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Eric W. Crawford

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WELFARE EFFECTS OF MAIZE PRICING POLICY ON RURAL HOUSEHOLDS IN KENYA

By

Elliot Wamboka Mghenyi

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ABSTRACT

WELFARE EFFECTS OF MAIZE PRICING POLICY ON RURAL HOUSEHOLDS IN KENYA

By

Elliot Wamboka Mghenyi

Welfare effects of food pricing are not straightforward when households are both producers and consumers of a main staple. Using 2000 and 2004 panel data, I examine the effects of the twin policy of maize price supports and import tariffs on poverty and the distribution of income in rural Kenya. In chapter 3, I discuss the conceptual framework for measuring changes in income due to the effects of the policy, leading to a second order approximation of equilibrium income changes. The framework forms the basis for poverty orderings between two income distributions; counterfactual incomes and incomes with the effects of price controls. The results indicate that the policy exacerbates poverty in all regions considered except the high potential maize zone. In the Western transitional zone, the number of the poor may not have increased but their income shortfalls are increased. In chapter 4, I consider the effects of the policy on the distribution of income. First, I specify a partly linear semi-parametric model to control for the influence of household characteristics, demographics, asset endowments, and infrastructure among other variables. The results indicate that the income distribution effects of the policy are very similar across different agro-climatic settings. Households at the lowest points of the income range lose at least 25% of their incomes while the wealthiest households either gain some proportion of their incomes or remain unaffected.

DEDICATION

This work is dedicated to my father, the late Mzee Zakayo Mghenyi. You asked me in my childhood whether I could go all the way and I answered in the affirmative, yet you left us before that could happen. The only consolation to me is that I am well on track.

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CHAPTER 1

INTRODUCTION

Maize is the most commonly grown crop in Kenya, and is the staple food for over 80% of the population. Maize is grown in virtually all agro-ecological zones, ranging from the Kenyan highlands to the semi-arid zones and the humid coastal lowlands. The crop supplies 40% to 45% of the calories, and 35% to 40% of the protein consumed by an average Kenyan. It is estimated that maize accounts for 20% of all agricultural production and 25% of agricultural employment (GOK 2003). A large portion of maize production (60%) is attributable to smallholders. However, large-scale commercial farms contribute a significant amount of total marketed maize output (Hassan and Karanja 1997; Jayne et al., 2002).

Because of its strategic position in Kenyan agriculture, maize dominates national food security considerations. Indeed, maize pricing was the central theme during the implementation of liberalization and privatization of key sectors in agriculture. Prior to these reforms, Kenya had government-controlled maize trading environment and agricultural input delivery system. The government was responsible for setting pan-seasonal and pan-territorial maize prices, as well as prices of inputs such as seeds and fertilizers. Maize marketing was monopolized by the National Cereals and Produce Board (NCPB), a grain marketing board run by the government.

The maize sector reform began in 1987/88 and intensified in the 1990s, when under pressure from international lenders, the government eliminated movement and price controls on maize trading, deregulated maize and maize meal prices, and eliminated direct subsidies on maize sold to registered millers (Jayne and Kodhek 1997). By the end of 1993, the market for maize was fully liberalized; maize could be distributed freely in the country by willing traders, and imported with minimal restrictions upon payment of a set tariff. The NCPB remained active in a liberalized market, but its role was reduced from that of a sole trader to an agency buying maize for the purpose of building national strategic reserves. These reforms proved controversial. Farmer lobby groups successfully argued that lower maize producer prices were a disincentive to production and therefore a direct threat to national food security. In 1999, the government reinstated NCPB to purchase maize at fixed support prices. The Government has since been engaged in a three-fold intervention in the maize market; applying import tariffs, authorizing procurement by the NCPB, and imposing non-tariff barriers on imports. These policies are strategies aimed at "getting the prices right" i.e. bidding up maize prices so that producers have more incentives to cultivate maize.

The rationale behind ensuring higher producer prices is based on the conjecture that for both microeconomic and macroeconomic reasons, no country has managed to sustain rapid economic growth without first obtaining food self-sufficiency, at least in the main staple (Timmer 1998a). At the micro-economic level, inadequate and irregular access to food limits labor productivity and reduces investment in human capital (Bliss and stern 1978; Strauss 1986; Fogel 1994). The macroeconomic impact of periodic food crises is to undermine both economic and political stability, hence reducing the levels and efficiency of investment (Timmer 1989, 1996; Dawe 1996). However, maize is the main food item in most diets. Higher maize prices would therefore erode real incomes of net buying households. In Kenya, maize expenditure accounts for over 18% of poor household's total income (GOK 2003). This suggests that higher prices might negate efforts to ensure that the poor can afford adequate food. It is the well-known food price dilemma concept first articulated by Timmer (1986).

The purpose of this thesis is to explore the effects of maize policy on the welfare of households in rural Kenya. The thesis is comprised of two papers. In the first paper, Chapter 3, I examine the effects of maize pricing policy on levels of poverty. This analysis will summarize the effects of the policy on the welfare of households that are considered poor, or become poor as a result of, but ignores effects on the welfare of the non-poor who retain their status. From a policy perspective, there are questions such as whether rich farmers benefit more relative to poor farmers (or vice versa), and how those patterns differ from one region to another. That is exactly the subject matter of the second paper, chapter 4. Specifically, the second paper focuses on how the policy affects the distribution of income.

Results from these analyses will be useful in informing national economic planning, especially because current government and donor plans favor policies that are geared towards poverty reduction and increased equality. The rest of the thesis is organized as follows. The second chapter presents an overview of maize production and marketing in Kenya. Chapter 3 serves two purposes; the first is to provide the conceptual framework used to estimate changes in incomes due to changing prices, and the second is to estimate the impact of the policy on poverty. The effect of the policy on the distribution of income is examined in chapter 4. Chapter 5 provides summary and conclusions.

CHAPTER 2

OVERVIEW OF RURAL HOUSEHOLDS MAIZE PRODUCTION AND MARKET PARTICIPATION

2.1 Introduction

This chapter provides background information on maize production and marketing patterns in rural Kenya. The chapter is intended to provide context for the analytical work that follows in the remainder of the thesis. First, I begin by discussing the data used in this section and the rest of the study. Secondly, comparative production and marketing patterns between maize and other crops are presented. In the third section, maize production and consumption in seven regions marked by differing agro-climatic potential are discussed together with the influence of rainfall patterns and household size. The seven regions considered are Coastal lowlands (Kwale and Kilifi districts), Eastern lowlands (Taita-taveta, Machakos, Makueni, Kitui, and Mwingi districts), Western lowlands (Kisumu and Siaya districts), Western transitional (Bungoma snd Kakamega districts), High potential maize zone (Bomet, Nakuru, Narok, Trans nzoia, Uasin gishu, upper Kakamega, and upper Bungoma districts), Western highlands (Kisii and Vihiga districts), and Central highlands (Nyeri, Meru, and Muranga districts). Section 4 provides a brief conclusion.

2.2 Data

The analysis uses household survey panel data collected by Tegemeo Institute of Agricultural Policy and Development in Kenya during the years 2000 and 2004. The primary purpose of the household surveys was to provide information for the Tegemeo

Agricultural Monitoring and Policy Analysis (TAMPA) project. Tegemeo data comprises information on agricultural input usage and production outcomes, purchases for home consumption, and sources and amounts of non farm incomes, among other variables. The first installment of the panel data was collected by Tegemeo in 1997. Subsequent surveys in 2000 and 2004 were conducted using an improved questionnaire. In some modules, the variables collected in the 1997 survey differ from those collected in 2000 and 2004; a reflection of improved data quality. For the purposes of this work, I consider the 1997 survey to have been a learning exercise, and therefore data collected in that year will not be used. The next section provides a discussion on the sampling procedure implemented by Tegemeo. The discussion is based on information from the 2000 survey data documentation and various Tegemeo working papers.

2.2.1 Sampling Procedures

The first step in the sampling process was to obtain a list of all non-urban divisions in the country from census data. The divisions were assigned to one or more agro-ecological zones (AEZ) based on information from the District Development Plans and the Farm Management Handbook. After dividing the Kenyan rural population into its constituent agro-ecological zones, two or three divisions were chosen from each AEZ based on their populations. Another factor that determined the choice of a division was diversity in agro-ecological conditions. More diversity within the division was preferred since the aim was to get a sample that represents well the varied conditions faced by farmers in the country. The selected divisions fell in 24 districts. The divisions were grouped into 9 broad agro-climatic zones - a hybrid of administrative boundaries and agro-ecological zones. The Northern Arid zone – one of the 9 zones, was not visited in 2004 and is therefore not included in the two year panel. Also excluded is the Marginal Rain Shadow zone because of a small sample size. Table 2.1 presents a summary of the 2000 and 2004 panel for the remaining 7 zones.

After identifying divisions, the next steps were to select locations, sub-locations, and villages in that order using a blind equal chance ballot. A list of households was then drawn from each of the selected villages with the help of village officials. Balloting was conducted to determine the beginning selection from the list. For example, if the ballot picked number 10, every 10^{th} household would be selected until the target number is reached. Because of the purposive sampling technique employed in selecting divisions and small sample sizes in some districts, concerns have been raised about whether the Tegemeo dataset is representative, and if so at which level. The sampling technique was aimed at selecting divisions between which there were variations in agro-climatic zones, and which showed within diversity in order to ensure that the resultant sample reflected the diverse conditions faced by farmers. As such, the sample represents well the diverse farming environments and agro-climatic zones facing Kenyan farmers. Tegemeo data can therefore be viewed to be representative at the level of broad agro-climatic zones rather than administrative boundaries such as districts and provinces.

Table 2.1. The Sample

Agro-climatic zone	District	Number of households Sampled	Percentage of total sample	Percentage of zonal sample
Coastal lowlands		**78**	**5.9**	
	Kwale	25		32.1
	Kilifi	53		67.9
Eastern lowlands		**153**	**11.7**	
	Taita-taveta	8		5.2
	Machackos	21		13.7
	Makueni	74		48.4
	Kitui	17		11.1
	Mwingi	33		21.6
Western lowlands		**163**	**12.4**	
	Kisumu	95		58.3
	Siaya	68		41.7
Western transitional		**156**	**11.9**	
	Bungoma	44		28.2
	Kakamega	112		71.8
Western highlands		**142**	**10.8**	
	Kisii	85		59.9
	Vihiga	57		40.1
High potential maize zone		**375**	**28.6**	
	Bomet	38		10.1
	Nakuru	102		27.2
	Narok	24		6.4
	Trans nzoia	56		14.9
	Uasin Gishu	95		25.3
	Kakamega	25		6.7
	Bungoma	35		9.3
Central highlands		**246**	**18.7**	
	Nyeri	99		40.2
	Meru	81		32.9
	Muranga	66		26.8
Total		**1313**		

Source: Household surveys 2000 and 2004; Tegemeo Institute

2.3 Comparative Farm Production and Marketing

The results from household surveys in 2000 and 2004 show that maize was the leading crop enterprise in terms of farm production value (table 2.2 and table 2.3). In both years, the percentage of households selling maize was second only to those selling fruits and vegetables; implying that the most common staple crop is also an important source of cash income to rural households. Similarly, fruits and vegetables rank higher than maize in terms of gross sales value. However, horticulture is typically both capital and labor intensive, and therefore after these factors are paid, net revenues from maize could be higher. From the national outlook we learn that maize and horticulture are the two leading crop enterprises, and therefore further discussions in this section will focus on the two.

Table 2.2. Total Production and Marketing of Annual Crops: Aggregate (1999/00 production year)

CROP	TOTAL PRODUCTION ('000 KG)	VALUE OF PRODUCTION (2000 US$)	% OF HHS SELLING	TOTAL SALES ('000 KG)	SALES VALUE (2000 US$)	SALES AS % OF PRODUCTION
Cereals (excluding maize)	495	99,843	16	383	76,265	77
Maize	2,417	359,316	38	1,151	164,948	48
Beans/Groundnuts /Oilseeds	279	75,249	30	88	23,850	31
Roots/Tubers	1,089	86,562	31	446	36,073	41
Non-food Cash Crops	12	10,001	4	9	6,843	79
Industrial sugarcane	7,015	154,224	10	7,015	154,224	100
Tea	756	198,139	13	752	197,043	99
Coffee	268	69,942	20	262	68,399	98
Fruits and Vegetables	4,034	268,673	74	2,107	152,143	52
Coconut and Cashewnut	152	7,109	3	101	4,539	67

Source: Jayne et al 2005

Table 2.3. Total Production and Marketing of Annual Crops: Aggregate (2003/04 production year)

CROP	TOTAL PRODUCTION ('000 KG)	VALUE OF PRODUCTION (2000 US$)	% OF HHS SELLING	TOTAL SALES ('000 KG)	SALES VALUE (2000 US$)	SALES AS % OF PRODUCTION
Cereals (excluding maize)	522	83,459	17	375	60,167	72
Maize	2,353	271,503	44	1,149	132,848	49
Beans/Ground nuts /Oilseeds ...	293	67,259	36	102	23,573	35
Roots/Tubers	1,015	63,864	35	441	28,704	43
Other Non-food Cash Crops	8	5,120	6	8	4,680	95
Industrial sugarcane	4,037	69,885	4	3,998	69,208	99
Tea	809	142,371	13	804	141,687	99
Coffee	169	18,666	18	162	17,813	96
Fruits and Vegetables	3,581	211,470	78	1,986	119,593	55
Coconut and Cashewnut	83	2,675	4	48	1,466	57

Source: Jayne et al 2005

In Kenya, fruits and vegetables have been viewed as an alternative for maize to farming household's with low land endowment and surplus labor. Figure 2.1 and figure 2.2 respectively provide production output and gross revenue lorenz curves for maize and fruits and vegetables. In both crop enterprises the higher 10% of sampled households produce 50% of total output (Figure 2.1). However, gross revenues from fruits and vegetables are relatively spread out among more households compared to maize. Figure 2.2 shows that 75% of gross revenues from maize accrue to 10% of the sample, while for fruits and vegetables the same proportion of the sample receives 65% of gross revenues.

This suggests that more farmers stand to benefit from cash incomes due to commercialized horticulture than to maize.

Concentration in the distribution of gross maize revenues suggests that the maize pricing policy might afford disproportionately large welfare gains to the 10% that sell 75% of total marketed maize. Other factors that would determine the net effects are consumption levels and initial levels of income. The next section considers maize production, marketing, and income levels across different agro-climatic settings.

Figure 2.1. Lorenz Curves for Pooled Production Volumes (1999/2000 and 2003/2004)

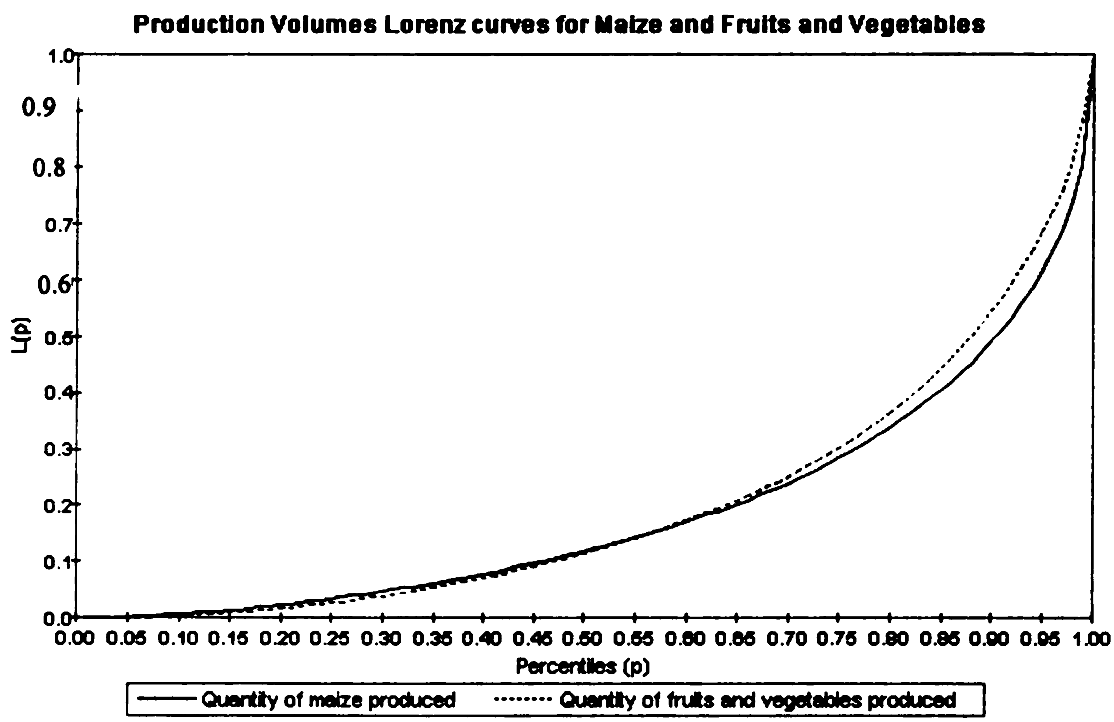
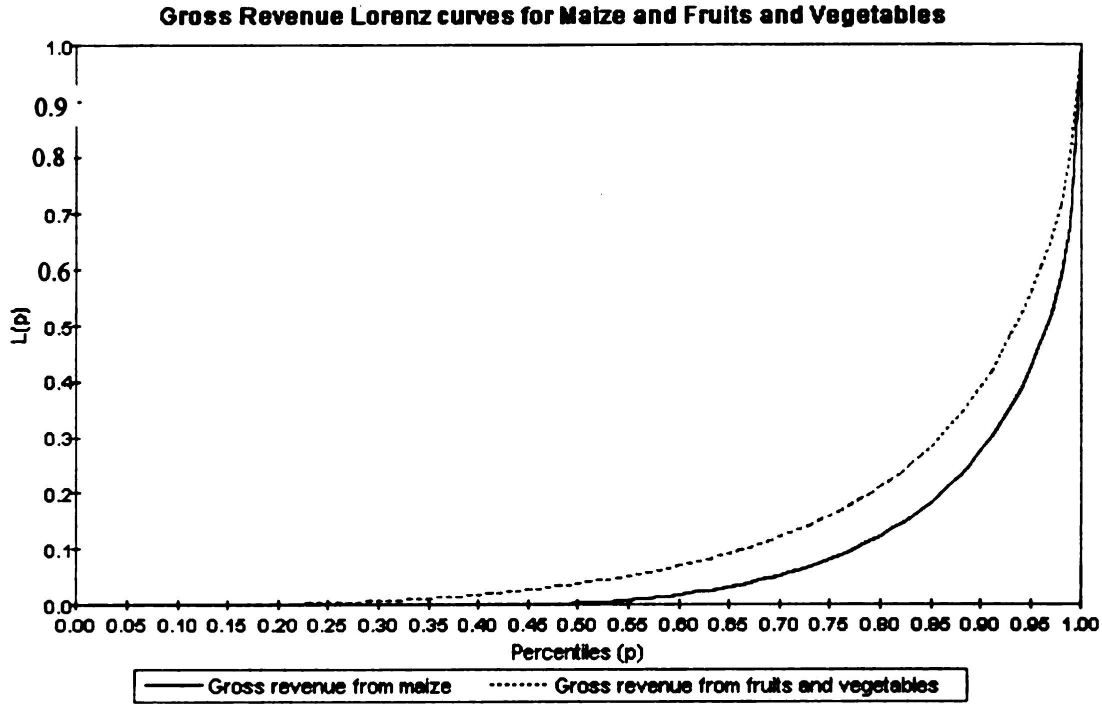


Figure 2.2. Lorenz Curves for Pooled Gross Revenues (1999/2000 and 2000/2004)



2.4 Regional Patterns in Maize Production, Marketing and Household Incomes.

Table 2.4 shows that with the exception of the high potential maize zone, households in other agro-climatic regions spend more money on maize purchases than the cash income they receive from maize sales. The high potential maize zone (HPMZ) is marked by excellent maize growing conditions as summarized by rainfall levels and altitudes in table 2.6. Maize production in the HPMZ is three times higher than in most of the sampled agro-climatic conditions, and land holding sizes are above the average. Jayne et al., (2002) observe that a large portion of total marketed maize in Kenya is produced in the HPMZ. On the other hand, households in coastal lowlands and western lowlands incur the highest level of negative balances from maize trading. It is expected that increases in the price of maize would significantly increase maize expenditures in these regions relative to the rest of the sample. Further, incomes are lowest in the western lowlands suggesting that farmers in these regions are faced with high maize budgets that would exacerbate welfare losses from a maize price increase. The western transitional zone and the Kenyan highlands (central highlands and western highlands) portray intermediate levels of trade imbalances from maize. Household sizes are fairly stable across different agro-climatic zones.

