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Income and Poverty Impacts of USAID-Funded Programs to Promote Maize, Horticulture, and Dairy Enterprises in Kenya, 2004-2010

by

Melinda Smale, Mary K. Mathenge, Thomas S. Jayne, Eduardo Magalhaes, John Olwande, Lilian Kirimi, Mercy Kamau, and James Githuku

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INCOME AND POVERTY IMPACTS OF USAID-FUNDED PROGRAMS TO PROMOTE MAIZE, HORTICULTURE AND DAIRY ENTERPRISES IN KENYA, 2004-2010

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EXECUTIVE SUMMARY

Since 2002, the United States Agency for International Development (USAID) has funded programs to promote maize, dairy, and horticulture enterprises among smallholder farmers in Kenya under the Strategic Objective 7 of Increased Rural Household Incomes. On behalf of USAID, Tegemeo Institute has conducted household surveys to help track key indicators that monitor progress in the implementation of these programs. The first survey was conducted in 2004. Subsequent surveys were conducted every two years (i.e., 2006, 2008, and 2010). The sample comprises households participating and those not participating in the programs. The programs monitored include the Kenya Maize Development Program (KMDP), the Kenya Horticulture Development Project (KHDP), and the Kenya Dairy Development Program (KDDP), which is now known as the Kenya Dairy Sector Competitiveness Program (KDSCP).

The analyses presented relate to the economic impact of three programs that received financial support from the USAID. These include the Kenya Maize Development Program (KMDP), the Kenya Horticulture Development Project (KHDP), and the Kenya Dairy Development Program (KDDP). The KDDP preceded the current Kenya Dairy Competitiveness Program (KDSCP).

The Kenya Maize Development Program (KMDP) began in late 2002, with Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance ACDI/VOCA as the lead implementing agency working with a diverse consortium of partners, including the Cereal Growers Association of Kenya (CGA), Farm Input Promotions Africa (FIPS) Ltd., and the Kenya Agricultural Commodity Exchange (KACE). The KMDP focuses on smallholder producers in high and medium potential maize producing districts of Kenya, which include Trans Nzoia, Uasin Gishu, Bungoma, Lugari, Nandi, Kisii/Nyamira, Nakuru, Bomet, and Laikipia. The program also operates on a lesser scale in maize deficit districts of Kitui, Mwingi, and Machakos. The Program's objectives have been to improve maize productivity, enhance access to business support services, increase participation in markets and trade, and strengthen the effectiveness of smallholder organizations. The KMDP incorporates a business development services paradigm that emphasizes non-financial services in the maize value chain. Major activities include business fairs, business skills training for farmer organizations, and a network of Market Information Centers (MIC) that serves as locations for prices and trade information. The KMDP also offers practical on-farm training (through using demonstration plots) on the use of improved varieties of seed and fertilizer and on conservation tillage (CT) and other natural resource management practices, through collaboration with FIPS, the Ministry of Agriculture and other stakeholders.

The Kenya Horticulture Development Project (KHDP) was established in October 2003 under the management of Fintrac, Inc., with the aim of supporting the development of the fresh and processed food sector. KHDP activities have marketing, postharvest handling, processing, and agronomic assistance to smallholders and allied agribusinesses. In its initial work program, the KHDP targeted six product categories: passion fruit (fresh and processed), chili products (fresh, processed, and dried), vanilla and spices, smallholder flowers, tree crops for processing (cashew and mango), and local market vegetables (onions, carrots, cabbage, tomato, and indigenous vegetables). The KHDP was discontinued in April 2010 to give way to a new program, the Kenya Horticulture Competitiveness Program (KHCP).

The Kenya Dairy Development Program (KDDP) was initiated in October 2002 and was implemented by a consortium of agencies led by Land O' Lakes. The program's goal was to raise the economic benefits earned by stakeholders in the dairy value chain and bolster rural household incomes. Activities aimed to enhance the productivity of smallholder dairy producers and to develop the capacity of processors and informal marketers ability to deliver higher-quality, safe, affordable, products to the marketplace. The KDDP also sought to stimulate the demand for quality dairy products in domestic and export markets, and to promote sustainable, local capacity of businesses, co-operatives, and enterprises to provide services demanded. The program's activities have been concentrated among the following districts: Murang'a, Kiambu, Nyandarua, Nyeri, Nakuru, Bomet, Kakamega, Kericho, Kirinyaga, Laikipia, Migori, Nairobi, South Nandi, Trans Nzoia, and Uasin Gishu. A new dairy program known as the Kenya Dairy Sector Competitiveness Program (KDSCP) was launched in May 2008, with the overall goal of increasing household incomes from the sale of quality milk.

In this study, Tegemeo/MSU have conducted an in-depth econometric analysis of the quantitative impacts of the three programs on household income and poverty from 2004 to 2010. The methods employed control for other factors affecting income and poverty during the same time period, and compare participants to non-participants (treatment vs. control groups) in each survey year relative to a baseline in 2004. The data used were drawn from the household surveys mentioned above. As a check on the reliability and generality of findings, data from a nationally representative panel household survey by the Tegemeo Institute were also used to construct a comparative group (counterfactual) in addition to the control mentioned above. The following broad results were obtained:

1) Using 2004 as the baseline, USAID programs significantly improved incomes of households targeted by the programs in the subsequent years; by an average of Kenyan Shilling (Ksh) 74,414 in 2006; Ksh 125,320 in 2008; and Ksh 124,071 in 2010. This finding holds not only when comparing beneficiary households to non-beneficiary households selected for the study, but also when comparing the beneficiary households to the Tegemeo's nationally representative sample of households. There were also significant average impacts on households that benefited indirectly from programs.

