.399*	4.819	-7.557**	3.267
Kikuyu/Westland region [b]	-0.184	0.123	-4.606	3.883	-4.703	2.753
Share of land under vegetables	0.130	0.081			1.605	0.986
Adjusted plot size *(acre-months)*			9.028***	2.405	4.742***	1.139
Exotic vegetables *(dummy)*			-3.405	3.213	-1.789	1.697
Number of observations	*400*		*400*		*400*	

*, **, *** Significantly different at the 10%, 5%, and 1% level, respectively.

[a] The reference occupation is non-agricultural employment.

[b] The reference region is Lari.

[c] These are bootstrapped standard errors.

Source: Own data

6.5. Conclusion

The expansion of supermarkets in developing countries presents potentials for employment generation. The production of high-value crops – such as vegetables – is often quite labor-intensive, thus entailing employment opportunities for agricultural wage laborers. Agricultural wages make up a relatively small share of rural off-farm income in general, but they are often an

important income source for the poorest population segments. While a few previous studies have analyzed rural labor market implications of emerging high-value food supply chains, most of them refer to the agricultural export sector. There is hardly any research on the employment effects of domestic high-value market developments, epitomized by the supermarket revolution. In this study, we have addressed this research gap by using Kenya as an empirical example. Building on data from a recent survey of vegetable farmers, we have developed and used a double-hurdle model to estimate the determinants of hired labor use in vegetable production.

Our estimates show that farmer participation in supermarket channels increases the likelihood of hiring labor in vegetable production by 13% and overall demand for hired labor by 38%. These are strong effects. They are partly due to specific supermarket quality and consistency requirements, which necessitate more labor for some on-farm operations, including new tasks such as cleaning and bundling the fresh produces. Furthermore, higher and more stable output prices in supermarket channels encourage higher input and labor intensities in general.

The recent expansion of supermarkets in Kenya and the increasing share of fresh produce in supermarket retailing therefore clearly have employment-generating impacts in rural areas. Profit and income effects for farmers supplying vegetables to supermarkets were demonstrated elsewhere (e.g., Hernandez *et al.*, 2007; Neven *et al.*, 2009). But these studies also revealed that disadvantaged farm households often find it difficult to supply supermarkets directly, due to technical, human capital, or institutional constraints. While support mechanisms are needed to better link smallholder farmers to high-value supply chains, the labor market results presented here suggest that rural households may benefit even when they are not (yet) supplying supermarkets directly.

The employment effects can also have wider implications for poverty reduction and rural development. First, agricultural wage labor is primarily an activity of low-income households, so that the poor benefit over-proportionally. Second, our gender disaggregation shows that positive employment effects are especially pronounced for female hired laborers, who often belong to the poorest and most vulnerable population groups. Better employment opportunities for rural women also imply higher female incomes. As is known from the literature, female incomes have more positive marginal effects than male incomes for household welfare and nutrition (Quisumbing *et al.*, 1995). Third, higher earnings from agricultural employment may also lead to productivity gains in traditional agriculture. Especially when agricultural growth is hampered by credit constraints, the additional resources can be used by farmers for the adoption of innovations and the purchase of inputs. Such positive feedbacks from off-farm income to agriculture and food security were recently shown by Oseni and Winters (2009) and Babatunde and Qaim (2010).

The supermarket revolution in Kenya is still in its early stages. Experience from other regions in the world shows that supermarket expansion and a maturing modern retail sector are often associated with stricter product and process standards, which could further increase the demand for hired labor in rural areas. Kenya is among the leading African countries in terms of the supermarket expansion, but the trend is also picking up in other countries. Thus, the supermarket revolution has the potential to cause broader positive growth and employment effects in Africa. Sound policies need to ensure that these potentials are realized and that possible negative distributional effects are avoided.

7. Conclusion

7.1. Synopsis

Agri-food supply chains in many developing countries are undergoing profound changes, with supermarkets and other modern retailers assuming an increasing role. These changes are largely driven by rapid urbanization, rising incomes and the accompanying changes in lifestyle. In particular, rapid urbanization and increasing income create an urban middle class with higher demand for processed food. This in turn provides scale economies that are an incentive for operations of large modern retailers. In addition, trade and market liberalization has increased product variety and provided further advantages for the operation of super- and hypermarkets that are well capable of stocking a wide variety of products. Furthermore, wider media penetration and accompanying westernization of diets are creating a shift in food demand patterns that can hardly be handled by traditional food systems.

The resulting transformation of food systems has seen a sharp increase in the operations of supermarkets. Such developments are already more predominant in the developing countries of Latin America, South Asia and South East Asia. But the trend is also picking up in sub-Saharan Africa, especially in Southern and Eastern Africa. Kenya is among the leading countries of sub-Saharan Africa that has experienced rapid growth in supermarkets. Several factors are responsible for supermarket growth in Kenya. Similar to developments elsewhere, urbanization is a major determinant of the recent expansion of supermarkets in Kenya. Reinforced by growth in income, urbanization is creating an urban middle class with higher purchasing power, thus

providing incentives for entry of modern retailers. Trade and domestic market liberalization in the last decade has also seen a surge in product variety, a development that favors large modern stores capable of stocking a wide assortment of products.

It is imperative to note that supermarket growth in Kenya is still at its early stages; as such supermarkets have been more predominant in processed food sales. Nevertheless, their share in fresh produce is also picking up, as media penetration and westernization of diets increasingly create a change in lifestyle and shifts in food demand patterns. The entry of supermarkets into fresh produce sale in Kenya presents interesting dynamics for the local economy. Food systems in the country are still largely traditional, which poses major challenges for modern retailers targeting consumers of high-value food products. Especially for fresh produce, modern retailers have to adopt tighter coordination in order to cope with the weak structures that usually characterize traditional food systems. The adopted mechanisms help retailers to meet consumer concerns, while minimizing transaction costs associated with product procurement under the uncertain conditions in traditional food systems.

The ensuing food system transformation in developing countries presents opportunities for farmers to integrate into high-value markets. Yet the procurement practices adopted by modern retailers may preclude smallholders from accessing supermarket channels. The mixed nature of the effects has attracted a lot of research interest. The existing literature analyzes determinants of farmer participation in modern supply chains and also explores potential institutional innovations that can enhance integration of potentially excluded farmers. There are also studies that attempt some economic analyses, including impacts on factor productivity. However, the existing literature builds on partial productivity analyses that may misrepresent overall effects. Previous economic analyses have also been based on enterprise budget comparisons that do not allow

conclusive statements about net impacts. Furthermore, while there are studies suggesting that farmers with access to modern supply chains employ more hired laborers, more thorough analyses of rural employment effects are missing.

In this study, we have contributed to the literature by undertaking more comprehensive analysis of productivity effects of supermarket access by farmers. Collecting and using household survey data from vegetable farmers in central Kenya, we have evaluated the effect of supermarket participation by farmers on total factor productivity. We find significant technological differences between vegetable farmers in supermarket channels and their counterparts in traditional channels. In particular, significantly more supermarket farmers use certified seeds and advanced irrigation technology. Farmers in the two market channels also differ in terms of input use, with supermarket suppliers using significantly more hired labor. In addition, supermarket suppliers use more organic manure as compared to farmers in traditional channels that use significantly more chemical fertilizer.

Much of the observed differences can be attributed to differences in farmers' technical knowledge, which is largely influenced by educational status. Our descriptive analyses show that supermarket farmers are more educated. It is also possible that farmers' technical skills are enhanced by the extension services offered by an NGO linking vegetable farmers to supermarkets, thus leading to adoption of a different production technology. More importantly, special requirements by modern supply chains also provide incentives for farmers to undertake productivity enhancing approaches such as investment in advanced irrigation technology.

In order to analyze productivity effects while acknowledging the revealed differences in technology, we have used a meta-frontier approach that enables measurement of productivity

with respect to a common frontier. And, to account for the fact that more productive farmers could self-select into supermarket channels, we have subjected productivity scores to statistical matching. This enables us to estimate average treatment effect of supermarket participation on farm productivity. Our findings show significantly higher productivity among supermarket suppliers as a net impact of supermarket participation. On average, supermarket participation leads to 35-38% improvement in productivity among vegetable farmers in central Kenya.