Table 2.4. Production and Marketing Patterns by Agro-climatic Zones (1999/2000 and 2003/2004 Production years)

	Maize Production (KG)		Sales value less purchases value (2000 US $)		Household Income (2000 US $)		Family size (adult equivalents)	
Production year	1999/2000	2000/2004	1999/2000	2000/2004	1999/2000	2000/2004	1999/2000	2000/2004
	Medians							
Coastal Lowlands	515	360	(143)	(75)	1,111	1,055	7.50	7.40
Eastern Lowlands	745	843	(54)	(12)	1,370	1,346	5.90	5.00
Western Lowlands	270	294	(56)	(30)	444	520	5.20	4.50
Western Transitional	810	1,047	(19)	0	1,969	880	6.00	5.53
High Potential Maize Zone	1,620	2,340	47	106	1,549	1,458	6.00	5.34
Western Highlands	630	786	(15)	(2)	975	786	5.85	5.00
Central Highlands	495	565	(13)	(8)	1,882	1,342	5.50	4.00
*National	720	859	(16)	(2)	1,365	1,139	5.90	5.00

Thus far, analysis in this section has focused on levels of maize sales and maize purchases relative to income levels. The average net purchase figures presented in table 2.4 above might give an impression that all households participate in the market both as buyers and sellers. That is not the case. Table 2.5 shows that in all regions, less than a third of households participate in the market both as buyers and sellers. 'Buyers only' are the majority in all zones except the high potential maize zone. This group forms up to 90% of households in coastal lowlands, and more than half in other regions. In the high potential maize zone, the majority of households (almost half) participate as 'sellers only'. However, even here a substantial number of households are 'buyers only' (about 20%). Autarkic households are barely more than 10% in all of the seven zones considered.

An examination based on net purchases and net sales patterns ignores the welfare effects of the maize pricing policy with regard to production consumed at home. Maize is the most commonly grown crop, and is the main staple for all rural households in Kenya. A maize price increase represents increased income with regard to the part of production not traded. On the other hand, a welfare loss is incurred when this portion of output is consumed; loss of consumer surplus due to increased prices. The welfare loss due to consumption would offset the welfare gain due to increased value of production if the proportion of production consumed at home is assumed to be inelastic to changing prices. If this were true, then examining trends in net sales would suffice for this study. However, it is very unlikely that the proportion of production consumed at home is price inelastic. For example, increased prices might provide incentives for hitherto net buyers to reduce the proportion of production consumed at home and become autarkic or even net sellers. Similar responses might occur among autarkic households who would become net sellers, and net sellers who might want to advance their status.

In summary, changes in the proportion of production consumed at home are possible for households in autarky, and for those that participate both as buyers and sellers; in total about 30% of sampled households. The next chapter presents a conceptual framework to examine welfare effects of households both as producers and consumers, and as traders of maize without assuming that the proportion of production consumed at home is price inelastic.

Table 2.5. Households maize marketing position

	Maize marketing position			
Agro-climatic zone	buyers only (%)	sellers only (%)	both buyers and sellers (%)	neither buy nor sell (%)
1999/2000 cropping season				
Coastal lowlands	90	4	5	1
Eastern lowlands	68	6	21	6
Western lowlands	69	3	18	10
Western transitional	51	17	25	7
High potential maize zone	25	40	23	12
Western highlands	55	19	19	7
Central highlands	58	11	23	8
Total in 2000	55	17	20	8
20003/2004 cropping season				
Coastal lowlands	88	0	9	3
Eastern lowlands	50	13	27	10
Western lowlands	73	6	15	6
Western transitional	37	24	27	12
High potential maize zone	19	49	24	8
Western highlands	43	22	23	12
Central highlands	58	11	18	13
Total in 2004	50	16	26	8

Table 2.6. Description of the Sampled Agro-climatic Zones

	Number of Households Sampled	Rainfall in the main season: 2003/2004 production year (Millimeters)			Rainfall in the main season: 1999/2000 production year (Millimeters)			Altitude (Meters above sea level)		
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Coastal Lowlands	79	29	189	103	123	493	210	17	671	471
Eastern Lowlands	161	118	272	188	309	473	434	3,140	5,904	4,669
Western Lowlands	177	693	862	769	681	778	717	3,804	4,420	3,983
Western Transitional	166	941	1,111	995	871	1,010	924	4,295	5,315	4,887
High Potential Maize Zone	399	605	1,111	894	275	928	590	5,647	8,120	6,678
Western Highlands	151	874	1,040	947	888	981	941	5,263	6,131	5,527
Central Highlands	259	286	822	628	191	624	334	4,889	6,998	6,137

2.5 Conclusions

This chapter provides an overview of maize production and consumption patterns in rural Kenya. The purpose of the chapter is to give context to the analysis in later sections of the thesis. Most of the conclusions may not be new, nevertheless; I will briefly discuss key observations.

Maize is the largest source of crop incomes for rural households in Kenya. Even though the crop is an important food staple, the percentage of households engaged in maize selling is second only to those selling fruits and vegetables. Also, gross revenues from maize are only exceeded by horticulture. This means that the most important staple is also a vital source of cash income to farmers. The pattern of maize production and marketing varies greatly between regions with differing agro-climatic conditions. On average, rural households purchase maize worth more than their cash earnings from maize sales. The highest trade imbalance from maize was observed among farmers in coastal lowlands and western lowlands. Further, up to three quarters of gross revenues from maize accrue only to a tenth of households sampled. From these preliminary findings it is clear that the price policy on maize will have differing impacts on households faced with different agro-climatic conditions. As such, analysis of welfare effects at the national level will mask important variations across regions. I therefore adopt broad agro-climatic zones as the level of analysis.

An analysis solely based on sales and purchase values ignores welfare effects with regard to the portion of production consumed at home. Such an approach would suffice if the proportion of production consumed at home were assumed to be inelastic to changes in the price level. The assumption may appear plausible given that the crop is the main staple in diets of farming households. However, maize is also a source of cash income, and therefore it is expected that higher maize prices could make selling more attractive while stocks last, and prohibit purchases when stocks are depleted, thereby reducing the proportion of production consumed at home. Price responses that change the proportion of production consumed at home are possible among households that participate both as buyers and sellers, and those in autarky. The two groups form about 30% of households in the sample – a substantial proportion. In the next chapter, a conceptual framework that allows for price responsiveness in the proportion of production consumed at home is presented. A second order approximation of equilibrium price changes discussed in section 3.2.3 forms the basis for estimating welfare effects of the price policy.

CHAPTER 3

MAIZE PRICE POLICY AND INCOME POVERTY

Abstract

This chapter serves two purposes. The first is to provide the conceptual framework used in estimating changes in incomes due to the price policy, a discussion that leads to the second order approximation of equilibrium income changes. Secondly, based on the framework, poverty orderings are generated between two income distributions; counterfactual incomes and incomes with the effect of price controls. Results indicate that the policy has aggravated poverty in all regions considered, except the high potential maize zone. Under the price policy, the number of the poor is higher in the Kenyan lowlands and the highlands. The policy does not increase the number of the poor in the western transitional zone; however, their income shortfall from the poverty line is increased.

3.1 Introduction

The importance of food price levels on the welfare of producers and consumers has over the years led governments to consider 'getting prices right' especially on key food commodities. The 'food price dilemma', articulated in Timmer (1986) embodies conflicting interests between producers and consumers of food commodities. Timmer's seminal contribution has been followed by an array of empirical work mostly in the context of developing countries. Empirical studies on the subject include; Deaton (1989) on rice prices and income distribution in Thailand, Barrettt and Dorosh (1996) on changing rice prices and farmers welfare in Madagascar, and Budd (1993) on changing food prices and rural welfare in Cote d'I Voire.

The main analytical tool used in these studies is the 'net benefit ratio' or 'net consumption ratio' that is used to estimate instantaneous (first order) welfare effects of changing prices[1]. By considering both supply and consumption adjustments together with the attendant responses in the rural wage labor markets, this paper extends the first-order model used in previous studies and considers a second order approximation of equilibrium welfare changes. Specifically, the chapter begins by providing a conceptual framework that leads to the development of the maize price elasticity of income, akin to the ratio used in previous work. The elasticity is then used to incorporate own price effects on maize supply and demand together with accompanying adjustments in rural wage labor market to estimate a second order approximation to equilibrium welfare changes.

Previous studies have inferred poverty outcomes from analyses of income distributional effects, probably due to a perceived correspondence between the two concepts. My hypothesis is that it is possible to have a policy that raises the incomes of the very poor yet causes more poverty; for instance, if the welfare gains are not enough to pull the beneficiaries out of poverty and are borne out of transfers from some of the non-poor who become poor. With this understanding, the effect of the policy on poverty examined here is separated from analysis on the effect of the policy on the distribution of income, which is the subject matter of chapter 4.

Most poverty analyses use some specified poverty line. The weakness of this approach is that when the threshold is varied, poverty rankings may be reversed which is

[1] The ratio is calculated as production value less sales value as a ratio of expenditure

clearly undesirable in the context of policy analysis. In this paper, methods that generate results which are robust to a wide range of poverty lines are used. First, the study considers all magnitudes of price changes within 5% standard deviation of the price impact suggested by (Jayne et al., 2005a). Each simulated price change is used to generate two vectors of incomes - counterfactual incomes and incomes that have occurred with price controls. Next, the paper exploits the parallel between stochastic dominance and commonly used measures of poverty to generate poverty orderings from each pair of income vectors. The poverty rankings generated hold for a wide array of poverty lines, including the World Banks $1 a day per person threshold and a poverty line for rural households developed and used by the government of Kenya. DAD[2] software is used to conduct stochastic (poverty) dominance tests. The software has previously been used for multidimensional poverty analysis in (Duclos et al., 2005) and in a study on Indonesian living standards (Strauss et al., 2004).

Results indicate that NCPB price supports and tariffs on imported maize jointly plunge some households into transitory poverty in all regions considered except the high potential maize zone (HPMZ). The proportion of the poor is increased in coastal lowlands, eastern lowlands, western lowlands, western highlands, and central highlands. In the western transitional zone, the policy may not have led to an increase in the number of the poor; however, their income shortfalls are increased. These results hold even when both supply and demand responses are assumed to differ across income ranges.

This chapter is organized as follows; the next section provides the conceptual framework for estimating changes in income due to the maize price policy, a discussion

[2] The software is well tailored for distributive analysis. It can be obtained upon request from its author Jean-Yves Duclos at www.ecn.ulaval.ca/~jyves/

that leads to a second order approximation of equilibrium changes in welfare. A note on measures of poverty and the parallel between stochastic dominance and poverty dominance completes the section. Section 3 briefly discusses data construction and section 4 presents the results. Conclusions are given in section 5.

3.2 Conceptual Framework

3.2.1 Estimating Changes in Income due to the Maize Pricing Policy

A social welfare function is postulated in theory as a weighted aggregate of individual utility functions. In reference to differing definitions and views on the social welfare function (Varian 1992) asserts that the most reasonable interpretation of such a function is that it represents a social decision maker's preference about how to trade off utilities of different individuals or households. According to (Deaton 1997), the social welfare function should not be thought of as the objective function of a government or policy-making agents, because there are few if any countries for which maximization of some social welfare function subject to constraints would provide an adequate description of the political economy of decision making. Instead, the social welfare function "should be seen as a statistical aggregator that turns a distribution into a single number which provides an overall judgment on that distribution, and that forces us to think coherently about welfare and its distribution". While economists hold varying views on practical ramifications of the social welfare function, the nexus of agreement is that a social welfare function can be used to theorize the distributional principles underlying economic policy.

In Deaton (1989), the indirect utility function of a household is given as

$$V = \psi(wT + b + \pi, p). \tag{3.1}$$

Where, V is utility value of household i, w is the wage rate, T is the total time worked, b is rental income or transfers, p is price vector, and π is the household's profits from farming or other family business. Households are assumed to be profit maximizers and therefore π is the value of the profit function $\pi(p, u, w)$. Where, u is a vector of input prices and w is wage rate.

Without attempting to speculate about functional form and assuming short run profit maximization decisions on rental income and wage employment, the representation of the indirect utility function can generally be given by

$$V\left[\pi(p_p, u, w), p_c\right]. \tag{3.2}$$

Where p_p and p_c are vectors of producer prices and consumer prices respectively. The price vector p_p includes rental property rates. Similarly, u includes prices associated with maintenance of rental property together with input prices in farm production and family businesses. Further, the price of maize (p_m) can be separated from the vector of other prices to give,

$$V\left[\pi(p_m, p_p, u, w), p_m, p_c\right]. \tag{3.3}$$

For simplicity, the study does not distinguish between consumer and producer prices for maize. This approach is tenable when consumer and producer prices are assumed to change by the same proportion. Equation (3.3) is the utility value of an individual household. The aggregate welfare level is the value of a social welfare function that aggregates household utility levels in accordance with a social decision maker's distributional principles.

$$W = \sum_{i=1}^{n} \theta_i V_i \,. \tag{3.4}$$

The θ parameters are subjective and represent hypothetical weights that the policy maker attaches to utilities of different households. In section 3.2.7 variants of Equation (3.4) namely; the Foster Greer and Thorbecke (FGT) measures of poverty will be used to assess aggregate welfare effects of a change in the price of maize.

To study the effects of a change in the price of maize on a household's level of utility we begin by totally differentiating Equation (3.3) holding all variables other than the price of maize constant.

$$dV = \left({\partial V}/{\partial \pi} * {\partial \pi}/{\partial p_m} \right) dp_m + {\partial V}/{\partial p_m}\, dp_m \tag{3.5}$$

From Hotelling's lemma

$${\partial \pi}/{\partial p_m} = o_m \,. \tag{3.6}$$

Where o_m is the profit maximizing maize output. Roy's identity implies that

$${\partial V}/{\partial p_m} = -c_m \, {\partial V}/{\partial \pi} \,. \tag{3.7}$$

In Equation (3.7), c_m is the utility maximizing quantity of maize consumed. Substituting Equation (3.6) and Equation (3.7) into Equation (3.5) and re-arranging terms we get

$$dV = {\partial V}/{\partial \pi} \left(o_m - c_m \right) dp_m \quad . \tag{3.8}$$

The first component of Equation (3.8) ${\partial V}/{\partial \pi}$ is the marginal utility of income (or marginal utility of households' profit). The second component $\left(o_m - c_m \right) dp_m$ is the change in net income caused by the change in the price of maize. The product of the two gives the change in utility due to a change in the price of maize. Essentially ${\partial V}/{\partial \pi}$ is a transformation factor that maps changes in incomes into utility changes. The second component will be computed from the 2000 and 2004 household survey data.

To estimate the marginal utility of income one would require an explicit model of the supply and demand systems. However, limitations in data availability render such estimation infeasible and therefore instead of estimating $\partial V / \partial \pi$, we assume that the marginal utility of income is constant across all households.[3] With this assumption $\partial V / \partial \pi$ is a common scaling factor that can be standardized at a value of 1, which is equivalent to assuming that changes in incomes are fully transformed into utility changes in a one-to-one correspondence for all households. In this manner, income has an interpretation as a 'money metric of utility'. The problem with using income as a 'money metric of utility' is that a certain level of it does not purchase the same basket of goods in different regions, more so because of geographical differences in prices. We therefore use same input and output prices in measuring household income, as well as same consumer prices for maize grains and maize products nationally.

From Equation (3.8), the realization of a change in utility for household i is

$$dV_i = (o_{mi} - c_{mi})dp_m = dy_i \,. \qquad (3.9)$$

In the very short run o_{mi} and c_{mi} are assumed to be fairly stable because of biological production lags and considering that the crop is the main staple in the diets of most households in Kenya.

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[3] This is equivalent to one of the fundamental assumptions in demand analysis; that aggregate demand is a function of prices and aggregate wealth. Both are obtainable when individual preferences admit indirect utility functions of the Gorman form i.e $v_i(p,w_i) = a_i(p) + b(p)\, w_i$. For further discussions on this topic Mas-colell et al (1995) and Deaton and Muellbauer (1980) are good references.

3.2.2 Maize Price Elasticity of Income

When divided by income before the price change, Equation (3.9) becomes

$$dy_i / y_i^o = (q_{mi} - l_{mi}) d \ln p_m . \tag{3.10}$$

Where, $q_{mi} = (p_m^o \times o_{mi}) / y_i^o$ is the value of maize production (gross revenue) for household i as a proportion of household income, and $l_{mi} = (p_m^o \times c_{mi}) / y_i^o$ is the budget share of maize. Equation (3.10) can be re-arranged to give

$$\left(dy_i / y_i^o\right) \Big/ \left(d \ln p_m\right) = (q_{mi} - l_{mi}). \tag{3.11}$$

Since $\left(dy_i / y_i^o\right) = d \ln y_i$, Equation (3.11) becomes

$$d \ln y_i \Big/ d \ln p_m = (q_{mi} - l_{mi}). \tag{3.12}$$

Equation (3.12) can readily be interpreted as the maize price elasticity of income. The elasticity is positive for households whose gross incomes from maize are larger than their budgetary expenditure on the commodity. Households purchase maize in a variety of forms ranging from whole maize grains to sifted maize meal. Therefore, the budget share of maize is comprised of multiple products:

$$l_{mi} = \sum_j \left(p_j^o \times c_j\right) / y_i^o . \tag{3.13}$$

Where, each j is a different form of maize purchased.