2) Although the beneficiary and non-beneficiary households moved gradually out of poverty during the period of study (2004-2010), the movement out of poverty among non-beneficiaries was not consistent, and sometimes negative (between 2006 and 2008), while that among the beneficiary households was consistent and always positive throughout the period. Taking into account other factors, only less than 3% of USAID programs' beneficiaries were predicted to be poor in 2010, compared to 18% of non-beneficiaries.

3) USAID programs had significant impact on beneficiary households' off-farm income in 2010 (an average increase by Ksh 77,207 compared to non-beneficiaries), suggesting that the programs may have improved the capacity of program participants to generate income from non-farm sources. This finding holds not only when comparing beneficiary households to non-beneficiary households selected for the study, but also when comparing the beneficiary households to the Tegemeo's nationally representative sample of households in 2010 relative to 2004.

4) There were limitations in analyzing individual program impacts due to small sample sizes, particularly with respect to poverty impacts. The following specific program results were obtained.

KMDP

KMDP had significant impact on maize production and value of maize sales in 2006 (by an average increase of 1,374 kg and Ksh 26,884, respectively). Statistical impacts of program effects on maize yields are not surprising, given the pattern of maize yields in Kenya over time and the higher variability of yields across farms. This should not be construed as evidence of lack of program impact. Farm land owned, proximity to market, and location in the High Potential and Central Highlands Zones, relative to the Western Transitional Zones had significant impacts on income, independent of the program.

KHDP

KHDP had significant impact on value of horticultural sales, particularly in 2010 (by an average increase of Ksh 28,113), and net household income (by an average increase of Ksh 68,247 in 2006; and Ksh 104,571 in 2010) among its participants in 2006 and 2010. Education of household head, farm land owned, and location in the High Potential and Central Highlands Zones, relative to either the Western Transitional or Western Lowlands Zones was associated with higher incomes, independent of the program. When comparing to Tegemeo's national representative sample, program participants produced more, sold more, and had higher income in 2010 relative to 2004.

KDDP

KDDP had significant impact on value of net livestock income and net household income in 2006 (average increase of Ksh 45,158), 2008 (average increase of Ksh 54,737), and 2010 (average income of Ksh 71,114) among its participants. Livestock income rose each year in terms of both magnitude and statistical significance for the target group and indirect beneficiaries relative to the control group. KDDP impact on total net household income is also visible in 2010, and in 2008, the value of livestock assets is affected positively. Of these findings, impacts of the KDDP on income in 2010 relative to 2004 are statistically significant in the regressions using the Tegemeo sample as the control group, compared to the program target group. Again, discrepancies in results between the two estimation procedures do not invalidate either set of results. Instead, they suggest that there are differences between locally (program areas) and nationally (beyond program areas) findings.

In terms of non-program factors influencing income and poverty, education has a strong, salient effect, as has been shown by many previous studies in Kenya, as does the extent of farm land owned. Regional effects are variable, but in many of the regressions, households in the high potential maize area and or Central Region appear to be better off.

Other findings may merit further consideration. The first is the evidence that farmers targeted by the programs were better off by most indicators of income, wealth, and poverty status than were non-participants at program inception in 2004. This is not unusual for development programs, and there are arguments for targeting leaders rather than followers. A second is that several of the findings suggest there may be a gender bias in program participation rates and impacts.

Several caveats should be borne in mind when interpreting findings. The first relates to the limitations of small sample sizes when conducting econometric tests, due in part to the changing composition of the control and target groups with evolution of program participation. These have limited the breadth of statistical tests researchers could apply and their reliability by program. In the future, we recommend the consideration of other sampling methodologies. A second, related caveat is the fluid definition of *beneficiary* group. Given the range of program activities, more precise definitions of beneficiary groups could be more informative. A third caveat is that the approaches applied here are narrowly quantitative. Ideally, they should be combined with other qualitative research in order to fully comprehend the nature of program impacts. To estimate maize yield impacts, on the other hand, a more controlled experimental design might be needed. However, other indicators may be more suitable for measuring overall impact on maize commercialization and farm household well-being.

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ACRONYMS

ACDI/VOCA	Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance
CGA	Cereal Growers Association of Kenya
CPI	Consumer Price Index
CT	Conservation Tillage
FAB	*Farming as a Business* training module
FERDI	*Fondation pour les études et recherches sur le développement international*
FIPS	Farm Input Promotions Africa Ltd.
FtF	Feed the Future
GEE	Generalized Estimating Equation
KACE	Kenya Agricultural Commodity Exchange
KDDP	Kenya Dairy Development Program, which is now known as the KDSCP
KDSCP	Kenya Dairy Sector Competitiveness Program
KHCP	Kenya Horticulture Competitiveness Program
KHDP	Kenya Horticulture Development Project
KMDP	Kenya Maize Development Program
Ksh	Kenyan Shilling
MIC	Market Information Centers
MSU	Michigan State University
OLS	Ordinary Least Squares
PPP	Purchasing Power Parity
SPSS	Statistical Package for Social Scientists
USAID	United States Agency for International Development

1. INTRODUCTION

1.1. Background

Since 2002, the United States Agency for International Development (USAID) has funded programs to promote maize, dairy, and horticulture enterprises among smallholder farmers in Kenya under USAID Strategic Objective 7 (Increased Rural Household Incomes). To achieve this objective, programs have undertaken a range of activities geared to enhancing farm productivity, improving farmer access to business services, and strengthening the capacity of smallholder organizations to provide these services and represent the business interests of their members. Expansion of agricultural trade in domestic, regional, and international markets has also been an aim of the programs.