Higher prices and market assurance provided by modern retailers can further reinforce the estimated productivity gains. Resulting improvements in crop income can also increase total household income for farm households supplying supermarket channels. Here, we have analyzed the effects of supermarket participation on household income and poverty. Building on the same survey data we show that participation in supermarket channels leads to significant improvements in income for vegetable producing households in central Kenya. Using an analytical approach that accounts for structural differences between farmers in the two market channels, our findings show a 48% improvement in household income that is attributable to supermarket participation. Furthermore, simulations demonstrate that poorer households with less land benefit over-proportionally. For such farmers, supermarket access represents an important avenue for farm commercialization, since the majority of the small-scale farmers are mostly involved in subsistence agriculture.

However, as there are access constraints and direct benefits for poor households are confined to those that have access and supply their vegetables to supermarkets. Our analysis confirms finding from previous studies that small and asset-poor farmers sometimes lack the capacity to meet the stricter supermarket supply requirements. Consequently, these farmers are at the risk of being by-passed by lucrative high-value chains. This also explains the relatively low number of

households below the poverty line in our sub-sample of supermarket suppliers. Nevertheless, we show some poverty-reducing effects of supermarket participation. Furthermore, our analysis highlights the important role of institutional innovation in helping disadvantaged farmers to access high-value chains, in order to realize the social benefits on a larger scale. In particular, collective action and technical training on production and market requirements are possible instruments that can enhance farmer integration into high-value markets. In this connection, public-private partnerships may also be an effective approach.

While poor households are sometimes excluded from high-value markets, there exist possibilities for them to benefit indirectly through labor markets. High-value export crops were shown to be labor intensive as compared to cereals and other food staples. Similarly, high labor intensity can also be observed for high-value crops entering domestic chains of modern retailers. Negative consequences for excluded farmers can therefore potentially be mitigated by employment gains of supply chains modernization. Particularly for poor rural households, there are opportunities to work as agricultural wage laborers on farms owned by supermarket suppliers. Indeed, our analysis shows that supermarket access by farmers has a positive and significant effect on demand for hired labor. Using an approach that acknowledges the two-step decision process involved in hiring in labor, we show that supermarket access increases both the likelihood of hiring labor and the quantity of labor hired. Strikingly, this effect is particularly pronounced for hired female laborers. Such aspects should not be ignored when evaluating the broader rural development effects of the supermarket revolution.

Similar effects have resulted from the restructuring of fresh produce export chains in developing countries. For instance, the restructuring of the vegetable export supply chain in Senegal has changed mechanisms through which households gain from high-value markets, with poor

households benefiting more from labor markets than from product markets (Maertens & Swinnen, 2009). Not all potential spillovers and dynamics are captured by our study. Nonetheless, our discussions highlight various mechanisms that can be applied to ensure that the poor are not by-passed by the opportunities offered through the food system transformation.

7.2. Policy implications

Overall, our study shows that the supply chain modernization observed in developing countries can have crucial positive effects for rural households. Besides positive impacts on income and employment, successful integration of households into emerging high-value markets can also cause sustainable productivity improvement, which has remained quite elusive for large parts of African agriculture. Our study also confirms the link between markets and farm productivity, thus underscoring the need for improvements in market structures faced by farmers. These findings are particularly important for Kenya, where many farm households are engaged in horticulture. Some of these farmers already supply export markets and may easily integrate into domestic high-value markets as demand grows. Nevertheless, a large proportion of farmers currently rely on domestic markets, especially the urban markets which are now undergoing rapid transformations. The majority of them are smallholders, who face the threat of exclusion from emerging high-value markets. For this group of farmers, action is needed to ensure that they are not further marginalized.

Different policy options can be employed to harness the benefits of high-value markets for these poor farmers. Institutional support – such as offered by the locally active NGO Farm Concern International (FCI) – could be scaled up. This will become particularly relevant, as supermarkets

gradually spread to other cities and towns. Despite the spread of supermarkets to regional cities, most supermarkets in Kenya still rely on centralized procurement systems. This means that supermarket branches in other regional cities rely on central procurement and distribution centers in Nairobi for fresh produce supplies. For some products that are produced in various parts of the country, it would be advisable to source locally. Such changes would allow for the scaling up of institutional support similar to the one offered by FCI. This will ensure that more farmers across the country are integrated into high-value chains. Furthermore, supermarkets will also be able to cut down on costs associated with centralized procurement. Development agencies facilitating market linkage initiatives can negotiate with supermarkets to adopt this system once they have identified certain groups of farmers they want to work with.

In the same spirit, the government should take a more pro-active role in partnering up with the private sector. Such cooperation could entail the government securing some markets from most of its institutions and outsourcing the market linkage service to a private intermediary. The private intermediary can then partner with government extension agents in training farmers on market requirements. It is evident that intermediaries supplying modern retailers in developing countries face difficulties in finding reliable suppliers. Making use of government extension staff to train farmers based on training modules developed by the intermediaries themselves would therefore provide important synergies. The public will gain by farmers having access to important market information provided to farmers through extension staff while the intermediary gains from having reliable trading partners at a reduced cost occasioned by use of government extension staff. Furthermore, the intermediaries will benefit from some of the markets secured by government while farmers will also benefit from existing markets already secured by the

intermediary. Such arrangements would of course require close monitoring and regular evaluation to ensure that the intermediary performs according to agreements.

7.3. Limitations of the study and suggestions for further research

While our study shows significant gains in productivity and household income for farmers supplying supermarket chains, there are a number of factors that limit the scope of our findings and conclusions. In particular, our analyses employ partial equilibrium approaches, which limit our ability to comprehensively evaluate secondary and tertiary effects. Given plausible shifts in activities that could be triggered by the increased dominance of supermarkets in domestic supply chains, general equilibrium analysis would provide more informative results. This would allow a better understanding of economy wide effects of supply chain modernization.

Another useful extension, especially with respect to analyzing effects over time, would be the collection and use of household panel data. For instance, panel data could provide a better understanding of what happens to households that are excluded from high-value chains over time. Do they simply lose livelihood opportunities and sink deeper into poverty, or do they shift to farm wage employments in the possibly expanding farms of supermarket suppliers? Another interesting question would be to analyze what happens over time to the structure of farms that do supply supermarket channels. Do they expand and create more employment, or is the expansion associated with mechanization such that there are eventually negative consequences for rural labor markets? Such analyses may constitute interesting topics for follow-up research, as they are extremely relevant for rural development policy making.

Another limitation of our study is that it does not evaluate what happens to traditional markets as demand for high-value products increases. One extreme possibility is that traditional food systems will simply vanish as supermarkets expand to dominate fresh produce supply chains. Alternatively, competition from high-value chains could ignite restructuring of traditional supply chains as well with the possibility that some farmers still find it attractive to supply traditional channels. Related to this is the question of what constitutes an optimal contract for farmers, both in traditional and modern supply chains. Quite a number of supermarket suppliers in our sample expressed dissatisfaction with the arrangements they presently have with the supermarkets. There is also evidence that market choices are influenced by economic as well as social factors. Contracts based on personal relationships and those involving provision of credit or inputs are often more preferred, as was revealed by Schipmann and Qaim (2010). In order to understand these issues in the Kenyan case, studies involving choice experiments or similar approaches to analyze farmer preferences could be interesting and innovative. Such additional details could be used to further improve the benefits that accrue to farmers from high-value markets. Related information may also be helpful to improve traditional market structures and make them more efficient and beneficial for disadvantaged farmers.

Bibliography

Alvarez A., Amsler C., Orea L., & Schmidt P. (2006). Interpreting and testing the scaling property in models where inefficiency depends on firm characteristics. *Journal of Productivity Analysis, 25* (3), 201-212.

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

Asfaw S., Mithöfer D., & Waibel H. (2009). EU Food safety standards, pesticide use and farm-level productivity: The case of high-value crops in Kenya. *Journal of Agricultural Economics, 60* (3), 645-667.