The very short run (VSR) percentage change in per-capita income is computed thus

$$VSR = (q_{mi} - l_{mi}) dp_{m-percent} . \tag{3.14}$$

Where, $dp_{m-percent}$ is the percentage change in the price of maize. The maize price elasticity of income in Equation (3.12) is analogous to the 'net benefit ratio' (NBR) or 'net consumption ratio' used to study the impact of food price changes on income distribution in Deaton (1989), Budd (1993), and Barrett and Dorosh (1996). These studies employed models that focused on the instantaneous effects of price policy on real incomes. In this study, the analysis is extended to include second round effects that account for both the response of households as demanders of the staple and a supply response, thereby providing an approximation to equilibrium responses to price changes.

3.2.3 A Second Order Approximation

Consumers are expected to respond to a price change as time passes, while a supply response would likely occur in the next production cycle. In areas with two cropping seasons, the supply response could be felt within the same year, while in the main grain basket of Uasin Gishu and Trans Nzoia districts, the response will happen a year later or longer because of a single cropping season. The supply side response will be accompanied by adjustments in rural wage labor markets for maize. Assuming under-employment of rural labor, the short run effects of supply adjustments are not likely to change the wage rate; rather the wage bill will change proportionally to the supply elasticity due to changes in man-hours hired. Under these postulates, the complete second order approximation of changes (SOAC) in income is given by

$$\begin{aligned} SOAC &= (q_{mi} - l_{mi})dp_{m-percent} + \tfrac{1}{2}\left[(q_{mi})\varepsilon^{s}_{mz} - (l_{mi})\varepsilon^{d}_{mz}\right](dp_{m-percent})^2 \\ &+ \tfrac{1}{2}\left[\varepsilon^{s}_{mz}(ws_{mi} - wr_{mi})\right](dp_{m-percent})^2 \end{aligned} \quad (3.15)$$

Where, ε_{mz}^{s} is own price elasticity of maize supply, ε_{mz}^{d} is the own price elasticity of maize demand, ws_{m_l} is the share of income from hired-out farm labor associated with the maize enterprise, and wr_{m_l} are payments to hired labor for maize production as a proportion of income. Further economy-wide adjustments are expected, especially in the production and consumption of compliments and substitutes.

The first part of Equation 3.15 is the percentage change in income evaluated at the initial share of maize income and initial budget share - the very short run effects. The second and third parts comprise the remainder term evaluated at some point between the initial values and the unknown equilibrium values of maize income share and maize budget share. We assume that at that point, there would have been sufficient adjustments such that the maize income share and budget share will approximate their initial values, even though production, consumption, and income levels would have changed. Therefore, the second derivatives with respect to income shares and budget shares are evaluated at their respective initial values; and so are hired labor payments to maize and income shares from supplying labor to maize farms.

The remainder term is an approximation of higher order effects after economy-wide adjustments on markets for other commodities and rural farm wages. Such impacts can ideally be estimated with the aid of a Computable General Equilibrium (CGE) models. However, standard CGE models based on household data would involve considerable aggregation across household types. Chen and Ravallion (2004) contend that they form crude tools for welfare distributional analysis and therefore do not yield results that can be considered necessarily superior to those from second order approximated equilibrium configurations.

The very short run (first order) effects are instantaneous income changes that are embedded in the income data of households. Therefore, to generate a second order approximation of resultant income changes only the second and third parts of Equation (3.15) are applied on income data. On the same vein, counterfactual incomes are generated by subtracting the first part of Equation (3.15) from the household income data. The policy is estimated to have increased the mean of maize prices by 19.7% between 1995 and 2004 (Jayne et al., 2005). Therefore we consider 19.7% for $dp_{m-percent}$ in Equation 3.15. We also consider 15% and 25% so that we can determine the sensitivity of impacts to the degree of price change, which might in fact vary somewhat geographically across the sample.

3.2.4 Own price demand and supply elasticity for maize.

A number of studies have estimated supply and demand elasticity of different categories of commodities. Even when similar methodologies were used the range of estimates differed (Rao 1988). Rao (1988) observes that a critical review of the literature reveals that cross sectional estimation of supply elasticity exaggerates aggregate supply responsiveness to prices, while time series studies underestimate the response somewhat. According to Chhibber (1989), the ranges of supply elasticity for developing countries could vary from as low as 0.2 for countries with very poor infrastructure to about 0.9 for countries with advanced infrastructure. Karanja (2003) summarizes short run supply and demand elasticity by zone from (Munyi 2000) and (Pitt and Sumodiningrat 1991). In the summary, the elasticity for different zones fall within the boundaries suggested by Chhibber (1989), and are therefore considered plausible for the purposes of this study.

Table 3.1 adapted from Karanja (2003) gives the following elasticity's for different zones.

Table 3.1. Maize Supply and Demand Elasticity

Zone	Own price supply elasticity	Own price demand elasticity
Lowlands	0.199	-0.400
Dry mid-altitude	0.399	-0.400
Moist mid-altitude	0.305	-0.450
Dry transition	0.338	-0.450
Moist transition	0.378	-0.500
Highlands	0.326	-0.500

Source: Karanja (2003)

3.2.5 Effects of Policy on the Mean of Maize Prices

The twin polices of NCPB price support and tariff on imports have had varying intensity since liberalization began in the late 1980s. During these early years of liberalization through early 1990s, NCPB was given substantial financing which was enough to purchase between 3 and 6 million bags per year - more than a half of domestically marketed maize output (Jayne et al., 2005a). By the mid 1990s, the government had reduced the NCPB operating budget, which resulted in reduced purchases of about 1 million bags during the 1994/95 marketing year. The government reneged on these reforms in 1999 due to intensive lobbying by commercial maize farmers and reinstated NCPB to purchase maize at support prices. Tariff on imported maize has also been varying over the years. The highest rate attained over the years was 50%. Between mid 1992 and mid 1995 the tariff on imported maize was scrapped altogether.

Despite the importance of maize prices in determining real incomes of both rural and urban households in Kenya, no study has been done to estimate the effect of NCPB purchases and import tariffs on mean levels and volatility of maize prices until Jayne et al., (2005a). They use a VAR technique to assess both the separate and joint impacts of the twin policy on wholesale prices in Kitale, a maize surplus region and Nairobi, an urban center with consumers in excess of 3 million. Table 3.2 below gives a summary of their findings.

Table 3.2. Summary of Cumulative NCPB and Maize Import Tariff Effects on Kitale and Nairobi Wholesale Maize Prices, Nominal Ksh per 90kg bag

Period	Kitale wholesale maize price (Ksh per 90kg bag)				Nairobi wholesale maize price (Ksh per 90kg bag)		
	Historical	No NCPB	% difference		Historical	No NCPB	% difference
April 1990 – May 1992							
Mean	335.24	227.81	47.6%		422.58	320.40	31.6%
Standard deviation	101.61	101.04	0.6%		53.77	86.73	-38.0%
Coefficient of variation	30.3%	44.5%	-31.8%		12.7%	27.1%	-52.9%
June 1992 – June 1995							
Mean	723.20	911.41	-20.7%		898.76	1081.20	-16.9%
Standard deviation	216.83	349.32	-37.9%		164.34	352.23	-53.3%
Coefficient of variation	30.0%	38.33%	-21.8%		18.3%	32.58%	-43.9%
July 1995 – June 2004							
Mean	996.71	831.79	19.7%		1212.56	1027.33	18.0%
Standard deviation	308.09	347.84	-11.4%		277.27	371.91	-25.4%
Coefficient of variation	30.9%	41.8%	-26.0%		22.9%	36.2%	-36.8%
Overall sample period (April 1990 – June 2004)							
Mean	848.56	787.83	7.7%		1033.64	963.19	7.3%
Standard deviation	355.34	397.69	-10.6%		365.58	429.33	-14.8%
Coefficient of variation	41.9%	50.5%	-17.0%		35.4%	44.6%	-20.7%

Note: "Historical" refers to actual prices; "no NCPB" prices are simulated from model results.
Source: Jayne, T. S., R. J. Myers, and J. K. Nyoro (2005a).

The study finds that between July 1995 and June 2004, the twin policy was responsible for a 19.7% increase in the price of maize in Kitale. Nairobi maize prices were increased by 18%. In addition to the price impacts found in Jayne et al., (2005a), this study also considers increases of 15% and 25% so as to ensure results that are robust to variations in the magnitude of changes across regions.

3.2.6 Measures of Poverty

When a social welfare function such as that postulated in Equation (3.4) gives zero weight to the welfare of households that are well off, it becomes a measure of the welfare of the poor (Deaton 1997). Viewed this way, poverty measures are special cases of social welfare functions; their distinction being the use of some poverty line as a yardstick to decide between utilities that are given positive weights and those that get zero weights. The use of a poverty line suggests some discontinuity of welfare with poverty on one side and lack of it on the other side. Existence of such a discontinuity in commonly used indicators (income, consumption, calories e.t.c.) has been doubted severely by many writers. Nevertheless, one can rationalize a poverty line by considering it to be the minimum expenditure needed to attain some threshold level of utility at given reference prices.

To quantify poverty the study employs the commonly used Foster, Greer, and Thorbecke (FGT) decomposable measures of poverty (Foster et al., 1984). Considering a cumulative income distribution function $F(y)$ that is right continuous and non-decreasing, Foster and Shorrocks (1988a) give the FGT poverty measures as

$$P_\alpha(F;z)=\frac{1}{z^{\alpha-1}}\int_0^{F(z)}\left[z-F^{-1}(p)\right]^{\alpha-1}dp, \qquad \alpha\geq 1 \tag{3.16}$$

Where y = $(y_1, y_2, y_3, \ldots\ldots\ldots y_n)$ is a vector of per capita household incomes in increasing order and z is the poverty line. The headcount ratio $p_1(F;z)$ measures the proportion of households falling below the poverty line and the income gap measure $p_2(F;z)$ considers total weighted shortfalls of individual household incomes below the poverty line - the weight being the poverty line itself. Welfare evaluations based on the FGT measures of poverty usually hinge on the choice of a particular poverty line. As such, it is possible that welfare rankings between income distributions are reversed with a different choice of a poverty line - an ambiguity that is clearly undesirable. The literature refers to this issue as the *identification* problem. In the next section, I will describe an approach that effectively addresses the identification problem by giving poverty rankings that are robust to a wide range of poverty lines.

3.2.7 Stochastic Dominance and Poverty Dominance

Foster and Shorrocks (1988a, 1988b) demonstrate that the FGT poverty measures correspond to a stochastic dominance partial ordering. Essentially, the poverty ordering P_α is precisely the stochastic dominance ordering denoted D_α. If P_α is the measure of poverty, we say $F(z)$ has more poverty or at least as much poverty as $G(z)$ if $G(z)$ dominates $F(z)$ in the α degree. For the purposes of this work, $p_1(F;z)$ the headcount ratio, and $p_2(F;z)$ the income gap measure are used; implying that first order D_1 and second order D_2 stochastic dominance evaluations are respectively considered.

A distribution $G(z)$ dominates another $F(z)$ in the first degree if the value of its cumulative distribution is less than or equal to that of $F(z)$ for all z, and strictly less than that of $F(z)$ in at least one z_i. This would imply that $F(z)$ has a higher probability for lower values compared to $G(z)$, and therefore the headcount ratio is higher in F than in G for any poverty line in $(0,z]$. Second degree poverty dominance could be used whenever first degree dominance cannot be established. This is equivalent to using the poverty gap measure when the headcount ratio fails to give conclusive results.

A distribution $G(z)$ dominates another $F(z)$ in the second degree when the cumulative difference of the area under $F(z)$ from the area under $G(z)$ is non-positive, formally given as $\int_0^z [G(y)-F(y)]dy \leq 0$ for $y\Xi[0,z]$. $G(z)$ dominates $F(z)$ in the second degree translates to the conclusion that the headcount ratio may be the same in G as in F but income shortfalls from any poverty line in $(0,z]$ are higher in F than they are in G.

Previous studies that have used dominance approaches include a comparison of multidimensional poverty ordering in Ghana, Madagascar, and Uganda (Duclos et al., 2005) and an analysis of Indonesian living standards (Strauss et al., 2004). However, this is the first application of these methods to examine welfare impacts of changing food prices.

3.2.8 The Setting

One of the major drawbacks of household surveys is that samples are often not representative at smaller disaggregated levels such as villages, and therefore estimates at these levels fail to have good statistical properties (Ghosh and Rao 1994). This issue has led to the development of poverty mapping techniques that combine household survey data with census data to develop small area estimates of poverty. The method takes advantage of the detailed information from household surveys and the wide coverage of a census to develop estimates for small areas. It is based on literature in small area estimation discussed in Ghosh and Rao (1994) and Rao (1999). Applications to welfare estimation are developed in Elbers et al., (2003).

This paper does not apply poverty mapping techniques because they are not needed where broad agro-ecological zones are the most suitable level of analysis. Moreover, for policy considerations the interest will hardly be on small geographical units such as villages, towns, or administrative classifications. Rather, policymakers would be interested in understanding welfare effects on regions characterized by differing maize productive potential, agro-ecological conditions, and input type usages. This way, same estimates are generated for regions within which rainfall, topography, market infrastructure, seed material usage, and soil types are fairly stable.

3.3 Data Construction

Poverty dominance analysis will require two vectors of income - counterfactual incomes and incomes with effects of price supports. These variables are constructed from the data described in section 2.2. I first compute incomes from various sources at household level. The sources are; crop income, livestock income, salaries and remittances, and incomes from business and informal activities. These are summed up to give total household income. The computations are done separately on the 2000 and 2004 survey data to generate a panel data of total household income. The vector of 2004 total household income is then deflated to 2000 using the relative official inflation rate profile between the two years.

The next step is to use the pooled total household income and generate the two vectors of income. To generate counterfactual incomes, Equation (3.14) is subtracted from the respective total income for every household. This is done in order to remove the very short run effects of the policy on incomes – the instantaneous income effects. On the other hand, a second order approximation of income changes due to price supports is computed by adding the second and third parts of Equation (3.15) on household income. Next I will discuss the computation of Equation (3.14) and the second and third parts of Equation (3.15).

Equation (3.14) is the product of the elasticity and the percentage change in price due to the policy. As in Equation 3.12, the elasticity is computed as value of maize production less consumption value divided by total household income. Maize output, sold quantity, and prices are available from the panel dataset and therefore computation of production value and sales value is relatively straightforward. To compute consumption value, I first subtracted sales value from production value to get retained value. The value of production carried over in the next production year was then subtracted from the retained value to get the value of production consumed at home. I then added the value of maize purchases for home consumption to the value of production consumed at home to get maize consumption value. The last step was to subtract maize consumption value from production value and dividing the result by total household income to get the maize price elasticity of income. Once I obtained the production and consumption value, the second part of Equation (3.15) was easy to do. I just multiplied the production and consumption values with zonal supply and demand elasticity in table 3.1. Computation of the third part posed some problems since income from labor hired out on maize farms could not be obtained directly from the data. What was available in the data was income from labor hired out on all farm enterprises. A simple approach was used to apportion these proceeds to maize. We multiplied total proceeds by the regional ratio of gross value of maize output to total farm output. Payments to hired labor on maize fields were directly obtained from the data.

The computations narrated above were done for three different changes in the price of maize - 15%, 19.7%, and 25%, resulting to 3 pairs of the 2 income vectors. The 19.7% impact emanates from the analysis in Jayne et al (2005a), and the other two are simulations within a 5% band. These simulations are used to simultaneously reflect possible variations in the magnitude of price changes across regions and to capture any sensitivity effects on poverty to the magnitude used. Stochastic (poverty) dominance tests were then conducted separately for each of the 3 pairs of counterfactual incomes and incomes with effects of price supports. The next section presents the results of poverty dominance tests.

3.4 Results

Commonly used poverty lines for Kenya include the World Bank \$1 a day per person poverty line (approximately \$30 per month per person), and the Welfare Monitoring Survey (WMS) Kshs 1,238 per adult equivalent per month poverty line[4], which is approximately \$16 per month per adult equivalent (GOK 2000). The wide difference between these poverty thresholds poses a potential source of uncertainty when

[4] This poverty line is for 2000 Kshs and therefore it does not need adjustments since the pooled incomes are also in 2000 Khs

welfare rankings are based on one and not the other – the identification problem. To avoid such, first degree poverty orderings are proclaimed only when they hold for the World Bank threshold. This is because the World Bank poverty line (approximately \$30 per month per person) nests the WMS threshold (\$16 per month per adult equivalent) and all other poverty lines less than \$30 per person per month. We consider second degree dominance tests whenever first degree dominance tests are inconclusive.