On behalf of USAID, Tegemeo Institute has monitored the indicators used to track the progress made towards achieving the SO 7. Tegemeo's monitoring activities have been implemented as part of the Tegemeo Agricultural Monitoring and Policy Analysis (TAMPA) and the Tegemeo Agricultural Policy and Research Analysis (TAPRA) projects. The Institute has conducted household surveys after every two years (2004, 2006, 2008, and 2010) on a sample comprised of households participating and those not participating in the programs. Specifically, the programs monitored include the Kenya Maize Development Program (KMDP), the Kenya Horticulture Development Project (KHDP), and the Kenya Dairy Development Program (KDDP), which is now known as the Kenya Dairy Sector Competitiveness Program (KDSCP).

1.2. Objectives of the Analysis

The first objective of this analysis is to summarize quantitative evidence of economic impact of the three programs from 2004 through 2010, with a focus on changes in income and poverty status. Since 2006, Tegemeo researchers have prepared reports comparing the performance of households participating in the programs with those who did not participate in the survey year, summarizing changes since the preceding survey. This reporting process was originally conceived as an informal exercise. Tegemeo and MSU now approach the close of the first phase of the TAPRA project in 2011. Our second objective is to take stock of methods since 2004 and propose an updated, more rigorous research design.

This type of analysis is timely for two reasons. First, under the Feed the Future (FtF) Strategy, we expect greater policy emphasis to be placed on comprehensive impact assessment. Secondly, over the past decade, a number of advances have been achieved in quantitative research methods.

One limitation of the analysis presented here is that it is starkly, and narrowly, quantitative. A more comprehensive analysis would include qualitative approaches, other types of impact, and a more complete description of the programs, farm populations, and pathways through which impacts might be observed. The analysis presented here is as quantitatively rigorous as the data permit, but should in no way be construed as definitive. Findings remain *indicative*. To portray a holistic view of what these data track, and explain their meaning fully requires the application of additional methods.

Section 1.3. presents a brief profile of programs as a point of reference. Section 2 follows with a summary of the survey methodology employed by Tegemeo. A summary of the analytical methods used in this paper is then presented. To the extent possible, we have sought to draw on the latest methodological advances in assessing economic impacts. A statistical description of key parameters in the target, control, and indirect beneficiary groups is then presented. This is followed by presentation of the econometric analyses, including cross-program and program-specific impacts. Conclusions are drawn and recommendations for future research are discussed in the final section.

1.3. Program Description

The analyses presented relate to the economic impact of three programs that received financial support from the USAID. These include the Kenya Maize Development Program (KMDP), the Kenya Horticulture Development Project (KHDP), and the Kenya Dairy Development Program (KDDP). The KDDP preceded the current Kenya Dairy Competitiveness Program (KDSCP).

1.3.1. The Kenya Maize Development Program

The Kenya Maize Development Program (KMDP) began in late 2002, with ACDI/VOCA as the lead implementing agency working with a diverse consortium of partners within the maize value chain. The partners in the consortium include the Cereal Growers Association of Kenya (CGA), Farm Input Promotions Africa (FIPS) Ltd., and the Kenya Agricultural Commodity Exchange (KACE). The KMDP focuses on smallholder producers in high and medium potential maize producing districts of Kenya, which include Trans Nzoia, Uasin Gishu, Bungoma, Lugari, Nandi, Kisii/Nyamira, Nakuru, Bomet, and Laikipia. The program also operates, albeit on a lesser scale, in maize deficit districts of Kitui, Mwingi, and Machakos. The objectives of these programs have been to improve maize productivity, enhance access to business support services, increase participation in markets and trade, and strengthen the effectiveness of smallholder organizations.

In pursuit of these objectives, the KMDP incorporates a business development services paradigm that emphasizes non-financial services in the maize value chain. Through business fairs, the KMDP seeks to stimulate an increase in demand for business services by providing linkages and awareness of the services and products available, while addressing constraints on the delivery of these services.

To improve the timeliness and accuracy of market information, KMDP established a network of Market Information Centers (MIC) that serves as locations for prices and trade information within local and regional markets. Through these centers, buyers are able to post purchase bids while farmers can review offers and sell their stocks /produce to willing buyers.

The Program conducts practical on-farm training (through using demonstration plots) on the use of improved varieties of seed and fertilizer and on conservation tillage and other natural resource management practices, through collaboration with FIPS, the Ministry of Agriculture and other stakeholders.

The KMDP provides business skills training for farmer organization leaders and their members, including the *Farming as a Business* (FAB) training module, which teaches producers to adopt a commercial approach to their farming activities.