Asfaw S., Mithöfer D., & Waibel H. (2010). Agrifood supply chain, private-sector standards, and farmers' health: Evidence from Kenya. *Agricultural Economics, 41* (3-4), 251-263.

Ayieko M., Tschirley D., & Mathenge M. W. (2008). "Fresh fruits and vegetables consumption patterns and supply chain systems in urban Kenya: Implications for policy and investment priorities". *Working Paper,* Tegemeo Institute of Agricultural Policy and Development.

Babatunde R. O. & Qaim M. (2010). Impact of off-farm income on food security and nutrition in Nigeria. *Food Policy, 35* (4), 303-311.

Balsevich F., Berdegue J. A., Flores L., Mainville D., & Reardon T. (2003). Supermarkets and produce quality and safety standards in Latin America. *American Journal of Agricultural Economics, 85* (5), 1147 - 1154.

Barrientos S., Kritzinger A., Opondo M., & Smith S. (2005). Gender, work and vulnerability in African horticulture. *IDS bulletin, 36* (2), 74-79.

Battese G. E. (1997). A Note on the estimation of cobb-douglas production functions when some explanatory variables have zero values. *Journal of Agricultural Economics, 48* (2), 250-252.

Battese G. E., Rao D. S. P., & O'Donnell C. J. (2004). A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. *Journal of Productivity Analysis, 21* (1), 91-103.

Beng-Huat C. (2000). *Consumption in Asia: Lifestyles and identities.* London: Routledge.

Berdegue J. A., Balsevich F., Flores L., & Reardon T. (2005). Central American supermarkets' private standards of quality and safety in procurement of fresh fruits and vegetables. *Food Policy, 30* (3), 254-269.

Bettignies J. E. D. & Ross T. W. (2004). The Economics of public-private partnerships. *Canadian Public Policy, 30* (2), 135-154.

Blaylock J. R. & Blisard W. N. (1992). US cigarette consumption: The case of low-income women. *American Journal of Agricultural Economics, 74* (3), 698-705.

Bolwig S., Gibbon P., & Jones S. (2009). The economics of smallholder organic contract farming in tropical Africa. *World Development, 37* (6), 1094-1104.

Boselie D. (2002). "Business case description: TOPS supply chain project, Thailand. KLICT international agri supply chain development program". Agrichain Competence Centre, Den Bosch.

Boselie D., Spencer H., & Weatherspoon D. (2003). Supermarket procurement practices in developing countries: Redefining the roles of the public and private sectors. *American Journal of Agricultural Economics, 85* (5), 1155-1161.

Burke W. J. (2009). Fitting and interpreting Cragg's tobit alternative using Stata. *Stata Journal, 8* (4), 584-592.

Caliendo M. & Kopeinig S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys, 22* (1), 31-72.

Caudill S. B. & Ford J. M. (1993). Biases in frontier estimation due to heteroscedasticity. *Economics Letters, 41* (1), 17-20.

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

Davis B., Winters P., Reardon T., & Stamoulis K. (2009). Rural nonfarm employment and farming: Household-level linkages. *Agricultural Economics, 40* (2), 119-123.

Dehejia R. H. & Wahba S. (2002). Propensity score-matching methods for nonexperimental causal studies. *Review of Economics and Statistics, 84* (1), 151-161.

Dolan C. S. (2004). On farm and packhouse: Employment at the bottom of a global value chain. *Rural Sociology, 69* (1), 99-126.

Doornik J. A. (2007). Object-oriented matrix programming using Ox, 3rd ed.: www.doornik.com.

Dorward A. (2001). The effects of transaction costs, power and risk on contractual arrangements: a conceptual framework for quantitative analysis. *Journal of Agricultural Economics, 52* (2), 59-73.

Dries L. & Swinnen J. F. M. (2004). Foreign direct investment, vertical integration, and local suppliers: Evidence from the Polish dairy sector. *World Development, 32* (9), 1525-1544.

Espey M. & Thilmany D. (2000). Farm labor demand: A meta-regression analysis of wage elasticities. *Journal of Agricultural and Resource Economics, 25* (1), 252-266.

FAO. (2009). *FAO statistical yearbook.* Rome, Italy: Statistical Division Food and Agricultural Organization.

Fuglie K. O. & Bosch D. J. (1995). Economic and environmental implications of soil nitrogen testing: A switching-regression analysis. *American Journal of Agricultural Economics, 77* (4), 891-900.

Government of Kenya. (2007). Economic survey report. Ministry of Planning and National Development, Nairobi

Greene W. H. (2008). *Econometric analysis.* Upper Saddle River, NJ: Prentice Hall

Grosh B. (1994). Contract farming in Africa: An application of the new institutional economics. *Journal of African Economies, 3* (2), 231-261.

Gulati A., Minot N., Delgado C., & Bora S. (2007). Growth in high-value agriculture in Asia and the emergence of vertical links with farmers. In J. F. M. Swinnen (Ed.), *Global supply chains, standards and the poor* (91-108). Cambridge, MA, CAB International.

Hayami Y. & Ruttan W. V. (1985). *Agricultural development: An international perspective.* Baltimore: John Hopkins University Press.

Heckman J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. *Annals of Economic and social Measurement, 5* (4), 475-492.

Hernandez R., Reardon T., & Berdegue J. (2007). Supermarkets, wholesalers, and tomato growers in Guatemala. *Agricultural Economics, 36* (2007), 281-290.

Hoff K., Braverman A., & Stiglitz J. (1993). *The Economics of rural organization: Theory practice and policy.* Oxford: Oxford University Press for the World Bank.

Hueth B., Ligon E., Wolf S., & Wu S. (1999). Incentive instruments in fruit and vegetable contracts: input control, monitoring, measuring, and price risk. *Review of Agricultural Economics, 21* (2), 374-389.

Hujer R., Caliendo M., & Thomsen S. L. (2004). New evidence on the effects of job creation schemes in Germany - a matching approach with threefold heterogeneity. *Research in Economics, 58* (4), 257-302.

Humphrey J., McCulloch N., & Ota M. (2004). The impact of European market changes on employment in the Kenyan horticulture sector. *Journal of International Development, 16* (1), 63-80.

IBRD, International Bank for Reconstruction and Development. (2008). *Global purchasing power parities and real expenditure: 2005 international comparison program.* Washington, D.C: The World Bank.

Irz X., Lin L., Thirtle C., & Wiggins S. (2001). Agricultural productivity growth and poverty alleviation. *Development Policy Review, 19* (4), 449-466.

Jaffee S. (1992). Enhancing agricultural growth through diversification in sub-Saharan Africa. In S. Barghouti, S. Garbus, and D. Umali (Eds.), *Trends in Agricultural Diversification: Regional Perspectives, Technical Paper No. 180, August 1992* (Washington, DC, The World Bank.

Jayne T. S., Shaffer J. D., Staatz J. M., & Reardon T. (1997). "Improving the impact of market reform on agricultural productivity in Africa: How institutional design makes a difference". *Working Paper,* Department of Agricultural, Food, and Resource Economics, Michigan State University.

Jayne T. S., Yamano T., Weber M. T., Tschirley D., Benfica R., Chapoto A., & Zulu B. (2003). Smallholder income and land distribution in Africa: Implications for poverty reduction strategies. *Food Policy, 28* (3), 253-275.

Jones A. M. (1989). A double-hurdle model of cigarette consumption. *Journal of Applied Econometrics, 4* (1), 23-39.

Kaganzi E., Ferris S., Barham J., Abenakyo A., Sanginga P., & Njuki J. (2009). Sustaining linkages to high value markets through collective action in Uganda. *Food Policy, 34* (1), 23-30.

Key N., Sadoulet E., & de Janvry A. (2000). Transactions costs and agricultural household supply response. *American Journal of Agricultural Economics, 82* (2), 245-259.

Kiggundu R. (2006). Technological change in Uganda's fishery exports. In C. Vandana (Ed.), *Technology, Adaptation, and Exports: How Some Developing Countries Got It Right* (301-334). Washington, DC, World Bank.

Kijima Y., Matsumoto T., & Yamano T. (2006). Nonfarm employment, agricultural shocks, and poverty dynamics: evidence from rural Uganda. *Agricultural Economics, 35* (3), 459-467.