Figures 3.1, 3.2, and 3.4 provide first degree poverty dominance curves for 19.7% increase in the price of maize for coastal lowlands, eastern lowlands, and western lowlands respectively. Simulated dominance curves for 15% and 25% increases are very similar to the ones for 19.7 % in all zones, and therefore are not presented here. However, their corresponding crossing points are provided together with the crossing points for 19.7% in table 3.3

Figure 3.1. First Order Poverty Dominance Curve for Coastal Lowlands

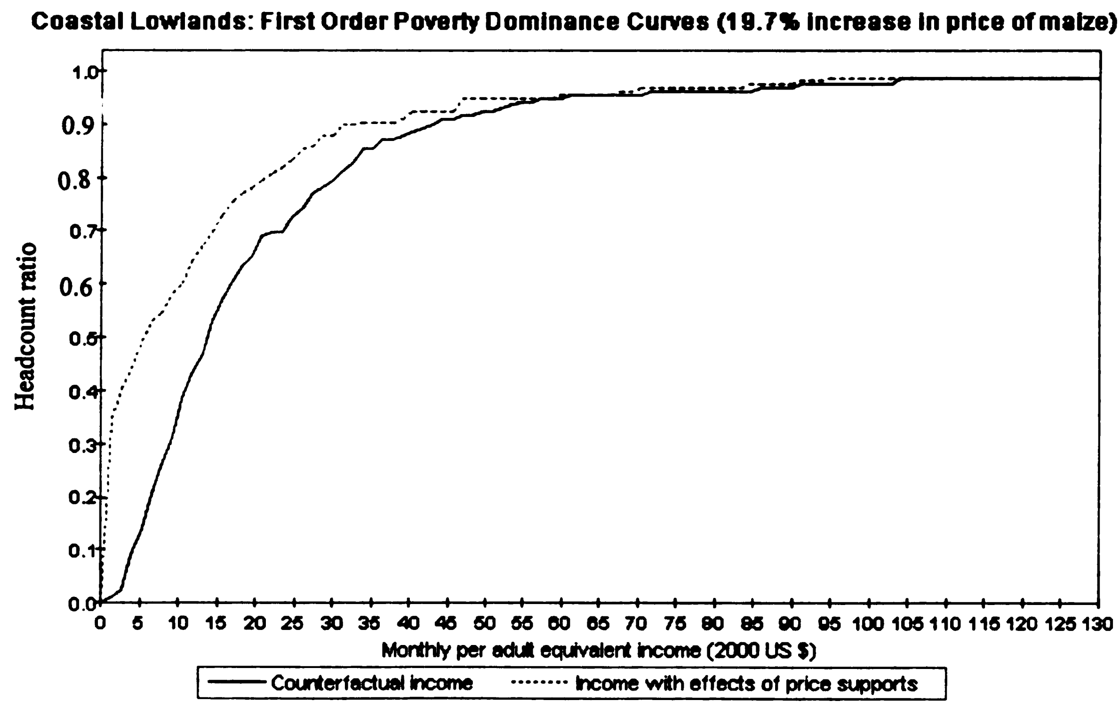


Figure 3.2. First Order Poverty Dominance Curve for Eastern Lowlands

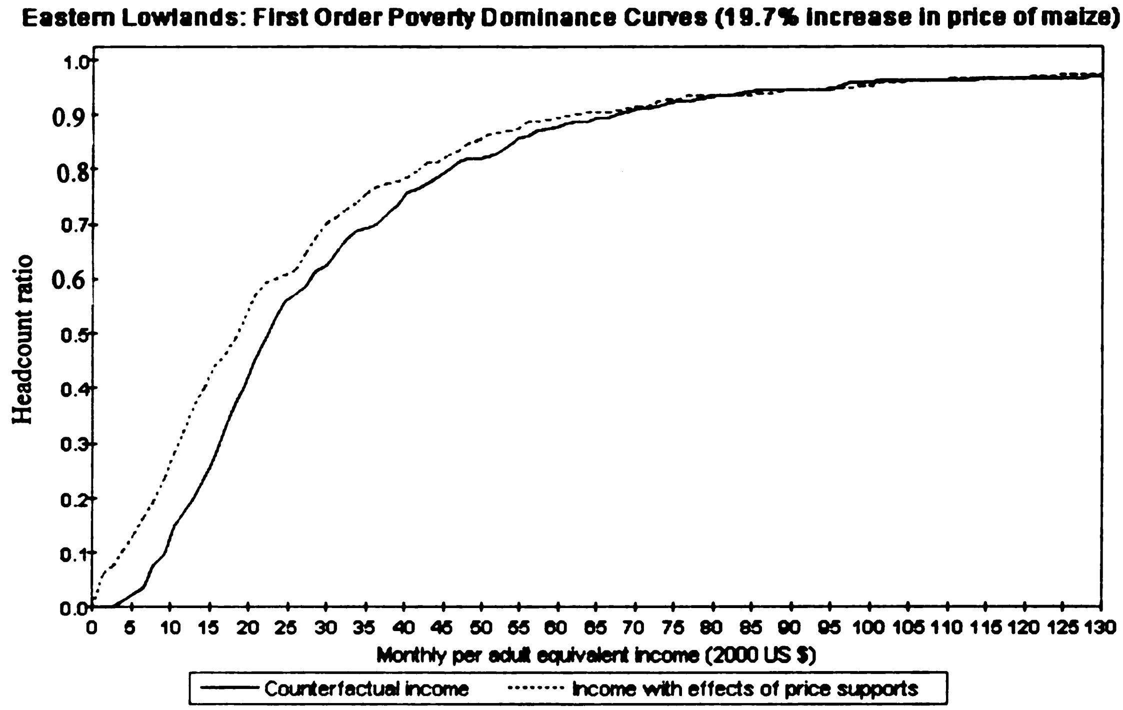


Figure 3.3. First Order Poverty Dominance Curve for Western Lowlands

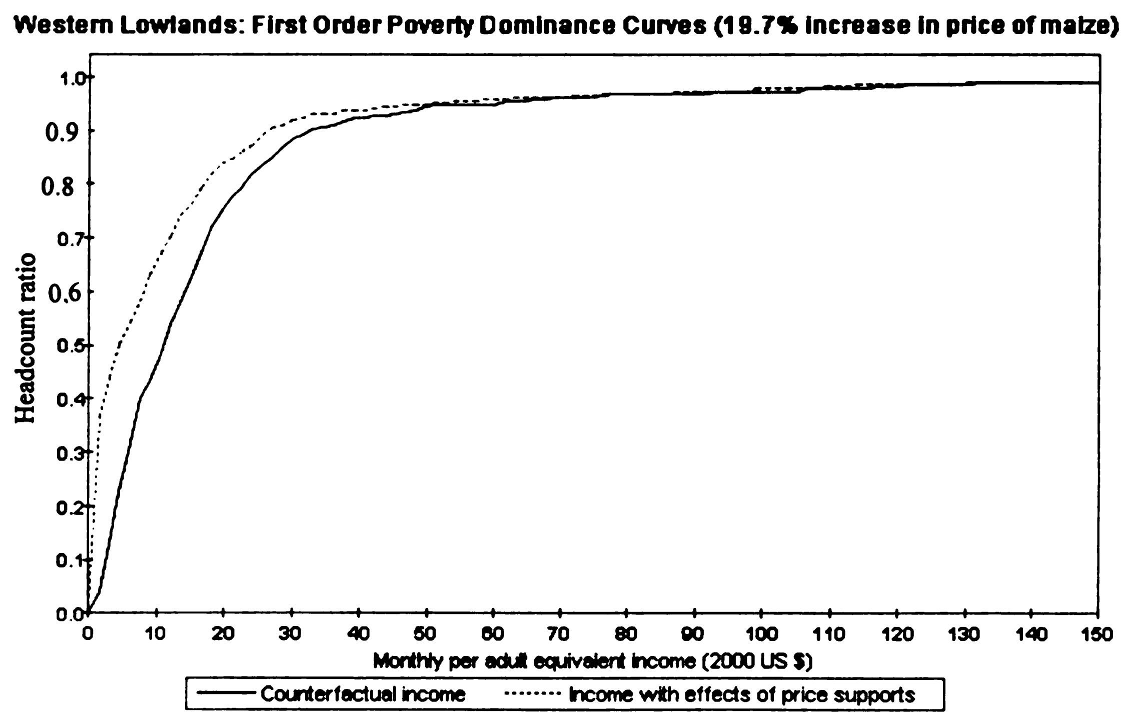


Table 3.3. First Order Poverty Dominance of Counterfactual Incomes over Incomes with Effects of Price Controls (Headcount ratio higher with Price Controls): All lowlands

Broad Agro-climatic Zone	First Crossing Point of Cumulative Income Distributions (Upper Bound Poverty Line for Headcount ratio)						Robustness to the World Bank and the WMS poverty line
	US Dollar ($) amount (std deviation)			Amount in Kenya shillings (Kshs) (std deviation)			
	15 %	19.7 %	25 %	15 %	19.7 %	25 %	
Coastal Lowlands	57.49 (0.00)	57.46 (0.00)	57.30 (0.00)	4,486 (0.00)	4,484 (0.00)	4,471 (0.00)	Satisfies both
Eastern Lowlands	69.90 (12.53)	80.43 (8.64)	80.43 (8.80)	5,455 (978)	6,276 (674)	6,276 (687)	Satisfies both
Western Lowlands	49.99 (0.00)	75.44 (5.58)	74.68 (4.11)	3,901 (0.00)	5,887 (435)	5,828 (321)	Satisfies both

Referring to figures 3.1 through 3.3, the first point at which the two cumulative income distributions cross is the upper-bound poverty line for the headcount ratio. For any level of income below the crossing point, the value of the cumulative distribution of counterfactual incomes is lower than that of incomes with effects of price supports. Because each of the two distributions has a single income observation from every household, the distribution with a higher cumulative value has more observations with values less than the crossing point, and hence a higher probability for lower incomes. It therefore follows that if we take the crossing point or any level of income less than the crossing point to be a poverty line, the headcount ratio will be higher with price supports.

The headcount ratio is estimated at the vertical axis and incomes (variable poverty lines) are in the horizontal axis. For example, in figure 3.1 and first row of table 3.3, the two cumulative distributions cross at US$ 57.46; which is higher than the World Bank (US $30) poverty line. Further, the cumulative value of the distribution of counterfactual incomes is below that of incomes with effects of price supports at any value less than the crossing point. This means that if any income level below the crossing point is taken as a yardstick (e.g. the US \$30 World Bank poverty line), the distribution of income with price supports has a higher probability for lower values compared to counterfactual distribution of income with no price supports. A higher probability for lower values translates to a higher headcount ratio, as measured in the vertical axis. We conclude that NCPB operations in the maize market have increased the number of the poor in Coastal Lowlands. Figure 3.2 and 3.3 show similar results for Eastern Lowlands and Western Lowlands respectively. Corresponding crossing points for figures 3.2 and 3.3 are respectively summarized in the second and third rows of table 3.3. The lowlands are characterized by poor soils, poor rainfall, and climatic conditions that are not conducive for high yielding maize varieties. CBS (2003) shows that some of the major poverty spots in the country are found in coastal lowlands and western lowlands. Evidently, an increase in the price of maize exacerbates poverty in these regions.

In contrast to the lowlands, the Kenyan highlands (western highlands and central highlands) boast high agricultural potential and favorable rainfall patterns. Crop production is highly diversified and well serviced by a decent physical infrastructure. Other than maize these regions are well suited for coffee, tea, horticulture, and dairy enterprises. Coffee, tea, and horticulture are major income earners and maize is largely grown as a food crop. Figures 3.4 and 3.5 show results similar to those obtaining in the lowlands. Corresponding crossing points are provided in table 3.4. We conclude that the policy has lead to an increase in the incidence of poverty in Western Highlands and Central Highlands.

Table 3.4. First Order Poverty Dominance of Counterfactual Incomes over Incomes with Effects of Price Controls (Headcount ratio higher with Price Controls): All Highlands

Broad Agro-climatic Zone	First Crossing Point of Cumulative Income Distributions (Upper Bound Poverty Line for Headcount ratio)						Robustness to the World Bank and the WMS poverty line
	US Dollar ($) amount (std deviation)			Amount in Kenya shillings (Kshs) (std deviation)			
	15 %	19.7 %	25 %	15 %	19.7 %	25 %	
Western Highlands	43.01 (3.83)	47.21 (11.94)	56.89 (9.08)	3,356 (299)	3,684 (932)	4,439 (709)	Satisfies both
Central Highlands	92.36 (40.89)	142.90 (22.94)	123.68 (47.55)	7,207 (3,190)	11,151 (1,790)	9,652 (3,711)	Satisfies both

Figure 3.4. First Order Poverty Dominance Curve for Western Highlands

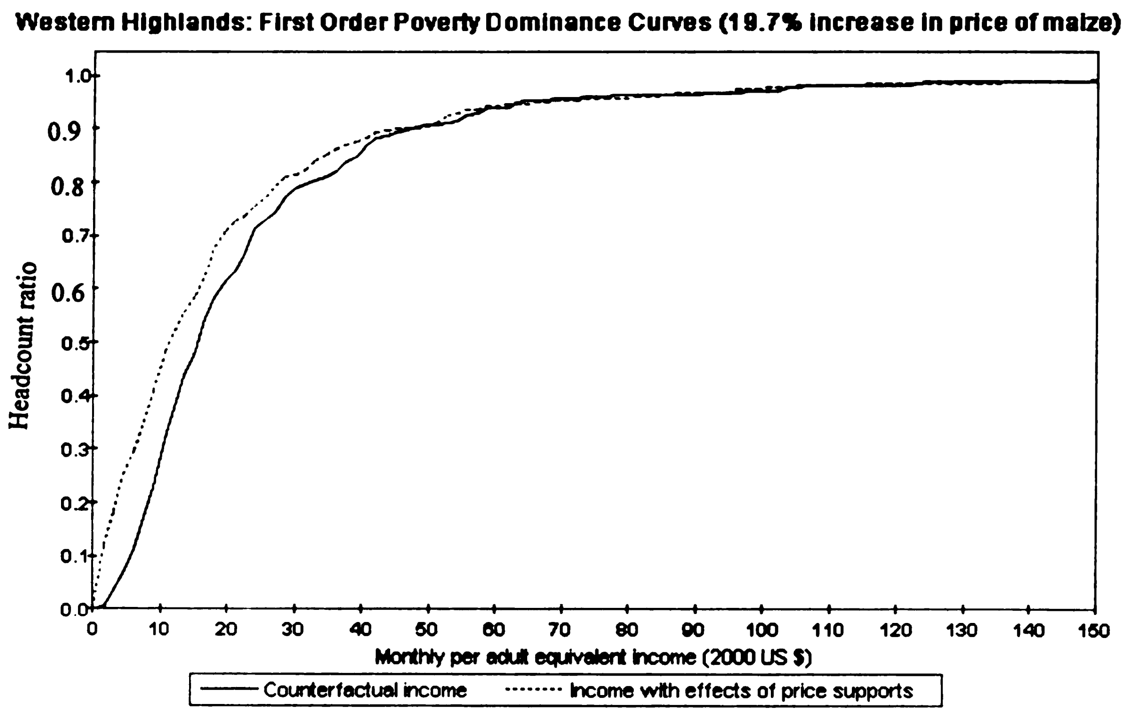
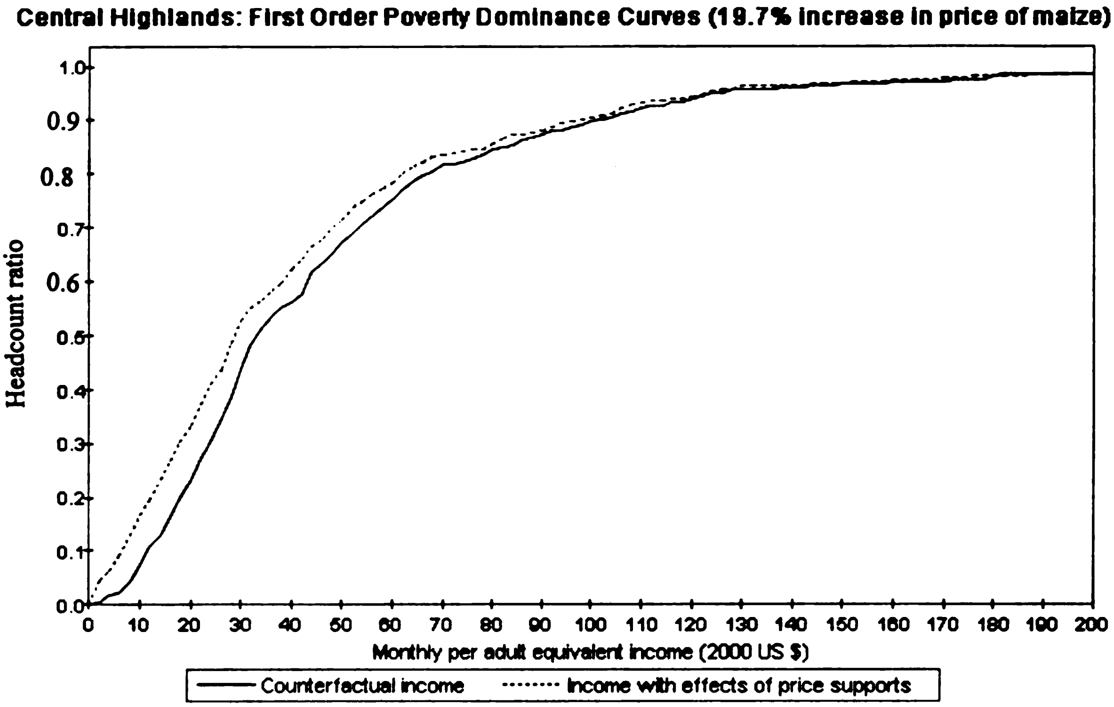


Figure 3.5. First Order Poverty Dominance Curve for Central Highlands



In the western transitional zone, the crossing point of first degree stochastic (poverty) dominance curves does not nest the World Bank threshold (figure 3.6 and table 3.5). Therefore poverty orderings in this region will be based on the poverty gap measure, which leads us to consider second degree dominance test (Figure 3.7). This test determines the cumulative difference of the area under the distribution of incomes with NCPB operations from the area under the distribution of counterfactual incomes. The latter dominates the former as long as the cumulative differences remain non-positive. Figure 3.7 shows that the differences are non-positive across the entire range of income. This means that the distribution of counterfactual income without price supports dominates in the second degree the distribution of income with price supports. Equivalently, we say that if any level of income is taken to be a poverty line then income shortfalls from any such poverty line are higher with price supports. We therefore conclude that in this region, the NCPB maize operations reduce incomes among those already poor, but do not appreciably affect the numbers of the poor.