1.3.2. The Kenya Horticulture Development Project

The Kenya Horticulture Development Project (KHDP) was established in October 2003 under the management of Fintrac, Inc., with the aim of supporting the development of the fresh and processed food sector. KHDP activities have marketing, postharvest handling, processing and agronomic assistance to smallholders and allied agribusinesses. In its initial work program, the KHDP targeted six product categories: passion fruit (fresh and processed), chili products (fresh, processed, and dried), vanilla and spices, smallholder flowers, tree crops for processing (cashew and mango), and local market vegetables (onions, carrots, cabbage, tomato, and indigenous vegetables). The KHDP was discontinued in April 2010 to give way to a new program, the Kenya Horticulture Competitiveness Program (KHCP).

1.3.3. Kenya Dairy Development Program and Kenya Dairy Sector Competitiveness Program

The Kenya Dairy Development Program (KDDP) was initiated in October 2002 and was implemented by a consortium of agencies led by Land O' Lakes. The program's goal was to raise the economic benefits earned by stakeholders in the dairy value chain and bolster rural household incomes. The objectives of the KDDP have been comprehensive. Activities aimed to enhance the productivity of smallholder dairy producers and to develop the capacity of processors and informal marketers ability to deliver higher-quality, safe, affordable, products to the marketplace. The KDDP also sought to stimulate the demand for quality dairy products in domestic and export markets, and to promote sustainable, local capacity of businesses, co-operatives, and enterprises to provide services demanded. The program's activities have been concentrated among the following districts: Murang'a, Kiambu, Nyandarua, Nyeri, Nakuru, Bomet, Kakamega, Kericho, Kirinyaga, Laikipia, Migori, Nairobi, South Nandi, Trans Nzoia, and Uasin Gishu.

A new dairy program known as the Kenya Dairy Sector Competitiveness Program (KDSCP) was launched in May 2008, again with financial support from USAID. The five-year program has an overall goal of increasing household incomes from the sale of quality milk. The program has three components: enhancing capacity for milk and production input quality certification and market promotion; developing dairy smallholder business organization; and increasing availability of dairy business development services.

2. SURVEY METHODOLOGY

2.1. Sampling Strategy and Sample Size

The initial sampling of households to be included in the survey was conducted in 2004. The documentation on the sampling procedure states that half of all divisions, followed by half of villages within divisions, were selected in districts where the three programs were operational. From a list of beneficiary households in the selected village and a list of non-beneficiary households in a neighboring village, eight households were selected with systematic random sampling from a household list (with a random start). In areas where Tegemeo was already conducting panel surveys, the panel households were to form the control group, although this arrangement did not go beyond the initial survey year. Indirect beneficiary households were selected from the treatment villages but were not directly participating in the programs.

The initial sample size was 960 households, and included the Kenya Business Development Services (KBDS) program, which ended in 2006. When these households were dropped from the sample, 479 households remained. Initially, Tegemeo planned to maintain the same sample of households in subsequent surveys to form a panel. This idea did not prove to be tenable. Program membership varied over the years because some farmers ceased to participate, new farmers joined, or the program shifted from one site to another. In 2008, due to time constraints, only 60% of the households interviewed in 2006 were re-interviewed. The KDDP program was succeeded by KDSCP in 2008, expanding the scope of activities and scale of geographical coverage. A new sample of households was drawn under the KDSCP in 2010.

In this analysis, the households who were reported to have dropped out of the programs in any one of the years were excluded for all the years. The sample includes new participants in all program locations. Table 1 presents the sample used in the analysis by program, year, and type of participant. In the text below, we refer to this sample as the USAID sample.

2.2. Data Collection and Management

The data were collected using structured questionnaires administered by enumerators in face to face interviews. The questionnaire used was largely the same in the four surveys. In 2004, the survey was conducted between June and August, and covered the 2003/2004 cropping year. Data collection in 2006 was conducted between September and October and covered 2005/2006 cropping year. In 2008, farmers were interviewed between October and November, and data represent the 2007/2008 cropping year. The 2010 survey refers to the 2009/2010 cropping year and data were collected between August and September. Although the surveys were conducted at different months across the years, the reference periods were based on cropping years, which makes the data points uniformly two cropping years apart. The surveys relied primarily on farmer recall, since the farmers did not keep records of their day-to-day economic activities. The data were entered, cleaned (validated), stored and analyzed using Statistical Package for Social Scientists (SPSS) and the statistical software package Stata.

Table 1. Sample Size by Program, 2004-2010

Program			Year				Total
			2004	2006	2008	2010	
KMDP	Sample	Target	71	69	37	61	238
		Control	33	31	27	36	127
		Indirect beneficiary	2	2	1	3	8
	Total		106	102	65	100	373
KHDP	Sample	Target	47	43	29	87	206
		Control	48	43	24	38	153
		Indirect beneficiary	24	22	14	23	83
	Total		119	108	67	148	442
KDDP/KDSCP	Sample	Target	162	149	92	200	603
		Control	21	21	18	100	160
		Indirect beneficiary	71	56	37	100	264
	Total		254	226	147	400	1027
Total	Sample	Target	280	261	158	348	1047
		Control	102	95	69	174	440
		Indirect beneficiary	97	80	52	126	355
	Total		479	436	279	648	1842

Source: [1]

2.3. Methods of Analysis

2.3.1. Construction of Outcome and Impact Variables

In this analysis, we began by exploring program outcomes in terms of primary impacts on productivity, production quantities, and sales. We refer to crop and milk yields, crop and milk production or sales as variables that measure primary outcomes. Next, we considered the outcomes that express secondary impacts of programs, which occur through the contribution of changes in specific crop or product earnings to the overall income and assets situation of the household, or the way the household allocates its labor or land among economic activities. These variables include crop income, off-farm income, livestock income, total household income, livestock, and total asset values. Finally, we explored an indicator related poverty reduction, which is perhaps the single most important variable for policy purposes, as expressed in the Millennium Development Goals. Construction and measurement of variables are shown in Table 2.