Kirsten J. & Sartorius K. (2002). Linking agribusiness and small-scale farmers in developing countries: Is there a new role for contract farming? *Development Southern Africa, 19* (4), 503-529.

Kodde D. A. & Palm F. C. (1986). Wald criteria for jointly testing equality and inequality restrictions. *Econometrica, 54* (5), 1243-1248.

Langyintuo A. S. & Mungoma C. (2008). The effect of household wealth on the adoption of improved maize varieties in Zambia. *Food Policy, 33* (6), 550-559.

Lee L.-F. (1978). Unionism and wage rates: A simultaneous equations model with qualitative and limited dependent variables. *International Economic Review, 19* (2), 415-433.

Leuven E. & Sianesi B. (2003). PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing: <http://ideas.repec.org/c/boc/bocode/s432001.html>. Version 11.

Lokshin M. & Sajaia Z. (2004). Maximum likelihood estimation of endogenous switching regression models. *Stata Journal, 4* (3), 282-289.

Maddala G. S. (1983). *Limited-dependent and qualitative variables in econometrics.* Cambridge: Cambridge University Press.

Maddala G. S. (1986). Disequilibrium, self-selection, and switching models. In Z. Griliches, and D. I. Michael (Eds.), *Handbook of Econometrics* (pp. 1633-1682). North-Holland, Elsevier.

Maertens M. (2009). Horticulture exports, agro-industrialization, and farm-nonfarm linkages with the smallholder farm sector: evidence from Senegal. *Agricultural Economics, 40* (2), 219-229.

Maertens M. & Swinnen J. F. M. (2009). Trade, standards, and poverty: Evidence from Senegal. *World Development, 37* (1), 161-178.

Markelova H., Meinzen-Dick R., Hellin J., & Dohrn S. (2009). Collective action for smallholder market access. *Food Policy, 34* (1), 1-7.

Masakure O. & Henson S. (2005). Why do small-scale producers choose to produce under contract? Lessons forn non-traditional vegetable export from Zimbabwe. *World Development, 33* (10), 1721-1733.

Mayen C. D., Balagtas J. V., & Corinne A. E. (2010). Technology adoption and technical efficiency: Organic and conventional dairy farms in the United States. *American Journal of Agricultural Economics, 92* (1), 181-195.

Mayer J., Butkevicius A., & Kadri A. (2002). *Dynamic products in world exports.* United Nations Conference on Trade and Development.

McCulloch N. & Ota M. (2002). "Export horticulture and poverty in Kenya". *IDS Working Paper* 174, Institute of Development Studies, University of Sussex. Brighton.

McCullough E. B., Pingali P. L., & Stamoulis K. G. (2008). Small farms and the transformation of food systems: An overview. In E. B. McCullough, P. L. Pingali, and K. G. Stamoulis (Eds.), *The transformation of agri-food systems: globalization, supply chains and smallholder farmers* (3-46). Food & Agriculture Organization of the UN (FAO).

Mergenthaler M., Weinberger K., & Qaim M. (2009a). Consumer valuation of food quality and food safety attributes in Vietnam. *Review of Agricultural Economics, 31* (2), 266-283.

Mergenthaler M., Weinberger K., & Qaim M. (2009b). The food system transformation in developing countries: A disaggregate demand analysis for fruits and vegetables in Vietnam. *Food Policy, 34* (5), 426-436.

Minten B., Randrianarison L., & Swinnen J. F. M. (2007). Spillovers from high-value agriculture for exports on land use in developing countries: Evidence from Madagascar. *Agricultural Economics, 37* (2-3), 265-275.

Minten B., Randrianarison L., & Swinnen J. F. M. (2009). Global retail chains and poor farmers: Evidence from Madagascar. *World Development, 37* (11), 1728-1741.

Miyata S., Minot N., & Hu D. (2009). Impact of contract farming on income: Linking small farmers, packers, and supermarkets in China. *World Development, 37* (11), 1781-1790.

Moore C. & Raymond R. D. (2006). *Back by popular demand: The benefits of traditional vegetables - one community's story.* Rome, Italy: IPGRI.

Moustier P., Tam P. T. G., Anh D. T., Binh V. T., & Loc N. T. T. (2010). The role of farmer organizations in supplying supermarkets with quality food in Vietnam. *Food Policy, 35* (1), 69-78.

Narrod C., Roy D., Okello J., Avendaño B., Rich K., & Thorat A. (2009). Public-private partnerships and collective action in high value fruit and vegetable supply chains. *Food Policy, 34* (1), 8-15.

Ndeng'e G., Opiyo C., Mistiaen J., & Kristjanson P. (2003). Geographic dimension of well-being in Kenya - Where are the poor? From district to locations. Ministry of Planning and National Development, Nairobi, Kenya

Neven D., Odera M. M., Reardon T., & Wang H. (2009). Kenyan supermarkets, emerging middle-class horticultural farmers, and employment impacts on the rural poor. *World Development, 37* (11), 1802-1811.

Neven D. & Reardon T. (2004). The rise of Kenyan supermarkets and the evolution of their horticultural product procurement systems. *Development Policy Review, 22* (6), 669-699.

Neven D. & Reardon T. (2008). The rapid rise of Kenyan supermarkets: Impacs on the fruits and vegetable supply system. In E. B. McCullough, P. L. Pingali, and K. G. Stamoulis (Eds.), *The transformation of agri-food systems: globalization, supply chains and smallholder farmers* (235 - 257). Food & Agriculture Organization of the UN (FAO).

Neven D., Reardon T., Chege J., Odera M., Weatherspoon D., & Mwaura F., (2005). *The rapid rise of supermarkets in Kenya: Impacts on the fresh fruits and vegetables supply system - final report.* Partnership for Food Industry Development - Fresh Fruits and Vegetables (PFID-F&V) Michigan State University.

Neven D., Reardon T., Chege J., & Wang H. (2006). Supermarkets and consumers in Africa: The case of Nairobi, Kenya. *Journal of International Food and Agribusiness Marketing, 18* (1/2), 103-123.

Ngugi I. K., Gitau R., & Nyoro J. K., (2007). Access to high-value markets by smallholder farmers of african indigenous vegetables in Kenya in Regoverning Markets, ed.: (IIED, London).

North D. C. (1990). *Institutions, institutional change, and economic performance: Political economy of institutions and decisions.* New York City, USA: Cambridge Univ Press.

Nyoro J. K., Ariga J., & Ngugi I. K. (2007). Countries with emerging modern supply chains: Kenya. In B Vorley, A Fearne, and D Ray (Eds.), *Regoverning markets: A place for small-scale producers in modern agrifood chains?* (163-171). Hampshire, UK, Gower Publishing Limited.

O'Donnell C. J., Rao D. S. P., & Battese G. E. (2008). Metafrontier frameworks for the study of firm-level efficiencies and technology ratios. *Empirical Economics, 34* (2), 231-255.

Okello J. J. & Swinton S. M. (2006). Compliance with international food safety standards in Kenya's green bean industry: Comparison of a small- and a large scale farm producing for export. *Review of Agricultural Economics, 29* (2), 269-285.

Omamo S. W. (1998). Transport costs and smallholder cropping choices: An application to Siaya district, Kenya. *American Journal of Agricultural Economics, 80* (1), 116-123.

Omiti J., Otieno D., Nyanamba T., & McCullough E. B. (2008). The transition from maize production systems to high-value agriculture in Kenya. In E. B. McCullough, P. L. Pingali, and K. G. Stamoulis (Eds.), *The transformation of agri-food systems: globalization, supply chains and smallholder farmers* (235 - 257). Food & Agriculture Organization of the UN (FAO).

Oseni G. & Winters P. (2009). Rural nonfarm activities and agricultural crop production in Nigeria. *Agricultural Economics, 40* (2), 189-201.

Pingali P. (2007). Westernization of Asian diets and the transformation of food systems: Implications for research and policy. *Food Policy, 32* (3), 281-298.