Figure 3.6. First Order Poverty Dominance Curve for Western Transitional

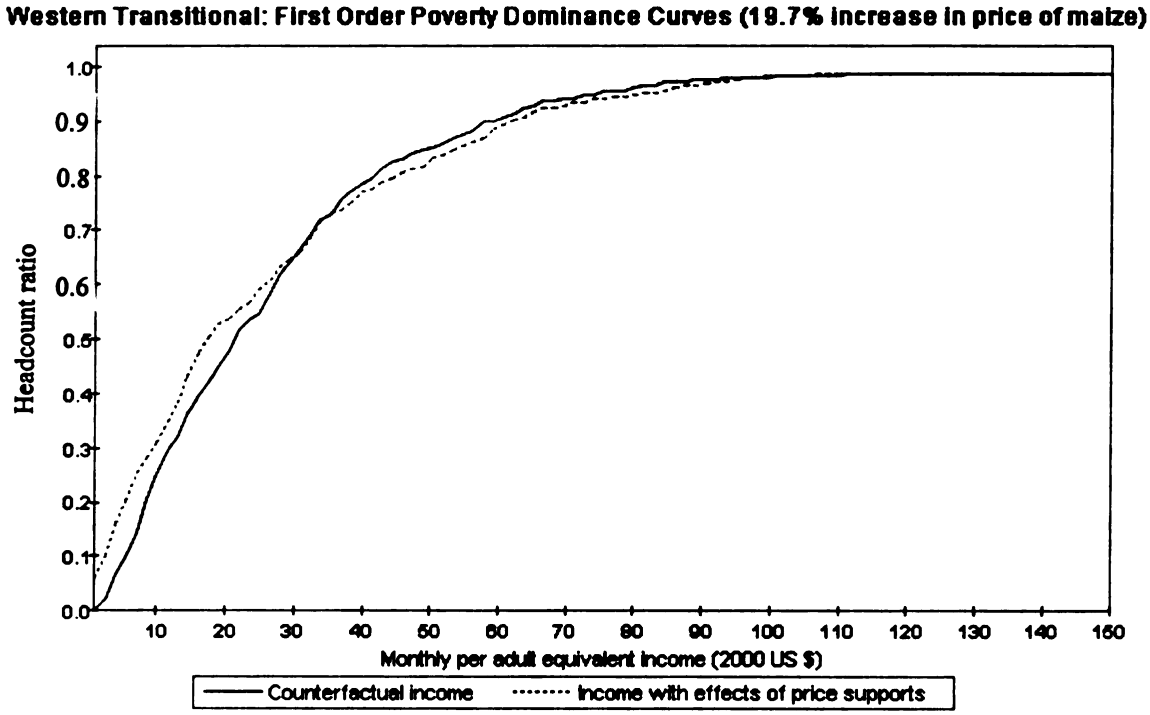


Figure 3.7. Second Order Poverty Dominance Curve for Western Transitional

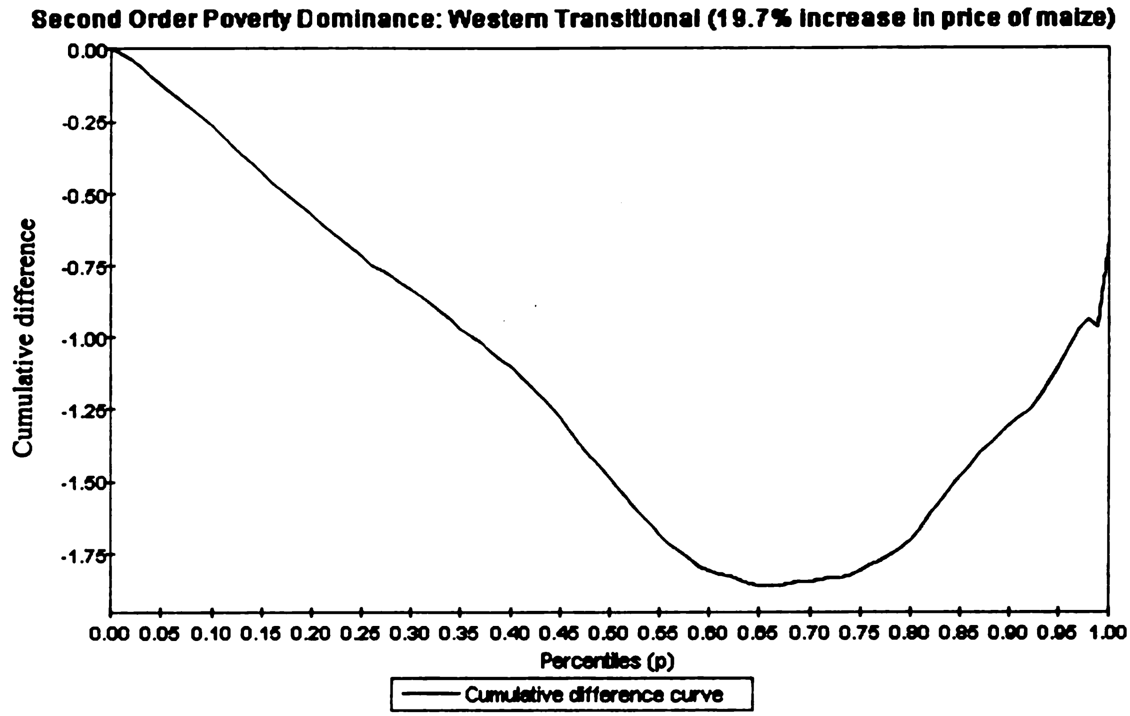


Table 3.5. First Order Poverty Dominance of Counterfactual Incomes over Incomes with Effects of Price Controls (Headcount ratio higher with Price Controls): Western transitional

Broad Agro-climatic Zone	First Crossing Point of Cumulative Income Distributions (Upper Bound Poverty Line for Headcount ratio)						Robustness to the World Bank and the WMS poverty line
	US Dollar ($) amount (std deviation)			Amount in Kenya shillings (Kshs) (std deviation)			
	15 %	19.7 %	25 %	15 %	19.7 %	25 %	
Western Transitional	29.52 (3.96)	30.10 (3.48)	30.61 (3.18)	2,304 (309)	2,349 (272)	2,389 (248)	Satisfies only WMS poverty line

Conditions in the western transitional zone with regard to land potential, market infrastructure, and crop mix approach those in the high potential maize zone (HPMZ). In Kenya, a large proportion of marketed maize is grown in the high potential maize zone. The region boasts excellent conditions for growing maize and wheat, and farm sizes are relatively large. Among the seven agro-climatic zones considered, it is only in this zone where the price-increasing maize policy does not increase poverty as measured by the headcount ratio and the poverty gap measure. In Figure 3.8 and table 3.6, the crossing point of the two cumulative distributions is below both the World Bank poverty line and the WMS threshold. Similarly, Figure 3.9 and Table 3.7 for second degree dominance test shows that cumulative differences in the area under the two distributions remain non-positive only up to the 45th percentile of income, which is equivalent to $27.17 or Kshs 2,120. This threshold is lower than the World Bank poverty line and therefore the test is inconclusive.

Figure 3.8. First Order Poverty Dominance Curve for High Potential Maize Zone

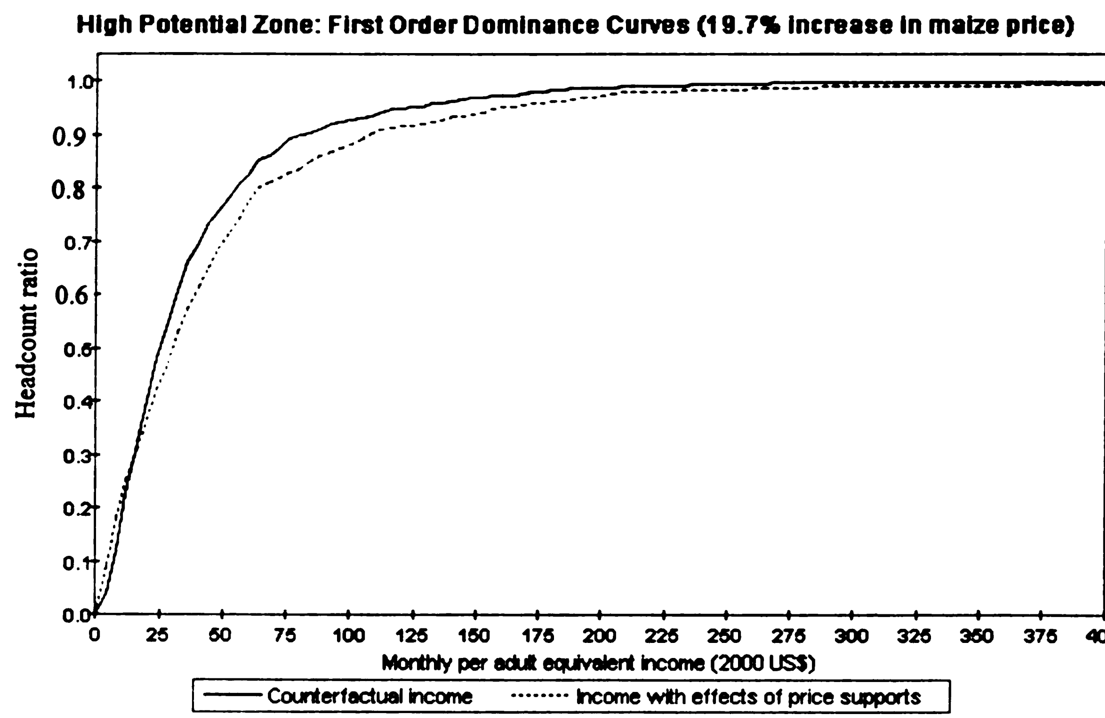


Figure 3.9. Second Order Poverty Dominance Curve for High Potential Maize Zone

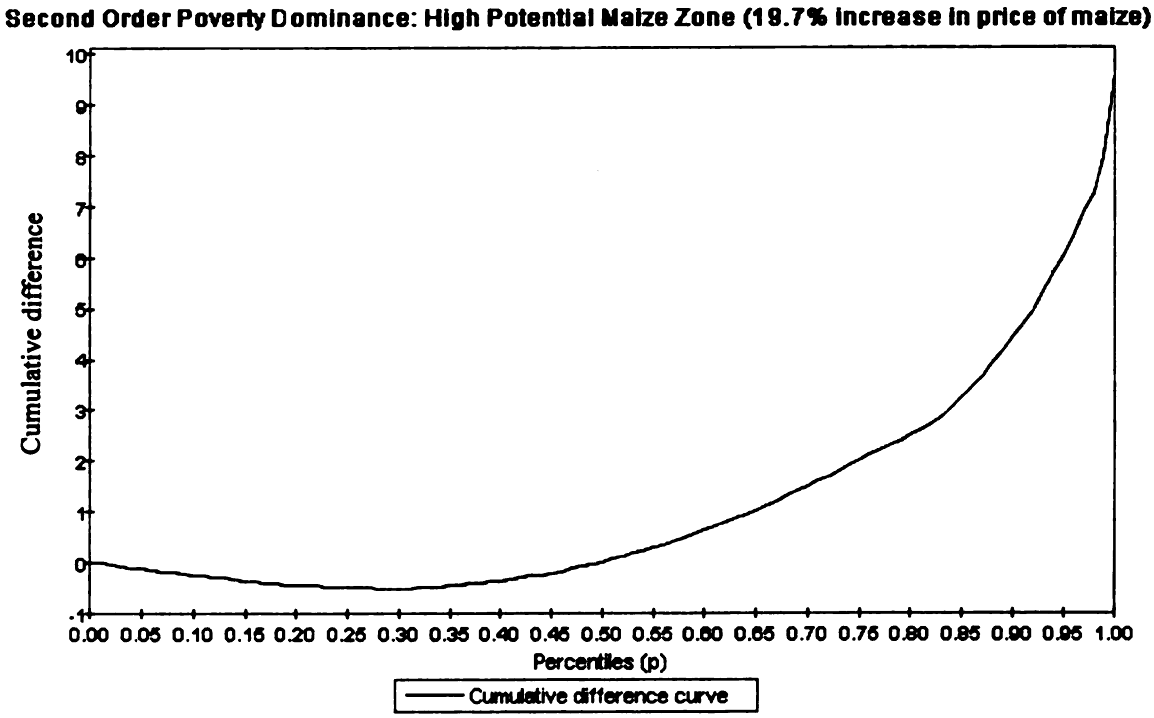


Table 3.6. First Order Poverty Dominance of Counterfactual Incomes over Incomes with Effects of Price Controls (Headcount ratio higher with Price Controls): High potential maize zone

Broad Agro-climatic Zone	First Crossing Point of Cumulative Income Distributions (Upper Bound Poverty Line for Headcount ratio)						Robustness to the World Bank and the WMS poverty line
	US Dollar ($) amount (std deviation)			Amount in Kenya shillings (Kshs) (std deviation)			
	15 %	19.7 %	25 %	15 %	19.7 %	25 %	
High Potential Maize Zone	13.59 (2.38)	14.49 (1.83)	14.49 (1.56)	1,061 (186)	1,131 (143)	1,131 (122)	Satisfies None

Table 3.7. Second Order Poverty Dominance of Counterfactual Incomes over Incomes with Effects of Price Controls (Poverty Gaps Higher with Price Controls): High potential maize zone

Broad Agro-climatic Zone	Amount at which cumulative difference between income distributions reaches zero (upper bound poverty line for poverty gap measure)						Robustness to the World Bank and the WMS poverty line
	US Dollar ($) amount (std deviation)			Amount in Kenya shillings (Kshs) (std deviation)			
	15 %	19.7 %	25 %	15 %	19.7 %	25 %	
High Potential Maize Zone	24.39 (1.89)	27.17 (1.82)	30.01 (2.07)	1,903 (147)	2,120 (142)	2,342 (162)	Satisfies only WMS poverty line

In summary, we find that the effects of the price-increasing policy of the NCPB is largely influenced by the proportion of net purchasing and net selling rural households in each zone. As shown in Table 3, the marketed maize output in Kenya is concentrated in one zone (High-Potential Maize Zone). Most other rural areas of Kenya derive the bulk of their cash income from other crops, non-farm income, and livestock.

3.4 Conclusions

This chapter serves two purposes. The first is to reveal the conceptual framework used in measuring the effects of price policy on welfare, and the second purpose is to examine the impact of the price policy on poverty. Methodologically, this study extends the previous disequilibrium model used in Deaton (1989), Budd (1993), and (Barrett and Dorosh 1996) and provides a second order approximation of the equilibrium income changes.

Second round effects on incomes are estimated with an assumption of equal supply and demand elasticity for maize farmers across the income divide. It can be expected that factor fixity would be different between the poor and the rich, and therefore the supply response could be higher for wealthy farmers who have more factors at their disposal. On the other hand, since maize purchases comprise a larger budget share among the poor, the ensuing augmented tilt in the budget constraint of the poor will probably be met by a demand response larger than that of rich farmers. To examine if possible differences could affect the results, I conducted a sensitivity analysis using different demand and supply elasticity for 3 income terciles. For the lower income tercile, the supply elasticity in table 3.1 was reduced by 20% while the demand elasticity was increased by the same margin. Similarly, I reduced the demand elasticity by 20% for the higher tercile and increased the supply elasticity by the same margin. The demand and supply elasticity in table 3.1 were maintained for the middle tercile. These changes did not affect the results.

Usually, welfare evaluations based on the commonly used FGT poverty measures employ a single poverty line. As such, it is possible that results could be reversed when a different poverty line is used; an ambiguity that is clearly undesirable. This paper does not suffer the weaknesses posed by the identification problem. The analysis has exploited the parallel between stochastic dominance and FGT measures of poverty to generate poverty rankings that hold for a wide array of poverty lines, including the commonly used World Bank $1 a day poverty line and a threshold used by the government of Kenya. Further, the analysis is conducted for all price increases within 5% standard deviation of the impact suggested by a recent study on the effects of the policy on price levels.

Results show that the joint effects of NCPB price supports and tariff on imported maize increase the number of poor farmers across Kenya, except in the maize surplus regions of the Rift Valley and Western provinces (HPMZ and Western Transitional zones). In the Western Transitional zone the policy seems to reduce incomes among those already poor, but does not appreciably affect their numbers. Looking at the varied poverty effects of the policy in different regions, we infer that empirical work at the national level may not be appropriate as it would mask important regional differences, especially in situations where farming conditions are not homogenous. Differences in agro-climatic conditions, land potential, crop diversification, and household incomes profile interact to produce varying intensities of the impact of changing food prices on poverty.

CHAPTER 4

MAIZE PRICE POLICY AND INCOME DISTRIBUTION

Abstract

Most empirical studies on the subject of welfare effects of changing food prices are focused on the income distribution aspect. The empirical methods used have barely evolved beyond the non-parametric framework used in the first analysis. This paper considers a partly linear semi-parametric model to control for the influence of variables that not only influence the elasticity but which are also correlated with income. The results indicate that households at the lower points of the income range loose at least 25% of their incomes while the wealthiest either gain some proportion of their incomes or remain unaffected. The gains improve as initial incomes rise and the losses become more adverse as initial incomes fall. This general pattern is common in all the regions considered.

4.1 Introduction

Empirical studies on the welfare effects of food pricing policies have mainly addressed the question of how price changes affect the distribution of income. Most studies on this subject have largely employed non-parametric methods following their first use in Deaton (1989). Deaton (1989) considered the distribution of 'net benefit ratio[5]' or 'net consumption ratio' conditional on expenditure to analyze the income distribution effects of price changes. The key finding from the study was that rice price

[5] Net benefit ratio (NBR) also called Net consumption ratio is calculated as production value less consumption value as a ratio of expenditure

increases in Thailand had little first order impacts on the welfare of the poor and the rich. It is farmers in the middle of the income distribution that were affected most either as gainers or losers. Budd (1993) found that changes in welfare due to changing prices of a single commodity or a group of commodities were quite small in Cote d'I Voire. This was the case because net purchases of individual commodities or a group of them formed a small portion of expenditures (less than 5%). This pattern was found to be stable across welfare levels.

Barrett and Dorosh (1996) focused on rice in Madagascar. They examined marketable surplus and net rice sales conditional on per capita income and per capita land, an approach which assumes that the proportion of production consumed at home consumption is inelastic to changing prices. The results they obtain are different from Deaton (1989) in that both marketable surplus and net rice sales were lowest among the income poor and land poor, but highest among the rich and those highly endowed with land assets. They conclude that increasing rice prices would mostly hurt the poor and that the gains would gradually improve as income and land endowment increases.

The non-parametric regressions used in all the previous studies were based on arbitrary bandwidth parameters - usually over-smoothed, and therefore the convergence properties of the estimated conditional expectation functions are highly compromised. Over-smoothing of regression curves can cause very misleading conclusions. For example, if the regression curve based on the optimal bandwidth parameter (the consistent estimate) is generally upward sloping but with a dip in the middle, over-smoothing would flatten the dip and give a gentle upward slopping curve. The information provided by the dip will clearly be lost, and therefore conclusions based on an over-smoothed regression curve could be very misleading. This critical shortcoming in previous analyses was probably entertained because of the complexity involved in computing optimal bandwidths. However, recent developments in statistical software have made such computations inexpensive. In this study, all regression curves are estimated using optimal bandwidths computed using the cross-validation method. The DAD software is used for this purpose.

This study provides two methodological extensions to earlier work. Using a second order approximation of equilibrium income changes, we are able to account for the effects of the policy on supply response, demand for maize, and the rural labor market. This is in contrast to previous studies which employed a disequilibrium first order analysis which inevitably gives estimates that are at the lower bound. The second extension regards the use of a partly linear semi-parametric model which enables us to control for the influence of household demographics, land access, input and output prices, rainfall, physical infrastructure, and household characteristics such as levels of education. The model is estimated using the Generalized Speckman Estimator (Speckman 1988).

Results suggest that household size (adult equivalent), age of household head, and the incidence of female-headed households are negatively related to gains from the policy. As it could be expected, the level of adult education and the value of farm assets have a positive relationship with gains from the policy. The income distribution bias of increased maize prices is not very different across the regions. Households with incomes at the lowest points of the range lose at least 25% of their incomes while the wealthiest either gain some proportion of their incomes or remain unaffected. These patterns are very similar to those observed with regard to rice in Madagascar (Barrett and Dorosh

1996). We therefore conclude that the policy engenders inequality in rural Kenya on top of the adverse consequences on poverty that were found in chapter 3.