[1] Unless otherwise noted, the source for the tables and figures in this paper is: Authors, based on analysis of data collected by Tegemeo Institute for the U.S. Agency for International Development, Kenya Mission.

Table 2. Construction and Measurement of Impact Variables

Conceptual Variable	Operational variable	Unit of measurement
Primary impact		
Maize yield	Quantity of dry and green maize harvested from an acre of land in the main season only. Reported harvest units standardized to kilograms. Land sizes were reported in acres.	Kg/acre
Maize production	Quantity of green and dry maize harvested from both main and short seasons. Reported units standardized to kilograms.	Kilograms
Value of maize sales	Quantity of dry and green maize sold from both main and short seasons valued at the district median price of maize for the respective district.	Shillings
Milk yield	Quantity of milk produced during the year divided by the number of cows that produced the milk.	Liters/cow/year
Milk production	Quantity of cow milk produced during the year. Quantities were reported in liters.	Liters
Value of milk sales	Quantity of milk sold valued at the district median price for the respective district.	Shillings
Horticultural production	Quantity harvested of all horticulture crops (excluding potatoes) from both main and short seasons. Reported harvest units for each crop standardized to kilograms.	Kilograms
Value of horticultural sales	Sum of quantity of all horticulture crops (excluding potatoes) sold from main and short seasons valued at the district median price of each crop for the respective district. Valuation of quantity sold was done for each horticulture crop before adding up the values.	Shillings
Secondary impact		
Crop income	Net income from cropping activities (gross value of crop production less cost of purchased inputs).	Shillings
Livestock income	Net income from livestock production (sum of sales of live animals and livestock products less sum of purchase of live animals and livestock inputs).	Shillings
Off-farm income	Sum of net income off the farm (salaries, remittance and business, and wages from informal labour activities) by all household members.	Shillings
Household income	Sum of net income from cropping activities, livestock production, off farm activities.	Shillings
Value of assets	Sum of value of all assets. The assets were primarily agricultural. The values were reported by respondents based on their own individual assessment.	Shillings
Poverty	(Household income divided by adult-equivalent household size) less than (World Bank poverty line per capita times 365) equal poor (1), non-poor (0) else.	Shillings

There are a number of ways that poverty status, and the change in poverty status, can be measured. Here, we have used the World Bank poverty line ($2/day/person), extracted directly from the World Bank Development Indicators. For each year in the sample, we obtained the value in current Kenya Shillings equivalent to $2 Purchasing Power Parity (PPP) a day. This value was then multiplied by 365 in order to obtain an annual measure against which we could compare the annual income variable. Since the poverty line is based on per capita measurement, we divided total net household income by the number of total adult equivalents (weighted by the number of months each individual was actually present in the household) and compared the resulting value with the poverty line. The table for adult equivalents is shown in Appendix 1. We then constructed a binary variable indicating whether the household's average adult equivalent qualified as poor or non-poor[2].

2.3.2. Econometric Methods

The general regression approach for the difference-in-difference models follows Imbens and Wooldridge (2007) and Wooldridge (Chapter 13, 2004). In the two-year case, using ordinary least squares (OLS) with treatment, year, and interaction effects is equivalent to differencing the independent variable, as in Yamano and Jayne (2004) and Chapoto, Jayne, and Mason (forthcoming). We apply the approach recommended for multi-year models.

The general equation estimated is:

$$y_{it} = \beta_0 + \sum_{j=1}^{p} \beta 1_j dt + \sum_{k=1}^{p} \beta 2_k dc + \sum_{k/j=1}^{p} \beta 3_{jk} dtdc + \sum_{l=1}^{p} \beta 4_l x_{it} + \varepsilon_{it},$$

where β_0 is the constant in the model, *dt* is a set of dichotomous dummy variables for all but one year, *dc* is a set of dummy variables for the treatments relative to control, and *dtdc* are interactions between the time dummies and the treatment dummies. x_{it} are other independent variables, continuous or discrete, that help explain the variation in *y* for cross-section *i* and time *t*. $\beta 1 - \beta 4$ are vectors of coefficients to be estimated for each time period *j*, each treatment *k*, the respective interactions and the *l* independent variables. Finally, ε is the error term.

The equation can be interpreted in the following way. The treatment dummies net out any systematic differences between treatment and control groups that existed prior to the program. These differences are also known as *selection bias*. Selection bias is potentially generated by a program procedure or self-selection process that targets particular individuals, deliberately or inadvertently. For example, projects often deliberately seek out leaders and willing participants in any community, and these are typically not the farmers who have the least resources or are less *resourceful*. In other instances, farmers who choose to participate in the program have different observable and unobservable characteristics.

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[2] 2004=21,170, 2006=22,630, 2008=25,550, 2010=27,740 (Ksh)

The time dummies account for other unobservable or unmeasured effects that took place in any of the years, including factors ranging from weather to post-election violence, to price ratios. Such factors could cause changes in outcome variables even in the absence of a program.

The coefficients of interest are those that express the effect of the interaction between treatment group and time dummy. These measure the effect of membership in the treatment group during the year interacted (e.g., 2006) relative to 2004, minus the change in the control group between 2006 and 2004, or the *difference in differences*. The comparison year for each interaction is 2004.