Pingali P., Khwaja Y., Meijer M., & Swinnen J. F. M. (2007). The role of public and private sectors in commercializing small farms and reducing transaction costs. In J. F. M. Swinnen (Ed.), *Global supply chains, standards and the poor* (267-280). Cambridge, MA, CAB International

Poole N. D., Del Campo Gomis F. J., Julia Igual J. F., & Vidal Gimenez F. (1998). Formal contracts in fresh produce markets. *Food Policy, 23* (2), 131-142.

Quisumbing A. R., Brown L. R., Feldstein H. S., Haddad L., & Pena C., (1995). *Women: The key to food security.* Food Policy Report. International Food Policy Research Institute, Washington DC.

Reardon T. (1997). Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Development, 25* (5), 735-747.

Reardon T. & Barrett C. B. (2000). Agroindustrialization, globalization, and international development: An overview of issues, patterns, and determinants. *Agricultural Economics, 23* (3), 195-205.

Reardon T., Barrett C. B., Berdegue J. A., & Swinnen J. F. M. (2009). Agrifood industry transformation and small farmers in developing countries. *World Development, 37* (11), 1717-1727.

Reardon T. & Berdegue J. A. (2002). The rapid rise of supermarkets in Latin America: Challenges and opportunities for development. *Development Policy Review, 20* (4), 371-388.

Reardon T., Timmer C. P., Barrett C. B., & Berdegue J. (2003). The rise of supermarkets in Africa, Asia, and Latin America. *American Journal of Agricultural Economics, 85* (5), 1140-1146.

Reardon T., Timmer C. P., & Berdegue J. (2008). The rapid transformation of supermarkets in developing countries: Induced organizational, institutional and technological change in agri-food systems. In E. B. McCullough, P. L. Pingali, and K. G. Stamoulis (Eds.), *The transformation of agri-food systems: globalization, supply chains and smallholder farmers* (47 - 65). Food & Agricultural Organization of the UN (FAO).

Republic of Kenya. (2001). Kiambu district strategic plan for the period 2002 - 2008. Ministry of Planning and National Development, Nairobi, Kenya

Republic of Kenya. (2002). Kiambu district strategic plan for the period 2002 - 2008. Ministry of Planning and National Development, Nairobi, Kenya

Republic of Kenya. (2005). Kiambu district strategic plan 2005 - 2010. Ministry of Planning and National Development, Nairobi, Kenya

Rivers D. & Vuong Q. H. (1988). Limited information estimators and exogeneity tests for simultaneous probit models. *Journal of Econometrics, 39* (3), 347-366.

Rosenbaum P. R. (2002). *Observational studies.* Springer Verlag.

Rosenbaum P. R. & Rubin D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika, 70* (1), 41-55.

Rosenbaum P. R. & Rubin D. B. (1985). Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *American Statistician, 39* (1), 33-38.

Ruben R., Boselie D., & Lu H. (2007). Vegetables procurement by Asian supermarkets: A transaction cost approach. *Supply Chain Management: An International Journal, 12* (1), 60-68.

Schipmann C. & Qaim M. (2010). Spillovers from modern supply chains to traditional markets: Product innovation and adoption by smallholders. *Agricultural Economics, 41* (3-4), 361-371.

Schwentesius R. & Manuel Á. G. (2002). Supermarkets in Mexico: Impacts on horticulture systems. *Development Policy Review, 20* (4), 487-502.

Senauer B. & Venturini L., (2005). *The globalization of food systems: A conceptual framework and empirical patterns.* Center for International Food and Agricultural Policy, University of Minnesota StPaul, USA.

Shiferaw A. B., Tewodros A. K., & Liang Y. (2008). Technology adoption under seed access constraints and the economic impacts of improved pigeonpea varieties in Tanzania. *Agricultural Economics, 39* (3), 309-323.

Shiundu K. & Oniang'o R. (2007). Marketing african leafy vegetables: Challenges and opportunities in the Kenyan context. *African Journal of Food Agriculture Nutrition and Development, 7* (4), 4-12.

Simmons P. (2002). "Overview of smallholder contract farming in developing countries.". *Working Paper No. 02-04,* Food and Agriculture Organization (FAO) of the UN. Rome, Italy.

Simmons P., Winters P., & Patrick I. (2005). An analysis of contract farming in East Java, Bali, and Lombok, Indonesia. *Agricultural Economics, 33* (2005), 513-525.

Sipiläinen T. & Lansink A. O., (2005). Learning in organic farming–an application on Finnish dairy farms, Paper prepared for presentation at the XIth Congress of the EAAE (European Association of Agricultural Economists) (Copenhagen, Denmark).

Smith J. A. & Todd P. E. (2005). Does matching overcome LaLonde's critique of nonexperimental estimators? *Journal of Econometrics, 125* (1-2), 305-353.

Solis D., Bravo-Ureta B. E., & Quiroga R. E. (2007). Soil conservation and technical efficiency among hillside farmers in Central America: A switching regression model. *Australian Journal of Agricultural and Resource Economics, 51* (4), 491-510.

Stiglitz J. E. (2000). The contributions of the economics of information to twentieth century economics. *Quarterly Journal of Economics, 115* (4), 1441-1478.

Swinnen J. F. M., ed., 2007. *Global supply chains, standards and the poor.* Cambidge, MA: CAB International.

Thurlow J., Kiringai J., & Gautam M. (2007). "Rural investments to accelerate growth and poverty reduction in Kenya". *Discussion Paper,* International Food Policy Research Institute.

Traill W. B. (2006). The rapid rise of supermarkets? *Development Policy Review, 24* (2), 163-174.

Trost R. P. (1981). Interpretation of error covariances with nonrandom data: An empirical illustration of returns to college education. *Atlantic Economic Journal, 9* (3), 85-90.

UN Population Division, 2007. *World population prospects: The 2007 revision population database.* [online] <http://esa.un.org/unup>, 20 July 2010

UN Population Division, 2009. *World population prospects: The 2009 revision population database.* [online] <http://esa.un.org/unup>, 18 August 2010

Wang H. J. & Schmidt P. (2002). One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis, 18* (2), 129-144.

Warning M. & Key N. (2002). The social performance and distrbutional consequences of contract farming: An equilibrium analysis of the *Arachide de Bouche* program in Senegal. *World Development, 30* (2), 255-263.

Watts M. (1994). Life under contract: Contract farming, agrarian restructuring, and flexible accumulation. In M. Watts (Ed.), *Contract farming and agrarian transformation in sub-Saharan Africa* (21-77). Madison, University of Wisconsin Press.

Weatherspoon D. & Reardon T. (2003). The rise of supermarkets in Africa: Implications for agrifood systems and the rural poor. *Development Policy Review, 21* (3), 333-355.

Weinberger K. & Lumpkin T. A. (2007). Diversification into horticulture and poverty reduction: A research agenda. *World Development, 35* (8), 1464-1480.

Whitaker M., Kolavalli S., & Directions U. C. (2006). Floriculture in Kenya. In Chandra Vandana (Ed.), *Technology, Adaptation, and Exports: How Some Developing Countries Got It Right* (335–367). Washington, DC, World Bank.

Wilkinson J. (2004). The food processing industry, globalization and developing countries. *eJADE Journal of Agricultural and Development Economics, 1* (2), 184-201.

Williamson O. E. (1991). Comparative economic organization: The analysis of discrete structural alternatives. *Administrative science quarterly, 36* (2), 269-296.

Williamson O. E. (1999). The vertical integration of production: Market failure consuderations. In O. E. Williamson, and S. E. Masten (Eds.), *The economics of transaction costs* (23-34). Massachusetts, USA, Edward Elgar Publishing, Inc.

Wollni M. & Zeller M. (2007). Do farmers benefit from participating in specialty markets and cooperatives? The case of coffee marketing in Costa Rica1. *Agricultural Economics, 37* (2-3), 243-248.

Wooldridge J. M. (2002). *Econometric analysis of cross section and panel data.* MIT Press.

World Bank. (2005). *Food safety and agricultural health standards: Challenges and opportunities for developing country exports.* Washington, DC: World Bank.

World Bank. (2006). *World development indicators.* Washington, DC World Bank.

World Bank. (2007). *World development report 2008: Agriculture for development.* Washington, DC: World Bank.