The chapter is organized as follows; the next section provides a conceptual framework for estimating distributional effects of the policy, a discussion that is centered on the specification and estimation strategy of the partly linear semi-parametric model. Results are presented in section 3 followed by conclusions in section 4.

4.2 Conceptual Framework

The poverty orderings in chapter 3 summarize the effects of the policy on incomes of households that are already poor and those who become poor as a result of the policy, but they ignore potential effects on incomes of the non poor who remain non poor. Questions such as whether rich farmers benefit more relative to poor farmers, or vice versa, and how that differs from one region to another are important for policy makers. The next section presents a model to study the effects of the policy on the distribution of income.

4.2.1 The Semi-parametric Model

The magnitude of changes in income as a result of the policy are influenced by factors determining production, marketing, and consumption levels; such as land assets, demographic characteristics, input and output prices, market access, and household characteristics e.g. levels of education[6]. Some of these factors are also correlated with income; for example, levels of education could move together with total household

[6] Table 3.3 summarizes variables considered in the model

income through their effects on non-farm income and salaried income. Others such as market access, land assets, and input and output prices determine the degree to which adjustments are made in markets for other commodities. The semi-parametric model controls for the influence of these factors in estimating the expected changes in income at different levels of it. These factors are assumed to have a parsimonious linear relationship with the dependent variable hence the parametric part of the model. Expected changes in income are estimated non-parametrically.

The panel data representation of a partly linear model takes the form

$$y_{it} = z_{it}\beta + m(x_{it}) + c_i + u_{it}. \tag{4.1}$$

Where, x_{it} is income of household i at time t and z_{it} is a vector of variables that include land assets, demographic characteristics, and household characteristics, among others. The dependent variable y_{it} is the second order approximated equilibrium changes in income. c_i is a time constant unobservable and u_{it} is a zero mean disturbance term. There are two reasons why semi-parametric estimation is preferred. The main thrust is that it provides a versatile method of exploring the relationship with respect to income without reference to a parametric specification, more so because economic theory does not offer much guidance on functional forms. As such the approach is well suited to analyze the effects on the distribution of income because the expected changes in income can be estimated at every point along the income continuum. The second advantage relates to the fact that income (an explanatory variable) and the second order approximated changes in income (the dependent variable) are jointly determined, which makes parametric estimation cumbersome.

Unlike in previous studies, we use optimal smoothing parameters in all non-parametric regressions to insure consistency of the conditional expectation function. The problems of using arbitrary smoothing (bandwidth) parameters in non-parametric regressions are similar to those of functional form misspecification in parametric parlance Hardle (1990). Regression curves based on arbitrary bandwidth parameters are usually over-smoothed and lead to imprecise estimation of the conditional expectation function. For example, if the regression curve based on optimal bandwidth parameter is generally upward sloping, but with a dip in the middle, an over-smoothed curve will flatten the dip leading to a gentle upward sloping curve. The resulting gentle upward sloping curve is a false conditional expectation function and therefore statements based on it could be very wrong.

4.2.2 The Estimation Strategy

A variety of techniques have been used to estimate partly linear models. Robinson (1988) constructed a feasible least square estimate of β based on separate estimates of the non-parametric component by a Nadaraya-Watson estimator. Under some regularity conditions, ordinary least squares (OLS) regression of y_{it} on z_{it} alone consistently and efficiently estimates β. Required for consistency is $E(z_{it}m(x_{it}))=0$, a condition attainable when either $E(z_{it})=0$, or through statistical independence between x_{it} and z_{it}. This approach is not considered here because there is evidence in the literature that income is correlated with variables such as asset values, land access, and some household characteristics.

Other techniques that could be used include Spline smoothing. This approach has been used in a variety of studies such as Green and Silverman (1994); Engle, Granger, Rice and Weiss (1986); Heckman (1986); and Rice (1986) to derive penalized estimators of β and m. In this context, a penalty parameter is used to reflect the degree of compromise between minimizing the residual sum of squares (in estimation of β), and smoothing of m (in estimation of the regression curve). Rice (1986) and Schimek (1997) show that the resulting estimators of β and m are inconsistent.

This study uses the Generalized Speckman Estimator (Speckman 1988) because the properties of the estimators are well known, and also because the procedure is relatively easy to apply. Specifically, $\hat{\beta}$ achieves $\sqrt{n}$ consistency while the rate of convergence of the estimator of $m(x_{it})$ and its derivatives is lower than $\sqrt{n}$ (Hardle 1990). The procedure is essentially an application of the Frisch-Waugh Theorem, formally presented and stated in Greene (2003) thus "In the linear regression of vector Y on two sets of variables, X_1 and X_2, the subvector β_2 is the set of coefficients obtained when the residuals from a regression of Y on X_1 alone are regressed on the set of residuals obtained when each column of X_2 is regressed on X_1. To demonstrate the procedure, I begin by taking expectations conditional on x_{it} from Equation (4.1).

$$E(y_{it} \mid x_{it}) = E(z_{it}\beta \mid x_{it}) + E\{m(x_{it}) \mid x_{it}\} + E(c_i \mid x_{it}) + E(\upsilon_{it} \mid x_{it}). \tag{4.2}$$

Subtracting the above from Equation (4.2) gives

$$y_{it} - E(y_{it} \mid x_{it}) = \{z_{it} - E(z_{it} \mid x_{it})\}\beta + c_i - E(c_i \mid x_{it}) + \upsilon_{it} - E(\upsilon_{it} \mid x_{it}). \tag{4.3}$$

Since $E\{m(x_{it}) | x_{it}\} = m(x_{it})$. The composite disturbance term in Equation 4.3 $\upsilon_{it} - E(\upsilon_{it} | x_{it})$ has a mean of zero since by definition Equation (4.1) implies $E(\upsilon_{it} | x_{it}, z_{it}) = 0$. It is important to note that $y_{it} - E(y_{it} | x_{it})$ and $\{z_{it} - E(z_{it} | x_{it})\}$ respectively give expected values of the dependent variable and the covariates after removing the effects of income.

In order to use Equation (4.3) to estimate β, we will first replace the terms $E(y_{it} | x_{it})$ and $E(z_{it} | x_{it})$ by their non-parametric estimators. Sample analogs of $E(y_{it} | x_{it})$ and $E(z_{it} | x_{it})$ are obtained using the Nadaraya-Watson estimator - in the same way that the non-parametric part of model is estimated. The discussion on non-parametric regressions is reserved for section 4.2.2.2. However, it is worth noting that it is the residuals from Equation 4.3 that will be used to estimate the non-parametric part of the model. These residuals represent the part of variation in y_{it} that is not explained by the covariates and which therefore could be attributed to variation in household incomes.

The next section will discuss various approaches that could be used to estimate β. The covariates in the parametric part of the model include various household characteristics such as age of the head of household, highest education level by an adult member, female head dummy, and household size (measured by adult equivalents), among others. District dummies are used to account for differences in maize prices and prices of production inputs such as fertilizers and hybrid seeds. Variables such as distance to motorable road and distance to hybrid seed seller are used to capture market access and the level of infrastructure development. Weather variations are captured by rainfall levels in the main planting season.

4.2.2.1 Estimating the Parametric Part

A variety of methods are possible for the estimation of β from Equation 4.3. First I considered pooled OLS. Standard tests on results from pooled OLS suggest the existence of both heteroskedasticity and serial correlation. The latter is usually related to a time-constant unobservable factor (unobserved heterogeneity) in the error term (Wooldridge 2001). Correlation between the unobserved time-constant factor and any of the explanatory variables renders pooled OLS inconsistent and therefore I considered other methods such as first differencing and fixed effects estimation. The motivation for first differencing is that the time constant unobservable variable is removed in the differencing process. However, the process would also remove other time constant variables such as education, land size, and demographic characteristics, and therefore partial effects of these variables cannot be estimated even when they are constant only for a section of the sample.

The fixed effects method is particularly attractive because it allows for arbitrary correlation between the unobservable factor and any of the observable explanatory variables. However, the method suffers the same weaknesses as first differencing – the effect of time constant observables cannot be estimated. Because of the nature of the estimator, it is important that the effects of all variables in the parametric part of the model are removed before estimating the non-parametric part. This leads us to the random effects estimator. With this method it is possible to get precise estimates of the partial effects of time constant observables such as education, household characteristics, and demographic characteristics. The key assumption that would allow us to proceed this way is that the time constant factor is uncorrelated with any of the explanatory variables.

Random effects estimation gives inconsistent estimates whenever the assumption is violated.

In the context of this work, random effects approach becomes attractive and practical since the interest is on the partial effects of variables some of which do not change over time. Before proceeding with the random effects procedure, I conducted the Hausman test to look for systematic differences between the random effects estimates and coefficients estimated through fixed effects. The null hypothesis in the Hausman test is that random effects estimator is consistent and efficient. Results show that we cannot reject the null that random effects estimator is consistent and efficient for five out of the seven regions. In the two regions where the null was rejected, the fixed effects procedure suggested that none of the variables in z_{it} had explanatory power. This means that all the variables in z_{it} could be ignored from the models for those two regions.

Estimation of β is largely an intermediate process which is used to remove the part of changes in income that is explained by the z_{it} variables. It is the residuals from this regression that will be used in the next step to obtain non-parametric estimates of the expected changes in income at its different levels (as will be discussed in the next section). Residuals from the fixed effects estimator will still contain that part of z_{it} that is time invariant e.g. the size of land owned and education levels. On the other hand, if we use random effects then we would fully remove all the variables in z_{it} and the accompanying residuals will just contain that part of income changes which is not explained by z_{it}. The next section will discuss the non-parametric estimator used for the regression between the residuals and log of income.

4.2.2.2 Non-parametric Regressions

After obtaining the residuals from Equation (4.3), the last step of the Generalized Speckman Estimator is to estimate $m(x)$ using the Nadaraya-Watson estimator from

$$E(y_{it} - z_{it}\beta \mid x_{it}) = m(x_{it}) + u_{it} \tag{4.4}$$

In the remaining sections we use the standard notation for the explanatory variable y_{it} in place of $(y_{it} - z_{it}\beta \mid x_{it})$. With this change in notation we can define the conditional expectation $m(x_{it})$ as

$$m(x_{it}) = E(y_{it} \mid x_{it} = x) = \int y_{it}\left[\frac{f_{x,y}(x,y)}{f_x(x)}\right]dy_{it} \tag{4.5}$$

Where, the numerator $f_{x,y}(x,y)$ is the joint density of x_{it} and y_{it}, and the denominator $f_x(x)$ is the marginal density of x_{it}. The conditional expectation in Equation (4.5) defines the regression curve of y_{it} on x_{it}. Following Hardle (1990) $\hat{m}_h(x_{it})$ the pooled estimator of the conditional moment is given as

$$\hat{m}_h(x_{it}) = \frac{nt^{-1}\sum_{i=1}^{n}\sum_{t=1}^{T} K_h(x - x_{it})y_{it}}{nt^{-1}\sum_{i=1}^{n}\sum_{t=1}^{T} K_h(x - x_{it})}. \tag{4.6}$$

Equation (4.6) is called the *Nadaraya–Watson estimator*. Where, n is the sample size, T is the length of the panel, and x_{it} and y_{it} are pair-wise values of the log of income and the changes in income after removing the effects of z_{it}. The estimator comprises a weighting function for each y_{it} defined by

$$w_{it}(x, x_{it}) = \frac{K_h(x - x_{it})}{\sum_{i=1}^{n} \sum_{t=1}^{T} K_h(x - x_{it})} . \tag{4.7}$$

The shape of the weight function is determined by the kernel density function K, whereas the bandwidth parameter h determines the size of the weights that sum to unity. In this study K_h is the Gaussian Kernel which takes the form

$$K_h(x - x_{it}) = \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{(x - x_{it})^2}{2h} \right]. \tag{4.8}$$

Unlike most kernel functions, the Gaussian kernel is not bounded on x_{it} which means that in theory all data points will be brought into every estimate. However, points outside three standard deviations hardly make a difference in practice.

Under 'independent and identically distributed' (iid) assumptions on u_{it}, the empirical regression curve $\hat{m}_h(x_{it})$ is consistent for the conditional expectation $m(x_{it})$. The rate at which $\hat{m}_h(x_{it})$ converges to $m(x_{it})$ is determined by the Kernel (K), and the bandwidth (h). Hardle (1990) shows that of the two determinants, the bandwidth is the most critical in the precision of $\hat{m}_h(x_{it})$. Bandwidth selection methods include leave-one-out cross validation, use of penalizing functions, and the plug-in method. A discussion of these methods and the optimality of resultant bandwidths can be obtained from Hardle (1990). Hardle and Marron (1985) have shown that the leave-one-out cross validation method leads to optimal bandwidth selection. The bandwidth parameter selected using this method minimizes the various asymptotic equivalent global measures of the distance[7] between $\hat{m}_h(x_{it})$ and $m(x_{it})$. The estimator $\hat{m}_h(x_{it})$ is said to be 'asymptotically optimal' when the cross validation optimal bandwidth parameter is used, because it achieves the optimal rate of convergence to $m(x_{it})$ (Hardle 1990).

The iid assumption on u_{it} is not tenable when panel data is used. This is because the error term in one period might be correlated with that of another period for the same household. The correlation speculated here may be related to unobserved heterogeneity. Ignoring correlation in errors leads to a choice of a small bandwidth parameter and compromises the convergence properties of $\hat{m}_h(x_{it})$; the reason being that the regression method will interpret the existing correlation in the errors as part of the regression curve. Given a two year panel with (y_{it}, x_{it}) ordered chronologically and stacked on top of one another, allowing for first order serial correlation suffices for the computation of optimal h. Usually regressions that allow for serial correlation in the error term lead to a higher bandwidth parameter than those that assume independence of the error term (Hardle 1990).

4.3 Data Construction

The data used in this analysis is compiled from the Tegemeo household surveys described in section 2.2. Household and demographic characteristics variables are easy to compute directly from the demography modules in 2000 and 2004 survey data. Similarly, the panel data has readily available information on land access, asset endowments, and

[7] Global measures evaluate convergence at all points-the mean square error looks at pointwise convergence.

infrastructure variables. Tegemeo also provided data on rainfall which they had originally sourced from the department of meteorology in Kenya.

Tegemeo data has very detailed information on various sources of income which include; crop income, livestock income, salaries and remittances, and incomes from business and informal activities. Incomes from each of these sources are computed and then summed up to give total household income. These computations are done separately on the 2000 and 2004 survey data. The vector of 2004 total household incomes is then deflated to 2000 using the official inflation rate profile in the two years. The data is then combined to form a two year panel data. Next I used the pooled total household income vector to generate a vector of counterfactual incomes. Computation of counterfactual incomes and the second-order approximated percentage changes in income is already explained in Section 3.3.

4.4 Results

4.4.1 The Influence of Factors Other Than Income

This section will discuss results from the estimation of Equation 4.3. As discussed in section 4.2.2.1, the estimation approaches considered in this study are fixed effects and random effects. With the random effects estimator, the variance due to the time constant unobservable was found to be higher than that of the idiosyncratic error. This means that estimates from the random effects generalized least squares are better compared to those from pooled OLS (Wooldridge 2001). It is for this reason that the random effects procedure is considered rather than pooled OLS. Table A4.1 through table A4.7 in the appendix section give results for the seven agro-climatic zones. Only variables that had joint significance were retained in the models because the aim of these regressions is to get residuals which will be used in the last step of the generalized speckman estimator.

The Hausman test which was performed for every zone suggests that the random effects estimator is consistent and efficient in five out of the seven zones. These five zones are coastal lowlands, eastern lowlands, western lowlands, high potential maize zone, and central highlands. The null that the random effects estimator is consistent and efficient is rejected in the models for western highlands and western transitional. The coefficients from the two estimators are of the same signs in models for all the regions.

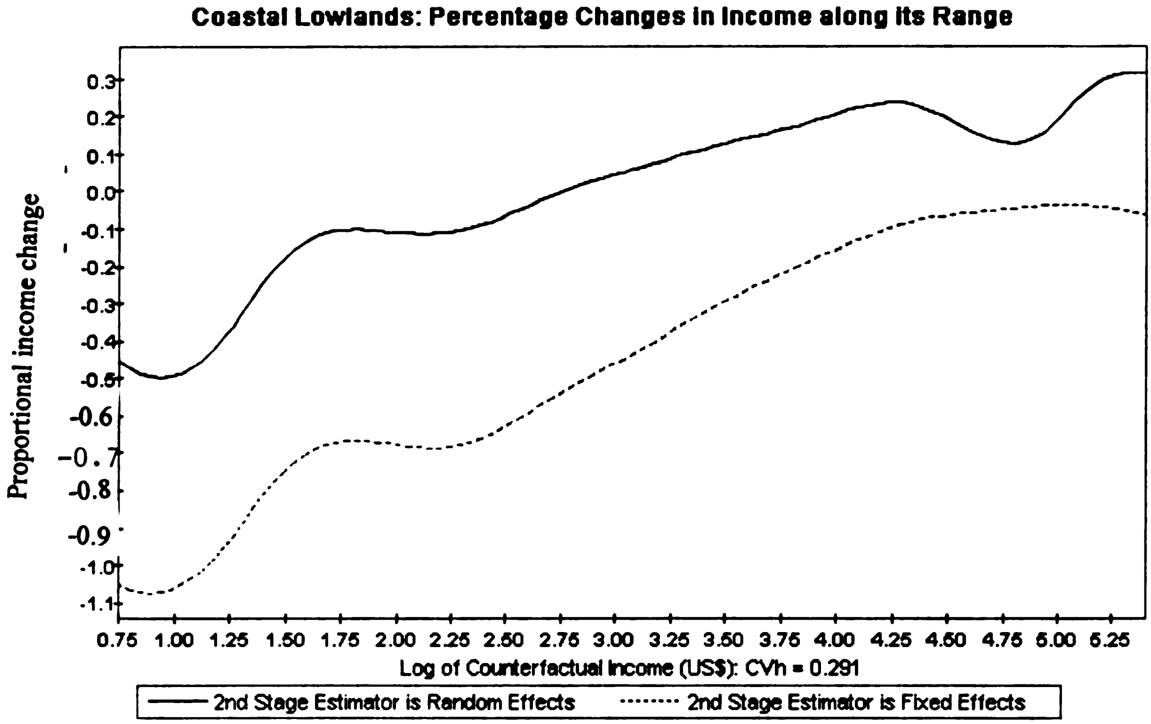
Where significant, the influence of household size is negative. This pattern could be attributed to prevalence of small farm sizes, to the extent that the marginal labor productivity of maize is infinitesimal for a majority of households. On the other hand, maize consumption requirements increase as household size expands. Both of these forces lead to a reduction in marketable surplus or an aggravated net buyer status. The age of the head of the household is negatively related to gains from maize price policy while squared age has a positive influence which depicts a situation of increasingly negative welfare effects as age advances. The value of farm assets and the level of adult education are associated with gains from the maize price policy. Higher levels of education give households an increased capacity for decision making with regard to allocation of factors of production to competing enterprises, crop husbandry practices, and consumption allocations. These results suggest that better decision making capacity could increase gains to net sellers or mitigate adverse effects to net buyers.