Most regressions were estimated in Stata 11 as OLS models with standard errors that are robust to heteroskedasticity. For censored variables, probit models, tobit models, truncated regression and double-hurdle models were tested, although in most cases, double hurdle models did not converge.

We estimated the models in three phases. First, we estimated the basic model as specified in the above equation, with years, treatment, and treatment by year interaction variables, and additional covariates using the entire USAID sample.

Next, we attempted to enhance the quality of the estimation through using propensity score matching to improve the comparability of households in target and control groups using the USAID sample. However, the distribution of the income variable did not change through matching households between the two groups based on observed characteristics, suggesting that common support in the treatment and control group distributions is adequate in the USAID sample with respect to the variables we have observed (Appendix 1). Regression results after matching were similar to those reported in the text. Logarithmic transformation did not improve estimates either. However, we chose to drop income outliers above Ksh 10,000,000.

Third, to test the robustness of our results, we used propensity score matching to develop common statistical support for the treatment groups in the USAID sample and a larger, more broadly representative control group provided by farm households in the Tegemeo panel survey. As noted above, the initial regressions we estimated include treatment dummies to handle pre-existing, observable, and unobservable differences between treatment and control households prior to the program. However, the control group selected in the sampling procedure is not necessarily representative of other households in Kenya. We considered that by utilizing the statistical base of a large, nationally representative control group, we can better discern the extent to which our findings can be generalized. In addition, as described in the sampling section, we were aware of numerous challenges related to sample selection—some of which we could address by employing an independent control group.

Survey years coincided for the USAID and Tegemeo panel survey samples only in 2004 and 2010. Propensity score matching was performed with the 2004 survey data from the two samples, in order to identify households located within a shared statistical distribution in the base year. Target and indirect beneficiaries were grouped together to represent the USAID treatment group. Tegemeo panel survey households were identified as the control group. The binary variable (treatment=1, control=0) was regressed against: acres of farmland, years planting maize, membership in associations (yes=1, no=0), attempt to obtain credit (yes=1, no=0), value of total assets, value of livestock assets, household total net income, net crop

income, net livestock income, whether the household head was male or female, years of education (schooling) of the household head, dummy variables for agro-regional zones, distance to fertilizer markets, distance to seed markets, distance to health center, distance to source of electricity, distance to telephone, distance to mobile phone, distance to extension services, and distance to veterinary services.

Households outside the common support in 2004 were dropped, and 5% of the households in the beneficiaries group for which the propensity score was lowest were trimmed from the common statistical distribution in 2004 (Appendix 2). After the 2010 data were included in the dataset, households that were not in the common support in 2004 but were still present in 2010 were also dropped.

Two regression approaches were then applied in the third phase. In the first, the regression model reported above was estimated, as an unbalanced panel or pooled cross-section. Data included households sharing the common statistical distribution in 2004 and new households that were not present in 2004 but were present in 2010, including some new USAID target and control households, although these are few. In the second approach, we estimated panel data regressions, including only households that were present in both 2004 and 2010. However, the sample in this second approach was extremely small (111 households in total for all programs in the USAID treatment group). We utilized a generalized estimating equation (GEE) method, which consisted of assuming independence among cross-sections and a population averaged estimator. Standard errors derived from both estimation models are robust.

With respect to descriptive statistics, Kruskal-Wallis (non-parametric) tests were used to compare means and the Kendall Tau test was used for correlations, because these make no assumption regarding underlying statistical distributions. Stochastic dominance tests using the Kolmogorov-Smirnov non-parametric test were conducted using predicted values.

3. COMPARISON OF PROGRAM PARTICIPANTS AND NON-PARTICIPANTS IN 2004

The data demonstrate systematic differences among target, control, and indirect beneficiary households in the initial survey year (2004). Program participants and non-participants differed in terms of the education of the household head, an important indicator of human capital, and farm land owned, which is related to such variables as access to credit and services, and acquisition of market-related sales information and services (Table 3). On average, target households owned more than twice as much land in 2004 than households in the control group. Household heads had an average of two more years of schooling.

On the other hand, socio-demographic characteristics such as household size, adult equivalent household size, the age of the household head, and the percentage of male- as compared to female-headed households, are statistically similar across groups. It is noticeable that the percent of female-headed households in the groups is lower than it is for the general population. An estimated 20.5% of 1,397 households surveyed were recognized as headed by women in Tegemeo's 2004 panel household survey.

Despite the apparent variation in means across groups, infrastructural characteristics do not differ significantly. This is important, because it means that the availability of a range of services is similar on average among household groups, even though household capacity to take advantage of these services is likely to differ because of the differences in capital endowments mentioned above.

Table 3. Characteristics of Participants and Non-participants, 2004

	Target	Control	Indirect	All groups
Socio-demography				
% Households head by men	93	90	88	91
Education of head (years)*	11	9	9	10
Age of head	53	51	50	52
Adult equivalent household size	5.40	4.99	5.70	5.37
Household size	6.24	5.86	6.74	6.26
Farm land owned (acres)*	6.99	2.59	4.00	5.45
Infrastructure (distances in km)				
Certified seed seller	8.15	6.14	12.40	8.64
Extension agent	5.05	4.02	5.07	4.83
Veterinarian	3.87	2.81	3.62	3.60
Market	2.95	1.74	6.28	3.36
Phone	4.73	2.91	6.30	4.66

*Kruskal-Wallis tests indicate statistically significant differences at less than <5% among groups with respect to farm land owned and education of the head.