World Bank, 2008. *World development indicators.* [online] <http://databank.worldbank.org/ddp/home.do?Step=2&id=4 >, 20 July 2010

WTO. (2009). *Trade profiles 2009.* Geneva, Switzerland: World Trade Organization.

Xu Z., Burke W. J., Jayne T. S., & Govereh J. (2009). Do input subsidy programs "crowd in" or "crowd out" commercial market development? Modeling fertilizer demand in a two-channel marketing system. *Agricultural Economics, 40* (1), 79-94.

Appendix A: Additional tables

Table A1: Two-stage estimation to test for exogeneity of the FCI variable

	FCI probit		Supermarket probit	
Variables	Coefficient	SE	Coefficient	SE
Gender of operator *(male dummy)*	0.419	0.487	0.356	0.281
Education of operator *(years)*	-0.027	0.041	0.067***	0.023
Age of operator *(years)*	0.044	0.063	0.151***	0.037
Age of operator squared *(years)*	-0.001	0.001	-0.002***	0.000
Household size *(number of people)*	0.014	0.083	-0.187***	0.044
Off farm employment *(dummy)*	-0.363	0.282	0.373***	0.138
Total area owned *(acres)*	-0.019	0.032	0.081**	0.034
Use of advanced irrigation technology *(dummy)*	1.236***	0.473	0.092	0.203
Ownership of livestock *(dummy)*	0.288	0.361	-0.010	0.183
Household access to electricity *(dummy)*	-0.517	0.329	0.108	0.221
Own means of transportation *(dummy)*	-0.043	0.346	0.812***	0.247
Availability of public transportation in village	0.659	0.412	0.410*	0.220
Proximity to tarmac road *(dummy)*	-0.785**	0.333	-0.017	0.156
Household access to public piped water *(dummy)*	-0.276	0.304	-0.248*	0.146
Credit accessed in last 12 months *(dummy)*	-0.036	0.442	0.055	0.314
Participation in FCI market linkage program	0.419	0.487	1.349***	0.394
Limuru region *(dummy)* [a]			-0.686	0.474
Kikuyu/Westland region *(dummy)*	5.388	357.797	0.966**	0.447
Githunguri and Lower Lari region *(dummy)*	7.598	357.798	0.250	0.509
Membership in farmer group	2.507***	0.392		
Availability of vegetable market in the village	1.165***	0.373		
Residual from FCI probit			**-0.204**	**0.182**
Constant	-11.369	357.803	-3.350***	0.995
Number of observations		*402*		*402*

*, **, *** Significant at the 10%, 5%, and 1% level, respectively.

[a] Since there were no FCI farmers in Limuru, this variable can be perfectly predicted by other covariates in the first step model and was therefore dropped in the estimation procedure.

Table A2: Two-stage parameter estimates for household income

	Supermarket suppliers		Traditional market suppliers	
Variables	Coefficient	SE	Coefficient	SE
Gender of operator *(male dummy)*	14.201	28.370	11.976	10.760
Education of operator *(years)*	2.191	2.821	1.376	0.903
Age of operator *(years)*	0.753	0.808	-0.158	0.270
Household size *(number of people)*	-8.627	6.679	-1.867	1.913
Off-farm employment *(dummy)*	56.655**	22.138	25.760***	6.933
Total area owned *(acres)*	1.791	1.204	7.267***	2.620
Use of advanced irrigation technology	14.489	19.356	18.047***	6.370
Ownership of livestock *(dummy)*	13.897	22.510	20.612***	7.867
Household access to electricity *(dummy)*	10.033	24.290	16.778***	5.323
Own means of transportation *(dummy)*	98.854**	38.119	35.284*	20.669
Proximity to tarmac road *(dummy)*	2.929	18.672	5.317	5.423
Household access to public piped water	-46.222**	17.675	9.059	7.204
Credit accessed in the last 12 months	-59.294***	22.199	-10.645*	6.007
Limuru region *(dummy)*	112.229*	60.980	10.973	11.095
Kikuyu/Westland region *(dummy)*	-9.225	55.710	6.789	12.522
Githunguri and Lower Lari region *(dummy)*	-34.688	52.871	6.288	13.080
Constant	5.451	82.166	-35.944*	19.681
IMR	-37.964	172.026	-0.755	6.704
Number of observations		*133*		*269*
R-squared		*0.355*		*0.357*
F-statistics		*3.860***		*7.080****

Note: The dependent variable is annual *per capita* income measured in thousand Ksh.

*, **, *** Significant at the 10%, 5%, and 1% level, respectively.

Table A3: Net income effects of supermarket participation predicted based on models excluding potentially endogenous variables

	No. of obs.	Without supermarket	With supermarket	Net change (%)
	Annual per capita income (1,000 Ksh)			
Full model	133	73.654	109.280	48***
Model without:				
Off-farm employment	133	67.516	109.224	62***
Credit accessed in the last 12 months	133	73.537	109.265	49***
Own means of transportation	133	68.359	109.418	60***

*, **, *** Significantly different at the 10%, 5%, and 1% level, respectively.

Appendix B: Survey Questionnaire

UNIVERSITY OF GÖTTINGEN

ACCESS TO HIGH-VALUE AGRICULTURAL MARKETS AND IMPLICATIONS FOR RURAL DEVELOPMENT: THE CASE OF VEGETABLE PRODUCTION IN CENTRAL KENYA.

HOUSEHOLD SURVEY

1.0 CONTACT INFORMATION

1.1 District _____

1.2 Division _____

1.3 Location _____

1.4 Sub-location _____

1.5 Village _____

1.6 Respondent _____

1.7 Phone number _____

1.8 Interviewer _____

1.9 Date of Interview _____

1.10 Questionnaire number _____

2.0 GENERAL FARMING INFORMATION

2.1 For how long have you been cultivating this farm and what was the size when you started cultivating it? _____ years/months Size _____ acres

2.2 What crops do you grow on your farm and what size of your farm is allocated to each crop grown?

Crop	Area owned (acres)	Area leased in (acres)
Vegetable		
Potatoes		
Maize		
Beans		
Tomatoes		
Onions		
Yams		
Tea		
Coffee		
Bananas		
Fodder		
Total area cultivated		
Area leased out		

2.3 Do you use irrigation on your farm? _____ (Yes =1; No =0)

2.4 If yes, how long have you been using irrigation? _____ years/months

2.5 For this year 2008, what portion of your total cultivated area is irrigated? _____ acres

2.6 If you irrigate part/whole of your farm, what special irrigation equipment do you have?

Irrigation equipment/tool	Yes=1; No=0
1) Water pump	
2) Borehole	
3) Water tank	
4) Drip irrigation system	
5) Special pipes	
6) Sprinkler	
7) Watering can	
8) Other (please specify) _____	

2.7 What is the **monthly** value of vegetable sold and consumed from the farm for the last year (2007)?

Rainy season			Dry season		
Value sold/month (Ksh)	For how many months	Value consumed from farm/month (Ksh)	Value sold/month (Ksh)	For how many months	Value consumed from farm/month (Ksh)

2.8 Please give the following revenue details for the crops grown last year **(2007)**?

Crop	**Long rains season**					**Short rains season**				
	Total Output	Qnty sold	Average price	Value (Ksh)	Value consumed	Total Output	Qnty sold	Average price	Value (Ksh)	Value consumed
Potatoes										
Maize										
Beans										
Tomatoes										
Onions										
Yams										
Tea										
Coffee										
Bananas										

2.9 For each crop mentioned above please give details of the cost of production for the year 2007. **Details should be for all plots and the two crop seasons mentioned above.**

Crop	Land rent [a]	Seeds		Fertilizer		Manure		Pesticide		Machinery (Cost) [b]
		Qnty	Cost (Ksh)	Qnty	Cost (Ksh)	Qnty	Cost (Ksh)	Qnty	Cost (Ksh)	
Vegetables										
Potatoes										
Maize										
Beans										
Tomatoes										
Onions										
Yams										
Tea										
Coffee										
Bananas										
TOTAL										

[a] Total land rent for the whole year for each of the crop on rented land

[b] If the farmer owns machinery ask for local rates of machinery use

2.10 How many permanent farm workers did you have last year and what was their monthly salaries?

Monthly salary	**How many workers**

2.11 Besides permanent workers give the following details on labor use and cost for causal workers employed on your farm on a weekly basis for last year (2007).