The incidence of female-headed households is associated with losses from increasing maize prices. Traditionally, women have been excluded from land access mainly because most cultures disallow land inheritance to female offspring's, yet inheritance is the most common way of passing the resource from one person to another. Women starting families outside marriage are mostly trapped into landlessness, which makes them natural net buyers. When widowed, most women lose control of important assets such as land to male relatives, even though they still work on the farms. With this mode of dispossession, households headed by widowed females receive mercy payments to their labor while controlling males from other households extract rents from all farming activities. This makes female headed households net buyers just because the share of production they receive is disproportional to their labor input and consumption requirements.

4.4.2 Expected Changes in Income along its Range

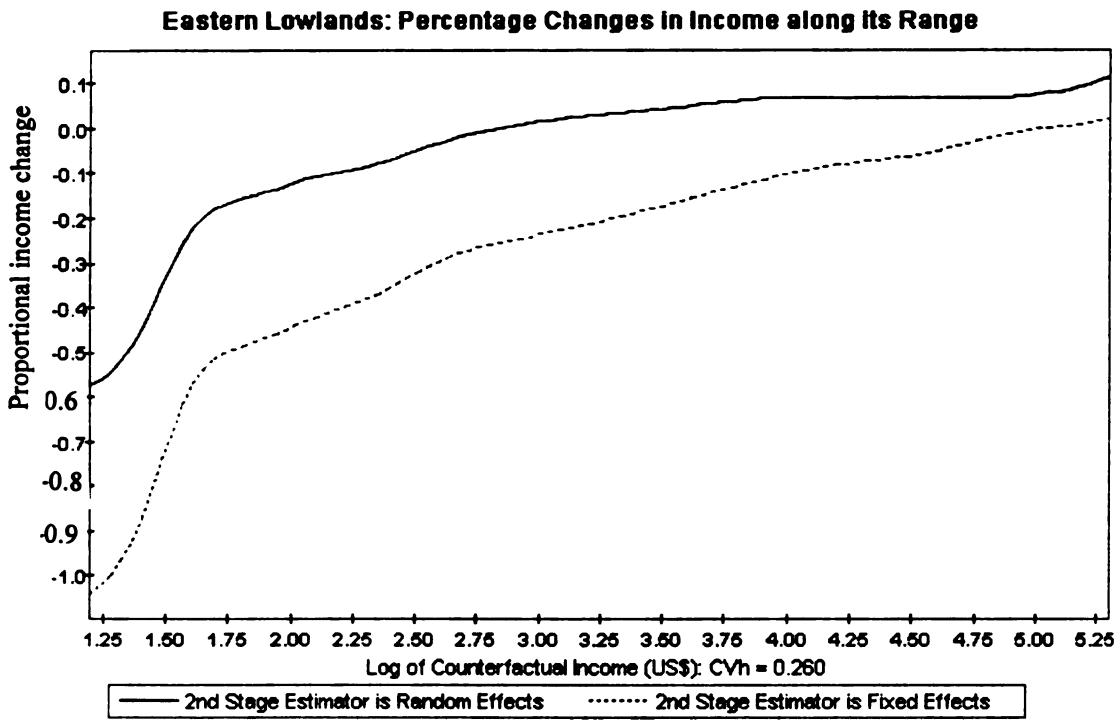
This section provides results of non-parametric estimates of expected changes in income at different points along its range. There are two regression curves in figure 4.1 for the coastal lowlands region, figure 4.2 (eastern lowlands), figure 4.3 (western lowlands), figure 4.4 (central highlands), and figure 4.5 for the high potential maize zone. The first one is derived from random effects residuals and the second is obtained from fixed effects residuals. In the discussion that follows I will be referring to the regression curve based on the random effects residuals because the Hausman test suggested that the random effects estimator is consistent and efficient. The regression curve based on the fixed effects residuals is included so as to demonstrate that those residuals include the effects of covariates that do not change over time. As a result of this, the regression curves based on the fixed effects residuals are a south-easterly shift of the one based on random effects residuals in all but the high potential maize zone.

Figure 4.1. Expected Changes in Income in Coastal Lowlands



The gains or losses from increasing prices are measured by the proportion of income changes along the vertical axis. In both regions we see that the regression curves are upward sloping, which means that households with higher income levels gain at the expense of those at the lower points of the income distribution. Households at the lowest point on the income range lose about 50% of their per-capita incomes while those at the highest end of the range gain by about 30%. There seems to be a threshold of income after which households turn from being losers to gainers. From figure 4.1 it can be inferred that households with per-capita income of about US$13.5 per month incur zero proportional changes in income in coastal lowlands. Those with income levels above this threshold experience gains from the maize price increasing policy. The findings in the coastal lowlands are very similar to what is observed in eastern lowlands (figure 4.2 below). A minor difference is that the threshold which separates gainer from losers is a little bit lower an US$ 11.0.

Figure 4.2. Expected Changes in Income in Eastern Lowlands



The results from coastal and eastern lowlands are quite different from what we will see in the western lowlands (figure 4.3). One of the key differences is that the gains from the policy are fairly stable after the zero proportional change threshold in western lowlands, while the regression curves for coastal and eastern were upward sloping beyond this point. Further, the threshold is much higher at approximately US$ 20.00 per-capita per-month, which means that households need to be more endowed if they are to gain from the maize price increasing policy. These results are very similar to those from the central highlands (figure 4.4).

Figure 4.3. Expected Changes in Income in Western Lowlands

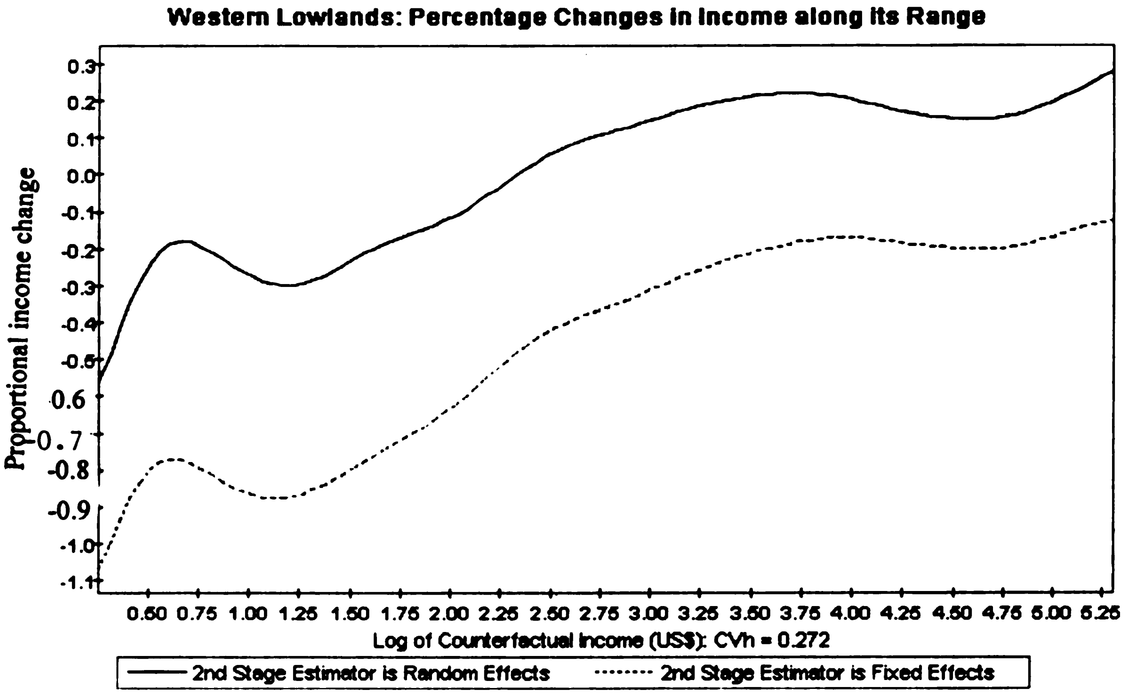
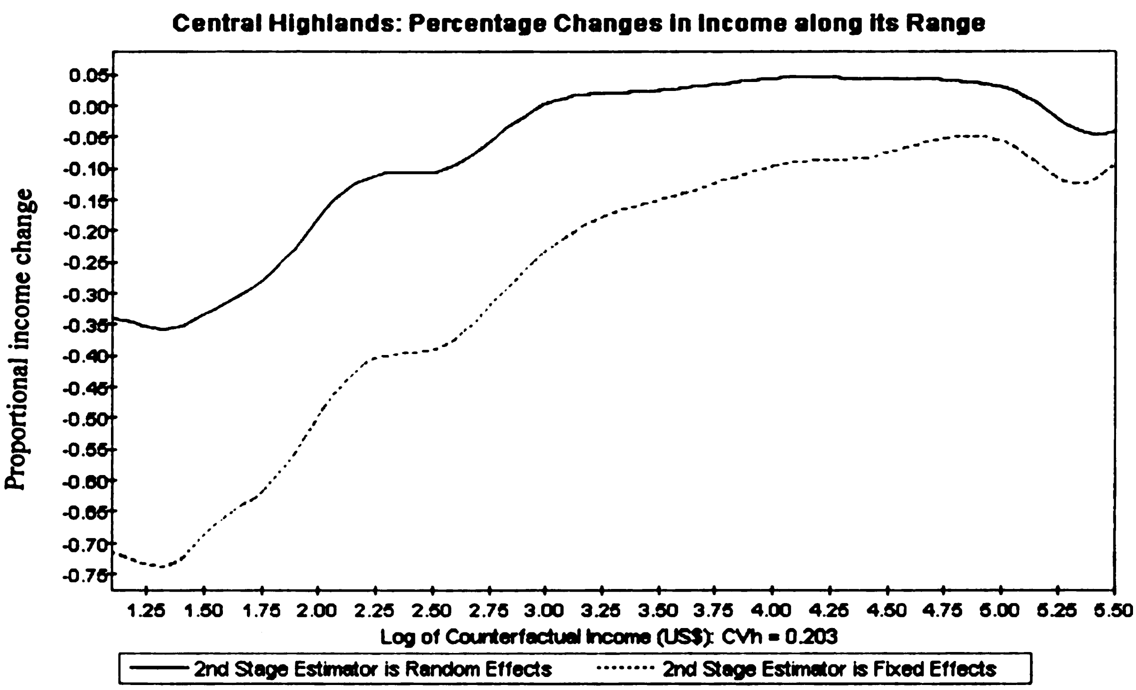
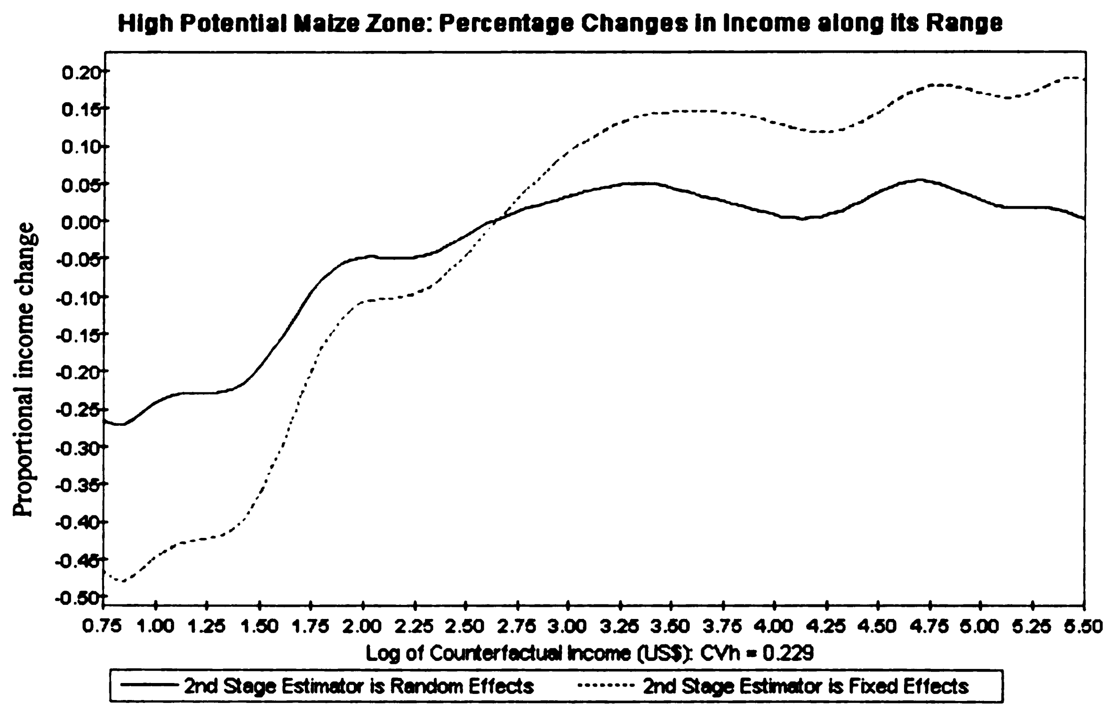


Figure 4.4. Expected Changes in Income in Central Highlands



Next we will look at the regression curve for the high potential maize zone (HPMZ). Maize is a major source of cash among farmers in the HPMZ. Other farm enterprises of choice to farmers in this region include wheat and commercial dairying. Figure 4.5 suggests that gains from the policy are stable above the threshold income level in this zone. This finding is very similar to what was observed in eastern lowlands and central highlands. However, there are some notable differences; for instance, the proportion of losses to households in the lowest point on the income range reduces to 25% compared to about 50% in the lowlands and the central highlands.

Figure 4.5. Expected Changes in Income in the High Potential Maize Zone



The other regions considered in this study are western highlands and the western transitional zones. As mentioned in the preceding section, the model did not perform well in these regions. The fixed effects model suggested that none of the variables had explanatory power and the Hausman test led to the rejection of the null that the random effects estimator is consistent and efficient. Both taken together imply that there is no need for the parametric part of the model in Equation 4.1. Essentially we could proceed by just regressing proportionate changes in income on log of per-capita income without controlling for the effects of other covariates. The ensuing regression curve has a very similar shape to the one based on random effects. It can therefore be inferred that just like in other regions of Kenya, the policy hurts households with less income more that it could hurt those with higher incomes. The regression curves for western highlands and western transitional are given below in figure 4.6 and figure 4.7 respectively.

Figure 4.6. Expected Changes in Income in Western Highlands

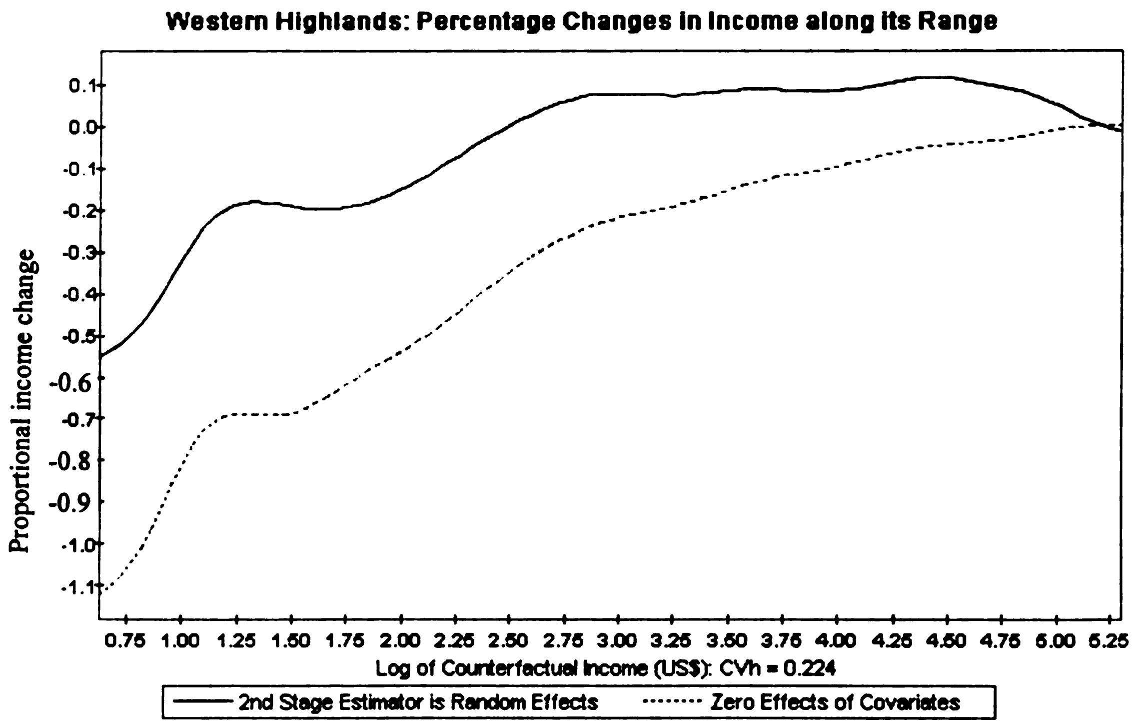
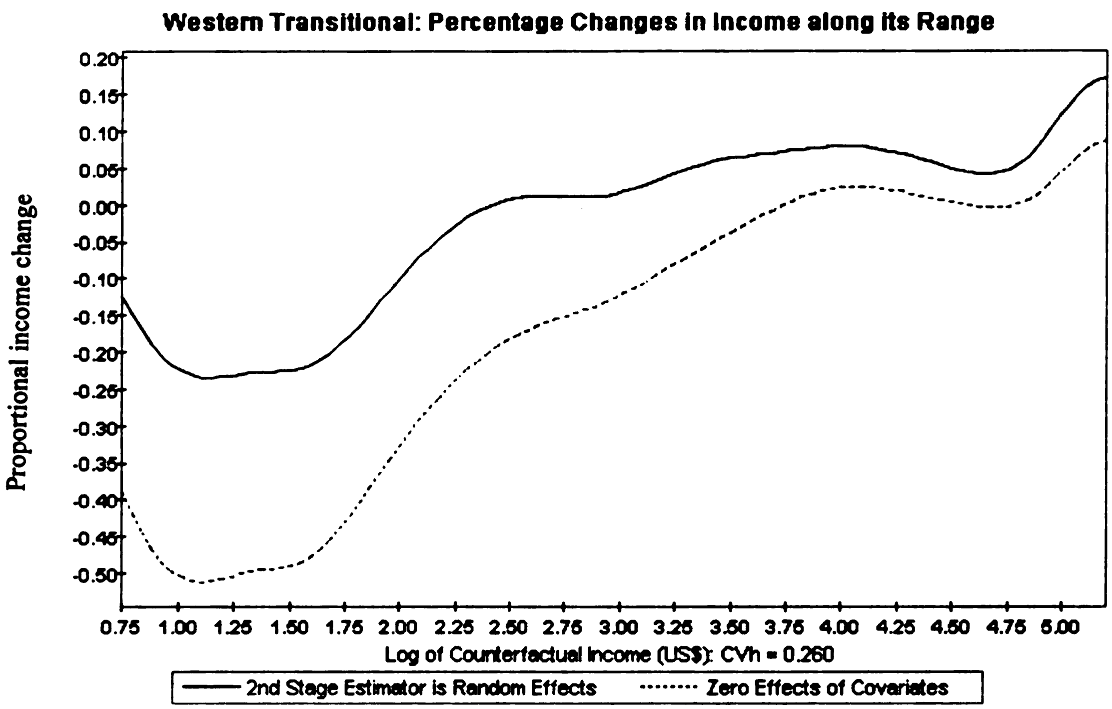


Figure 4.7. Expected Changes in Income in Western Transitional



4.4.2.1 Concerns about Measurement Error

The dependent variable used in the regressions is calculated as the value of net maize sales divided by total household income, and the explanatory variable is log of income. There is a possibility that incomes were measured with error. The most pervasive source of measurement error would be due to under-reporting of income by wealthy households. This would have two effects. The first will be an increase in the magnitude of the dependent variable for under-reporting households and the second is that these households will be moved towards the center of the distribution of income. When put together the two effects will result to a regression curve that is mountain shaped. We did not find a regression curve of such a shape in any of the seven regions and therefore we conclude that there was no significant measurement error of this type.