Table 4. Average Income Amounts (Ksh) and Shares by Source, Participants and Non-participants, 2004

	Total household income	Share of total household income				
		Crops	Livestock	Wages and salaries	Remittances	Business and Informal Labor Activities
Target	300,320	48	19	17	2	14
Control	168,015	34	20	20	1	24
Indirect	213,837	41	32	21	1	5
All groups	253,139	44	22	18	1	14

Kruskal-Wallis (non-parametric) tests indicate statistically significant differences at <5% among groups for income, crop share and informal business share of income.

We also see prior differences among the groups in variables used to measure impact, such as income (Table 4). The target group is significantly better off in terms of both nominal and real income than the control and indirect beneficiary groups in the initial program year. The groups also differ statistically with respect to the share of income earned through production of crops and business and informal labor activities.

In 2004, the percentage of households with nominal income per capita below the official poverty line was significantly lower for the beneficiary groups compared with the control group (Table 5).

Prior differences were also statistically significant for the value of livestock, household and total assets (Table 6). Target households began with more than twice the average value of livestock assets, and more than three times the average value of total assets owned by households in the control group. Additional means are shown by program in Appendix 3.

Table 5. Percent of Households with Per capita Income below the Poverty Line, Participants and Non-participants, 2004

	% Poor (below poverty line)
Target	17.8
Control	31.4
Indirect	24.7
All groups	22.1

Kruskall-Wallis (non-parametric) tests indicate statistically significant differences at <5% among groups. Income deflated by CPI.

Table 6. Nominal Asset Values (Ksh), Participants and Non-participants, 2004

	Value of livestock assets	Value of household assets	Total value of assets
Target	112,275	426,813	539,088
Control	53,350	122,168	175,518
Indirect	66,174	235,248	301,422
All groups	90,437	323,364	413,801

Kruskall-Wallis (non-parametric) tests indicate statistically significant differences at <5% between groups for all asset categories.

In a randomized, fully experimental situation, as compared to our quasi-experimental situation such as this one, we would expect the observed characteristics of all three groups to be similar at least in central tendency. Any changes observed from one year to the next would then be attributable to the program, or to unobserved factors. Instead, as shown here, the data suggest major differences in observed characteristics prior to program activities.

As suggested in the methods discussion, prior differences are not unexpected and they do not invalidate the research design for estimating impact. Development programs often target those who are better placed to take up new ideas and approaches—and there are arguments for doing so.

However, initial differences between target and control groups are a potential source of bias in estimates of program impact. To reduce this potential bias, we can control statistically for initial conditions when analyzing differences in indicator values among groups in subsequent years. That is, we can compare the differences over the years in one group to the differences over the years in the other group (difference-in-difference). This is the purpose of the econometric analysis that follows.

It is also informative to explore the *trajectories* followed by target households in successive survey years. Differences can only be compared meaningfully if outcome indicators move in similar directions for each of the groups. We see that the target group ranks higher in terms of nominal and real income than either the control or indirect beneficiary group in the initial year and all subsequent survey years (Figures 1 and 2).

Similarly, in each survey year, the percent of households with total net income below the poverty line is greater for the control group compared with either the target or indirect beneficiary group; although the indirect beneficiary group appears to be better off than the others in 2010. The difference between 2008 and 2010 for this group is surprising. The target group is better off in 2008 relative to other years, and the other groups are better off in 2010 (Figure 2).

In this analysis, the research question we seek to answer is whether the differences in indicator values from year to year are greater for the target group than for the control and indirect beneficiary groups, when both observed and unobserved factors are taken into consideration. This is the justification for econometric analysis presented next. In the following section, we explore cross-program impacts first, followed by impacts by program.

Figure 1. Comparison of Mean Nominal Income by Group and Survey Year, USAID Sample