Peak season (_____ months)									
Hired labor					**Family labor**				
No	No. of Male	No. of female	Hours per day	No. of days/week	No	No. of Male	No. of female	Hours per day	No. of days/week
Off peak season (_____ months)									
No	No. of Male	No. of female	Hours per day	No. of days/week	No	No. of Male	No. of female	Hours per day	No. of days/week

2.12 What is the average daily wage rate for men and women in this area?
Men _____ Ksh/day Women _____ Ksh/day

2.13 What is the typical number of working hours per day? _____ hours

2.14 Do you have any livestock on your farm? _____ (Yes = 1; No = 0)

2.15 For the last year (2007), please list all categories and numbers of livestock owned.

Animal/Birds	**Number**	**Animal/Birds**	**Number**
Cows		Pigs	
Goats			
Sheep			
Chiken			
Donkeys			

2.16 For the **whole of last year**, please give details of revenue and cost of livestock production?

Animal	Units sold	Total sales (Ksh)	Total Cost of Production (Ksh)			
			Fodder	Labor	Veterinary care	Other
Cows						
Goat						
Sheep						
Chicken						
Donkeys						
Pigs						
Rabbits						
Animal product						
Milk						
Eggs						

3.0 GENERAL INFORMATION ABOUT VEGETABLES

Please find out who is in charge of vegetable production and interview this person.

3.1 Who makes decision about vegetable farming and marketing? Relationship to household head _____[a] Gender _____[b]; [a] (*Husband(Household head) = 1; Wife = 2; Son/Daughter = 3; Relative = 4*) [b]*(0 = female; 1 = male)*

3.2 How long have you been growing vegetables on this farm? _____ years/months

3.3 For the past three years, how much of the indigenous and exotic vegetables have you been growing?

Type of Vegetable	Area cultivated in each year for each type (acres)		
	2006	**2007**	**2008**
AIV [a]			
Exotic [a]			

[a] **AIV- African Indigenous Vegetables (*Terere, kunde, managu etc*); Exotic (*sukuma wiki, spinach, lettuce etc)***

3.4 For the present season (2008), how much of your vegetable area is irrigated? _____ acres

3.5 From where do you get information on production of vegetables such as information on production techniques, new seeds, pest control, input use etc? ***(Rank three most important sources)***

	Rank (1-3)
1) Government extension (field days etc)	
2) Agricultural cooperative	
3) NGO (Please specify) _____	
4) Input dealer	
5) Other farmers (e.g., neighbors)	
6) Public gathering (*barazas*)	
7) Public media (e.g., radio, newspaper, magazines)	
8) Traders	
9) Contracting retailer (supermarket etc)	
8) Other (please specify):	

3.6 In your own opinion, do you feel that you have good access to the best information on vegetable production? If not, what kind of information do you feel you are lacking?

Type of production information				
1. I have good access to information on vegetable production ***(rank)*** [a]	1	2	3	4
I do not have good information on;				
2. New varieties				
3. Correct pesticide				
4. Production techniques				
5.				
6.				

[a] **1** = No access; **2** = Somehow no access; **3** = Somehow good access; **4** = Very good access

4.0 INFORMATION ON MARKETING OF VEGETABLES

4.1 Are you always able to sell all your vegetable that you wish to sell? If not please give reasons why you are unable to sell. (*Please tick appropriate choice*)

Reasons	
1. **Am able to sell all**	
Am unable to sell sometimes because	
2. The price is unbearably low	
3. There is no willing buyer (lack of market)	
4. I have no means of transporting	
5. Flooded market	
6.	

4.2 Whenever you want to sell your vegetables, where do you get information on possible market opportunities and market prices? ***(Rank three most important sources)***

Source of market information	**Rank (1–3)**
1. From fellow farmers	
2. From cooperative society	
3. From agricultural extension staff	
4. From NGO	
5. From public media (radio, television etc)	
6. From public gatherings (chief's *baraza* etc)	
7. Self search	
8. From traders	
9. **Others (specify)**	

4.3 In your own opinion, do you feel that you have enough information on all possible market opportunities and prices to enable you decide where to sell your vegetables? If not, what kind of market information are you lacking? (***Please tick appropriate choices***)

Type of market information				
1. I have information on market opportunities ***(rank)***[a]	**1**	**2**	**3**	**4**
I do not have enough information on;				
2. Market opportunities (where to sell)				
3. Prices				
4. Market requirements or standards				
5.				
6.				

[a] 1 = Not enough; 2 = Somehow not enough; 3 = Somehow enough; 4 = Enough

4.4 For this season, where do you sell/plan to sell your vegetables? **(*Please choose 3 most common markets and rank them in the order of importance*).**

Market Channels	**Rank**	**How long have you sold to this buyer?**
1. **To the supermarket/ city park market/mugoya vegetables**		
2. Middleman/broker		
3. Specialized broker (specify) _____		
4. Institutions (hotels, groceries etc)		
5. At the spot market		
6. **Others (specify) _____**		

4.5 Why do you mostly prefer the **buyer ranked 1 in 4.4 above** to other **market channels**? (*Please ask the respondent to rank the each reason from 1-4* [a]).

Reasons: The buyer …..	**Rank** [a]			
	1	**2**	**3**	**4**
1. Offers good price (higher than other options)				
2. Does not manipulate price (does not change price arbitrarily)				
3. Offers attractive payment system				
4. Will always buy the produce (market assurance)				
5. I have no means of transporting vegetables to other markets				
6. Welfare or financial support (social capital)				
7. **I have no other alternative market (buyer)**				
8. Other reasons (specify) _____				

[a] **1** = Not important **2** = Somewhat **un**important **3** = Somewhat important **4** = Very important

4.6 If the farmer does not sell to supermarket, please ask the farmer why he/she does not sell to supermarkets? (*Please ask the respondent to rank each reason from 1-4* [a]).

Reasons: Supermarkets ……	**Rank** [a]			
	1	**2**	**3**	**4**
1. Not aware of possible sale to supermarkets				
2. Do not pay promptly				
3. Demand strict standards				
4. Require reliable means of transport				
5. Unable to supply required quantity consistently				
6.				
7.				
8. Others (specify) _____				

[a] **1** = Not important **2** = Somewhat **un**important **3** = Somehow important **4** = Very important

4.7 Is there any kind of agreement between you and the buyer of your vegetables or any kind of requirement that your vegetables should fulfill to be accepted by the buyer? *Please give details of the agreement.*

Agreement on transaction (Transaction attributes)	
1. On price	
2. To supply continuously (all year round)	
3. To deliver regularly (twice/week etc)	
4. I should have a cell phone for receiving orders	
5. Other (specify _____	
6. No agreement	
Agreement of product attributes	
1. Vegetable should be harvested at certain age	
2. Deliver fresh produce (delivered within hours of harvesting)	
3. Vegetable should be cleaned before delivery	
4. Vegetable should be free from pests	
5. Vegetable should be packed in certain quantity and ready for shelf	
6. Others (specify) _____	
7. No requirement	

4.8 If there is any agreement, at what stage of your production do you make this agreement? ____ (*Before production = 1; Before supply = 2; Once at the beginning = 3*).