4.5 Conclusions

This chapter examined the effect of maize pricing policy on income distribution. Unlike previous studies, I was able to control for the influence of household characteristics, asset endowment, and other covariates. These factors are not only correlated with income but they determine the degree of changes in income due to changing prices through their influences on production and consumption of maize. Moreover, the degree to which households would adjust in factor and output markets for other commodities and in rural wage markets is driven by some of the covariates. Therefore it is only by controlling for the influence of these covariates that we are able to apply the ceteris peribus analogy in interpreting the regression curve. This is crucial more so because we have used a second order approximation which does not fully account for higher order adjustments in consumption and production of commodities with significant maize cross price elasticity of demand. The small methodological contribution was made possible by the use of a partly linear semi-parametric model. The model was estimated using the Generalized Speckman Estimator (Speckman 1988).

The prevalence of small farms among the farming population implies that increased household size reduces marketable surplus or aggravates household's net buyer status. We find that household size (adult equivalent) is negatively related with gains from the policy. Also negatively related with gains from the price policy is the age of household head. Age squared shows a positive relationship which means that welfare gains decrease increasingly as the age of household head advances. The influence of education and farm assets is positive. Education improves capacity for making decisions in activities such as factor allocation among competing farm enterprises, crop husbandry practices, and consumption allocations, all of which interact to advance gains to net sellers and mitigate adverse effects to net buyers.

After controlling for the influence of the above factors we estimated region level regression curves of proportionate changes in income on log of per capita income were estimated using the Nadaraya-Watson estimator. The estimator had been used in similar studies such as Deaton (1989), Budd (1993), and Barrett and Dorosh (1996). Results from previous studies were varied. Deaton (1989) found that increasing rice prices in Thailand would largely cause welfare losses and gains to farmers with medium incomes, while the rich and the poor remained largely unaffected. In Cote d'I Voire, (Budd 1993) concluded that price changes of a single food commodity, or a group of them has little effect on farmers welfare not only because the budget share of net food purchases was small (less than 5 %), but also since welfare levels differed little between farmers. In Madagascar, by contrast, both net sales and marketable surplus from rice gradually increased from the poor to the rich, implying that wealthy households would benefit from increasing prices while the poor would incur welfare losses (Barrett and Dorosh 1996).

This study finds results that are similar to those obtained in (Barrett and Dorosh 1996). Specifically, we find that gains from the policy increase as per-capita income increases in all the seven regions considered. The poor in all these regions incur losses in income while the rich either gain some proportion of their incomes or are unaffected. In most of the regions, households with the lowest incomes lose about 50% of their incomes as a result of the maize price increasing policy. The notable exception is in the high potential maize zone where the lowest income households lose about 25% of their incomes. The results on the income distribution effects of the policy are very similar across different zones while in chapter 3 we found some differences with regard to effects on poverty. I consider this is another indication of the need to separate analysis on these two aspects of welfare.

CHAPTER 5

SUMMARY AND CONCLUSIONS

The process of structural transformation is widely regarded to be the avenue for development of agriculturally oriented countries with low incomes (Johnston and Mellor, 1961; Mellor, 1976). The process begins with increased agricultural productivity per worker, which creates a surplus that can be tapped into the rural non-farm sector. Efficient flow of resources out of agriculture requires the sector to attain market-equilibrium linkages through integration with the rest of the economy, in both factor markets and product markets. Liberalization was regarded to be a first step for the integration of agriculture in the economy.

There are two major schools of thought regarding the experience of liberalization in key sectors of African economies (Jayne et al 2005b). One school of thought with a heavy political economy orientation posit that the process was hardly implemented (van de Walle, 2001); (Jayne et al., 2002); (Bird, Booth and Pratt, 2003). They concur among themselves that developing countries were forced to 'adopt' the policy as a condition to further aid and therefore gave the process barely more than lip service. As a result donor funds that were accessed after accepting the process were used to further the same set of policies as before, albeit in a smaller scale commensurate with decreased funding.

In sharp contrast, the other school of thought conjectures that the process indeed took place. The opportunity provided to private participants was not taken up effectively due to high transaction costs, weak physical infrastructure, and poor coordination between different stages of marketing. Most smallholders were provided with expensive but poor quality inputs, while at the same time loosing stable and remunerative output markets, both of which resulted to declining farm productivity. In essence, liberalization was the antithesis to structural transformation. This school of thought surmises that the reforms are responsible for the disappointing trends in farm production in the post-reform era. They argue that for structural transformation to be successful (or probably begin), price stabilization and farm input subsidization policies should be re-considered so as to increase farm productivity (Dorward et al., 2004); (Gabre-Madhin, Barrettt, and Dorosh, 2003). Such policy tools are well identified with the 'green revolution' in Asia and have a semblance with the current policy on maize marketing in Kenya, save for the liberalization of the input sector. The purpose of this paper was to study near term effects of the policy on poverty and income distribution.

In chapter 3, provided the conceptual framework used to estimate the effects of the policy on rural incomes income, following an overview of maize production and marketing in chapter 2. The discussion leads to the formulation of the maize price elasticity of income or the net benefit ratio which has been used in previous studies. The elasticity captures instantaneous (first order) changes in income following a change in price and therefore estimates the lower bound of effects. By considering both production and consumption responses, I extend the model to a second order approximation of the equilibrium configurations. This is followed by a discussion on the framework used to measure poverty. Specifically, I take advantage of the parallel between stochastic dominance and poverty measures to generate poverty rankings between counterfactual incomes and incomes with effects of price controls. This way, I am able to obtain poverty rankings that are robust to a variety of widely used poverty lines, and varied impacts of the policy on price levels.

Empirical results on poverty rankings indicate that the policy does not increase poverty in the high potential maize zone. The situation is very much different in other regions of the country. With the policy, the headcount ratio is higher in both the lowlands regions (coastal lowlands, eastern lowlands and western lowlands) and the highlands regions (western highlands and central highlands). The policy does not lead to an increase in the headcount ratio in the western transitional zone even though it significantly reduces incomes of the poor.

Chapter 4 examines the income distributional effects of the policy. In the first section, I provide the conceptual framework used to control for the influence of household characteristics, land and asset endowment, and demographic characteristics, among other covariates that influence maize production and consumption, and which are also correlated with income. Specifically, I propose a partly linear semi-parametric model and give an estimation strategy that affords good properties to the estimators. Variables such as farm asset base and education are associated with gains from the policy. Higher levels of adult education reflects an increased ability for decision making in factor allocation, crop husbandry, and consumption allocation, all of which interact to mitigate adverse effects of the policy. The prevalence of small farm sizes mean that an increase in household size raises maize consumption requirements without a matching effect on production ostensibly due to infinitesimal marginal productivity of labor in maize. Also associated with negative impacts are variables such as age of head of the household and female head dummy. In most parts of the country women are not considered for land inheritance, yet this is the most common way of transferring land resources. When widowed, most women lose control of land and other resources to male relatives who seize a disproportionately larger share of the returns from such assets. After controlling for these factors, we proceed to estimate the expected proportionate changes in income along its range in different agro-climatic settings. Results show that the effect of the policy on the distribution of income does not vary much across different zones.

We form the view that NCPB price supports and tariffs on imported maize are a production incentive to all maize farmers in Kenya. Higher prices provide an opportunity for net sellers in the high potential maize producing zones to increase their crop revenues. On the other hand, farmers in low and medium production zones would cultivate more maize to bridge their consumption needs, so that they purchase less. It is very doubtful that these trends represent a path towards structural transformation; rather they stimulate subsistence production even in areas where drought resistance crops such as cassava, millet, and sorghum are better suited. The ensuing productivity growth due to the policy in high potential zones may not be enough to lower the price both in the medium and long run because of limited production technologies. It can therefore be envisaged that this policy will continue to stimulate subsistence production among farmers in low and medium zones.

If policies of price stabilization and farm input subsidization are having adverse effects on poverty and income distribution then they should be revised. Rather than spending huge budgets on NCPB price mechanisms, the government could focus on policies that directly raise farm productivity, such as aggressive extension and research. Most analysts agree that maize varieties in Kenya achieve between 20% and 60% of their potential. An improvement in their performance could trigger adjustments that create widely shared productivity growth which could lead to price reductions and more employment of rural labor. Expenditure in extension and research is a matter that governments in developing countries are yet to appreciate. These efforts have in the past been largely identified with donors and this perception needs to change. Even small amounts consistently invested in research and extension could make a difference in the long run. Increased maize productivity would lead to a gradual price decline that would ease out subsistence production, thereby creating a market for surplus maize from the high potential maize zone, while at the same encouraging cultivation of crops with comparative advantages in low and medium potential areas.

This process can happen if research and extension is followed by efforts to develop low cost exchange mechanisms, such as road infrastructure development and grain sorting standards for marketed maize. With such policies long run welfare gains to farmers in both maize surplus and deficit regions could be higher than what is induced by the current pricing policy. Needless to say, farmers in low and medium potential regions would benefit not only from low maize prices but also from increased production of crops that have comparative advantage in these regions.

With regard to literature on welfare effects of changing prices, this study makes two small contributions. First, unlike past studies that measured first order effects of changing prices in a disequilibrium framework we are able to include both supply and demand responses and effects on the rural wage market. Secondly, this study has introduced empirical applications of stochastic dominance techniques in the study of welfare impacts of changing prices. The main advantage of this approach is that it can be used to rank income distributions and generate poverty orderings that are robust to varying poverty lines. The third contribution regards estimating the income distribution effects of changing food prices. Earlier studies on the subject failed to control for the influence of variables that not only affected the net consumption ratio but which were also correlated with income. With the aid of a partly linear semi-parametric model, we are able to control for the influence of land and asset endowment, levels of education, infrastructure, differences in output and input prices, and demographic characteristics. This way the regression curve of expected proportionate changes in income along its range attain a ceteris peribus interpretation.

APPENDIX

Table A4.1. The Effects of Covariates Other than Income: Coastal Lowlands (N=63)

Explanatory variables	Random effects (r)		Fixed effects (f)		Difference between the coefficients (f-r)
R Squared	0.204		0.032		Estimate (std. error)
Explanatory variables	Estimate (std. error)	P value	Estimate (std. error)	P value	
Constant	-.029 (.039)	0.446	-.028 (.006)	0.000	
Year dummy	.227 (.083)	0.006	.224 (.094)	0.020	-.003 (.043)
Education	.019 (.008)	0.019			
Age	-.049 (.024)	0.038	-.081 (.057)	0.161	-.032 (.052)
Square of age	.001 (.000)	0.060	.001 (.000)	0.165	.000 (.000)
Log of value of farm assets	.055 (.018)	0.003	.036 (.031)	0.246	-.019 (.024)
Female head dummy	-.308 (.109)	0.005			
Kilifi dummy	.004 (.095)	0.969			
Hausman test	Test statistic - chi2(4) = 4.72 P Value = 0.317				

Table A4.2. The Effects of Covariates Other than Income: Eastern Lowlands (N=150)

Explanatory variables	Random effects (r)		Fixed effects (f)		Difference between the coefficients (f-r)
R Squared	0.206		0.102		Estimate (std. error)
Explanatory variables	Estimate (std. error)	P value	Estimate (std. error)	P value	
Constant	-.003 (.015)	0.832	-.003 (.000)	0.000	
Year	.404 (.079)	0.000	.535 (.117)	0.000	.131 (.087)
Education	.010 (.004)	0.004			
Household size	-.024 (.008)	0.005	-.006 (.014)	0.642	.017 (.011)
Rainfall in main season	.001 (.000)	0.000	.002 (.000)	0.000	.000 (.000)
Log of the value of farm assets	.028 (.007)	0.000	.003 (.014)	0.852	-.026 (.012)
Hausman test	Test statistic - chi2(4) = 8.33 P value = 0.110				

Table A4.3. The Effects of Covariates Other than Income: Western Lowlands (N=134)

Explanatory variables	Random effects (r)		Fixed effects (f)		Difference between the coefficients (f-r)
R Squared	0.326		0.110		Estimate (std. error)
Explanatory variables	Estimate (std. error)	P value	Estimate (std. error)	P value	
Constant	-.011 (.028)	0.692	-.046 (.005)	0.000	
Year	.078 (.064)	0.224	.035 (.060)	0.551	-.041 (.014)
Education	.018 (.005)	0.000			
Household size	-.040 (.011)	0.000	-.039 (.027)	0.146	.001 (.025)
Kisumu district dummy	-.389 (.066)	0.000			
Female head dummy	-.186 (.063)	0.003			
Distance from seller of seeds (kms)	0.001 (0.000)	0.014	0.001 (0.000)	0.364	0.000 (0.000)
Hausman test	Test statistic - chi2(3) = 1.36 P value = 0.7138				

Table A4.4. The Effects of Covariates Other than Income: HPMZ (N=368)

Explanatory variables	Random effects (r)		Fixed effects (f)		Difference between the coefficients (f-r)
R Squared	0.235		0.092		Estimate (std. error)
Explanatory variables	Estimate (std. error)	P value	Estimate (std. error)	P value	
Constant	.028 (.018)	0.124	.031 (.002)	0.000	
Year	.058 (.030)	0.051	.070 (.036)	0.050	.011 (.019)
Bomet district dummy	-.419 (.044)	0.000			
Nakuru district dummy	-.272 (.049)	0.000			
Education	.014 (.004)	0.000			
Household size	-.028 (.008)	0.000	-.023 (.013)	0.063	.004 (.010)
Age	-.016 (.008)	0.052	-.011 (.016)	0.488	.005 (.014)
Squared age	.001 (.001)	0.085	.001 (.001)	0.588	.000 (.000)
Distance from seller of seeds (kms)	.001 (.000)	0.030	.001 (.000)	0.086	.000 (.000)
Log of the value of farm assets	.052 (.010)	0.000	.017 (.015)	0.247	-.035 (.011)
Hausman test	Test statistic - chi2(6) = 0.52 P value = 0.9976				

Table A4.5. The Effects of Covariates Other than Income: Central Highlands (N=241)

Explanatory variables	Random effects (r)		Fixed effects (f)		Difference between the coefficients (f-r)
R squared	0.250		0.003		Estimate (std. error)
Explanatory variables	Estimate (std. error)	P value	Estimate (std. error)	P value	
Constant	-.002 (.011)	0.827	-.003 (.000)	0.000	
Year dummy	-.022 (.029)	0.439	-.019 (.028)	0.499	.003 (0.001)
Muranga district dummy	-.202 (.030)	0.000			
Nyeri district dummy	-.109 (.024)	0.000			
Education	.008 (.002)	0.001			
Household size	-.019 (.008)	0.027	-.015 (.010)	0.127	.003 (.005)
Age	-.007 (.006)	0.270	-.014 (.019)	0.470	-.007 (.018)
Square of age	.001 (.000)	0.459	.001 (.000)	0.396	.000 (.000)
Rainfall in main season	-.001 (.000)	0.002	.001 (.000)	0.000	.000 (.000)
Log of value of farm assets	.024 (.006)	0.000	.007 (.013)	0.603	-.017 (.011)
Hausman test	Test statistic - chi2(6) = 2.01 P value = 0.9186				

Table A4.6. The Effects of Covariates Other than Income: Western Highlands (N=134)

Explanatory variables	Random effects (r)		Fixed effects (f)		Difference between the coefficients (f-r)
R squared	0.373		0.000		Estimate (std. error)
Explanatory variables	Estimate (std. error)	P value	Estimate (std. error)	P value	
Constant	-.001 (.022)	0.960	-.011 (.002)	0.000	
Year	.036 (.037)	0.335	.033 (.036)	0.342	-.002 (0.001)
Vihiga district dummy	-.226 (.047)	0.000			
Female head dummy	-.199 (.064)	0.002			
Education	.018 (.004)	0.000			
Log of the value of farm assets	.047 (.011)	0.000	.001 (.012)	0.986	-.047 (.006)
Hausman test	Test statistic - chi2(2) = 66.02 P value = 0.0000				

Table A4.7. The Effects of Covariates Other than Income: Western Transitional (N=153)

Explanatory variables	Random effects (r)		Fixed effects (f)		Difference between the coefficients (f-r)
R Squared	0.127		0.047		Estimate (std. error)
Explanatory variables	Estimate (std. error)	P value	Estimate (std. error)	P value	
Constant	.004 (.024)	0.856	.005 (.000)	0.000	
Year	-.020 (.049)	0.686	.046 (.075)	0.541	.066 (.057)
Kakamega district dummy	-.073 (.047)	0.124			
Rainfall in main season	.001 (.000)	0.099	-.001 (.001)	0.564	-.001 (.001)
Log of the value of farm assets	.042 (.009)	0.000	-.001 (.016)	0.977	-.043 (.014)
Hausman test	Test statistic - chi2(3) = 11.42 P value = 0.0097				

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