4.9 Do you receive any other services or assistance from the buyer of your vegetables?

I receive service or assistance on;	
1. Seeds supply	
2. Pesticide supply	
3. Fertilizer supply	
4. Information on production techniques (extension)	
5. Credit on output (welfare support)	
6. Loan guarantee	
7. Market information	
8. I receive no service/assistance	

4.10 Please list any problems or complaints you have about your present buyer? **(*Please rank your complaints/problems*).**

Problem	**Rank** [a]			
	1	**2**	**3**	**4**
1. Reneges on price agreement				
2. Reneges on quality agreement (cheating on quality)				
3. Does not fulfill purchase orders				
4. Offers low price				
5. Dishonest				
6. Cheating on damage/breakages				
7. Others (specify) _____				

[a] **1** = Not a serious problem **2** = Somehow not a serious problem **3** = Somehow a serious problem **4** = Serious problem

5.0 <u>INPUT AND OUTPUT DATA FOR VEGETABLE PRODUCTION (FOR ONE PLOT)</u> *The following questions relate to the present season, and the farmer's **<u>main vegetable</u> that supplies farmer's <u>number 1(most preferred)</u> buyer as mentioned in 4.4**. Farmers supplying supermarkets should give information for the main vegetable that they mostly supply to supermarket.*

5.1 Which is the main vegetable that you sell in highest volume to your **most preferred market** chosen in 4.4?

African Indigenous Vegetables (AIV)	**Exotic**
1) Managu	5) Kales
2) Sargeti	6) Cabbage
3) Terere	7) Spinach
4) Thoroko	8)Others _____

Please identify one plot where the vegetable chosen in 5.1 above is grown and ask the following questions <u>at the sight of this plot</u>.

5.2 Please give the following information for the chosen plot that contains the main vegetable sold to the most preferred market.

Area (acres) [a]	**Total seed cost (Kshs)**	**Seed source** [b]	**No. of harvesting rounds** [c]

[a] ***1 acre = 4000m^2;***
[b] ***1= input dealer; 2= NGO; 3= trader; 4= fellow farmers; 5 = informal market; 6 = others specify_____.***
[c] ***Number of harvesting rounds before the plot is replanted;***

5.3 Please give the following details about sales of vegetables from this plot.

Output per harvest		**Price per unit (Ksh.)**		**Sales revenue per plot per harvesting round (Kshs)** [a]
Bags	Bundles	Highest	Lowest	

[a] ***If sale is per plot, determine approximately how many bags or bundles one round of harvest can yield***

5.4 If output is measured in bags, approximately how many bundles can one make from one bag of vegetables? _____ bundles [***](***You can divide the price per bag with the known average price per bunch _____ Ksh***)

5.5 For the identified plot of vegetable, please specify all inputs that you use during **the entire crop cycle**, their prices per unit, and the total amount of money spent **on this plot?** ***Please give information for one full plot planted at once.***

Input	**No. of times applied**	**Amount used (kg or liter) each time**	**Total amount used**	**Product price (Ksh/liter or kg)**	**Total cost (Ksh)**
Organic matter (specify)					
Own farm-yard manure					
Purchased farm-yard manure					
Fertilizers					
Pesticides					
Insecticide					
Fungicide					
Herbicide					
Electricity/fuel for irrigation					
Others					
Other inputs (specify)					

5.6 For the identified plot, please specify how often the following operations are carried out for one complete growing cycle. ***Please give information for one full plot planted at once.***

	How many times?	No. of persons involved		No. of days each time	No. of hours per day	How many of those are usually hired laborers?	
		Male	Female			Male	Female
a) Land preparation							
b) Planting							
c) Gap filling							
d) Manual weeding							
e) Irrigating							
f) Fertilizer application							
g) Pesticide application							
h) Other chemicals							
i) Harvesting							
j) Packing							
k) Other, specify:_____							

5.7 What method of land preparation (*plowing and harrowing*) do you use? _____ (1 = Tractor 2 = Animal traction 3 = Manual)
If you use tractor or animal how much do you pay for this service? _____ (Ksh/acre). **(*If the farmer owns tractor or animals, what is the local rate for these services?*)**

5.8 How many times in a year do you grow this vegetable? _____

5.9 How long is one full growing cycle? _____ months

6.0 INFORMATION ON CREDIT ACCESS AND SOCIAL NETWORKS

6.1 How do you finance the cost of inputs (seeds, fertilizer etc) for production of vegetables?

Source of finance	
1. I always have sufficient money to pay for all inputs	
2. I receive credit to buy inputs or receive inputs on credit	
3. I do not use inputs due to lack of cash or credit to purchase required inputs	

If the farmer does not receive credit, please go to question 6.4

6.2 If you receive credit *(or inputs on credit)*, please specify by ticking as appropriate the source of credit that you have access to.

	Tick only one option
1. I can easily buy input on credit from the input dealer/NGO.	
2. I can easily buy input on credit from NGO.	
3. I get a crop loan from the bank.	
4. I get a crop loan from cooperative society.	
5. I can get loan from group	
6. I borrow from friends/relatives	
7. I borrow money from a local moneylender.	
8. Other (explain):	

6.3 If you receive credit (*input on credit*), how many times in **the past 12 months** have you received credit from the following sources and how much did you receive? (*Include the value of inputs if inputs are provided on credit*)

Source	Number of times loan received	Amount (Ksh)
1. Input dealer/NGO.		
2. Bank/cooperative society.		
3. Friends/relatives		
4. Moneylender.		
5. Other (explain):		

6.4 Are you a member of any group or an association? ___ (No = 0; Yes =1) *(If no please go to question 7.0)*

6.5 If yes what type of group do you belong to? *(If no, please go to question 7.0)*

Type of group	
1. Producer group	
2. Farmers cooperative society	
3. SACCO	
4. Women group/Youth group	
5. Community welfare group	
6. Other (specify) _____	

6.6 How long have you been a member of the group/association etc? _____ (Years/months)

6.7 How often in **the past 6 months** did you participate in the activities of this group(s) *(e.g. group meetings, field days, farmers training)*?

Group activities	
1. Formal meetings	
2. Informal meeting	
3. Field day	
4. Farmers training	
5. Election	
6. Other (explain):	

6.8 What type of benefits/services do you receive from your group(s)?

Benefits/Service	
1. Credit service	
2. Input access	
3. Training on crop production and marketing	
4. Marketing of farm produce	
5. Welfare/social support	
6. Other (explain):	

7.0 GENERAL HOUSEHOLD INFORMATION

7.1 **Household composition and income details:** Please list all household members (All those who are under the care of household head in terms of food and shelter provision).

H/hold member	Relationship to HH head[a]	Sex (M = 1;F = 2)	Age	Years of schooling	Marital Status[b]	Main Occupation[c]	Monthly income from occ (Ksh).	Participate in farm work (Yes = 1, No = 0)	Other occupation	Monthly income from other occupation (Ksh)
1	H/hold head									
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										

[a] **Relationship with household head**

Head	= 1	Step children	= 8
Spouse	= 2	Step parent	= 9
Son/daughter	= 3	Father/mother-in-law	= 10
Father/mother	= 4	Sister/brother-in-law	= 11
Sister/brother	= 5	House girl	= 12
Grandchildren	= 6	Farm laborers	= 13
Grandparents	= 7	Other relatives	= 14

[b] **Marital status**

Married	= 1
Single	= 2
Divorced/separated	= 3
Widow/widower	= 4

[c] **Occupation**

Paid employment (civil servant, working in private company etc)	= 1
Self-employed outside farm	= 2
Working on farm	= 3
Wage labor (working on other peoples farms)	= 4
Student	= 5

7.2 What was your household's income from the following sources during the past 12 months? (***include the income of all household members listed***)

Income source	**Ksh. in past 12 months**
Income from machinery services for other farms (plowing etc.)	
Income from own **non-agricultural** businesses	
Pensions	
Remittances from family members/friends who do not live in the household	
Revenues from leasing out land	
Other sources (please specify _____)	

7.3 Do you own a… (Please tick)

	Yes = 1 No= 0
Tractor	
Car/van	
Irrigation equipment (pump, sprinkler, pipes etc)	
Motorbike/bicycle	
Television	
Radio	
Telephone	
Refrigerator	

8.0 HOUSEHOLD ACCESS TO SOCIOECONOMIC INFRASTRUCTURE

8.1 Please indicate by ticking as appropriate, whether the following facilities are available in the village and answer whether or not you have access to them.

Social facilities	**Available in this village Yes = 1 No = 0**	**If available does your household have access to it? Yes = 1, No = 0**	**If not available here**	
			Distance to the nearest (km)	**Cost to travel There (Ksh)**
1. Electricity				
2. Piped water system				
3. Bank				
4. Tarmac road				
5. Public Transport system				
6. Agric extension Agent				
7. Agricultural input market				
8. Agric. product market				

Thank you for your time and patience!