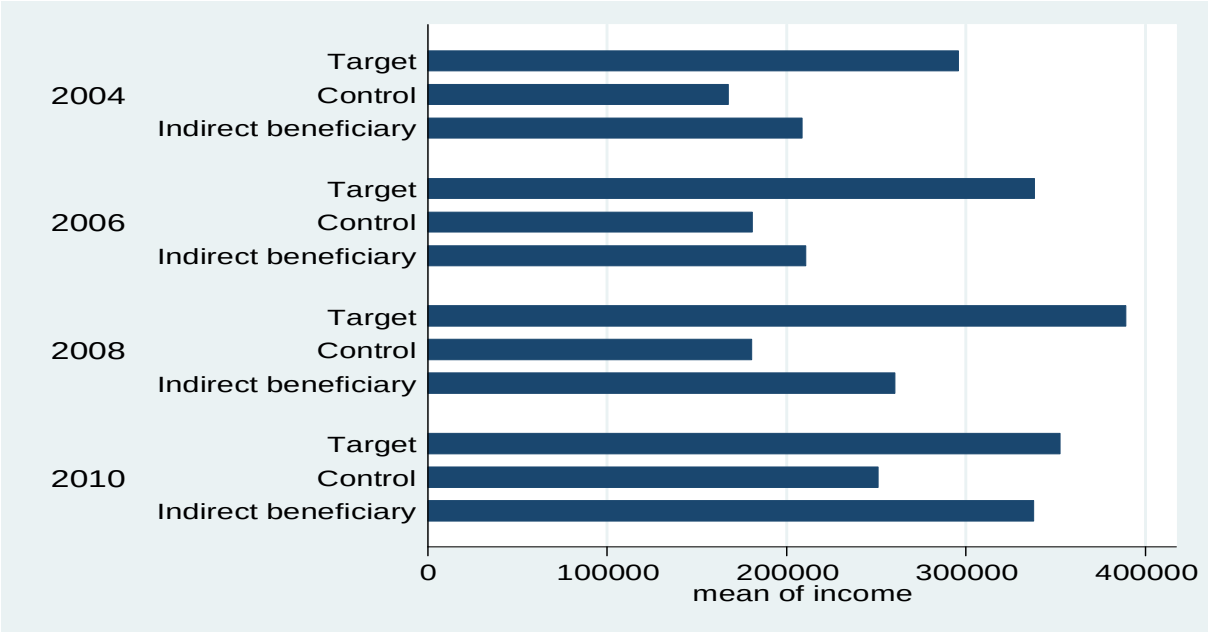
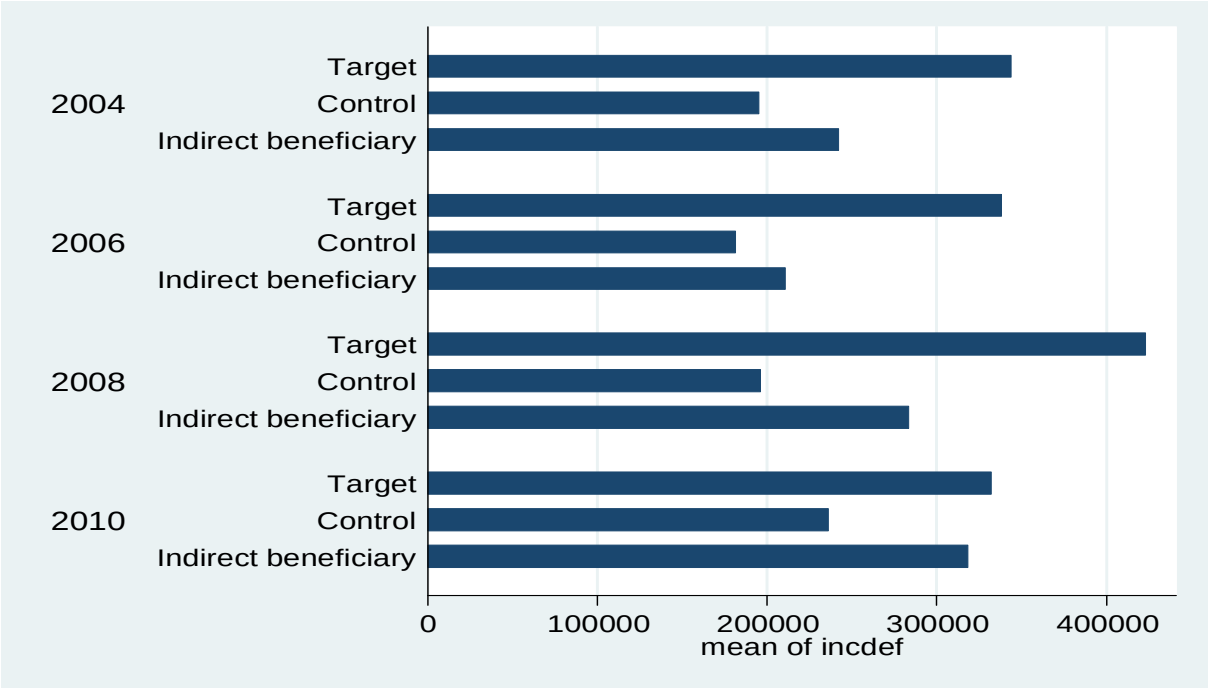


Figure 2. Comparison of Mean Real Income by Group and Survey Year, USAID Sample



4. INCOME IMPACTS ACROSS PROGRAMS

Guided by the approach outlined in the methods section and the descriptive statistics reported above, we began by estimating difference-in-difference models for all programs combined using the USAID sample. These models control both for important observed household characteristics and by construction, unobserved household characteristics. Observed characteristics include human capital (sex of household head, education of household head, household size), natural capital (farm land owned), and distance to nearest market. Year effects, treatment effects, and the interaction of treatment and year are included, as well as dummy variables for all agro-regional zones. Outcome variables for cross-program equations are secondary income and poverty indicators.

Regressions indicate that the combined programs had an impact on total net household income in 2006, 2008, and 2010 (Table 7). The magnitude of the effect, and its significance, rose between 2006 and 2008, and dampened slightly in 2010. When income is deflated by the consumer price index (CPI), these effects are still visible in 2008 and 2010, for target and indirect beneficiaries. The slight reduction in the magnitude of the effect in 2010 can be attributed to the residual effect of the post-election violence in early 2008, which disrupted the livelihoods of some households. The region most affected by the violence was Rift Valley Province, in which the KDDP and the KMDP programs were being implemented. In addition to post-election violence, most parts of Kenya, including the high potential areas, experienced severely depressed rainfall during the long rains season of the 2009/2010 cropping year, which induced low levels of agricultural production in that year.

Among the covariates, the education of the household head and extent of farm land owned have strong, positive effects on income. Income is lower in the two Western agro-regions, and higher in the High Potential Maize zone, relative to the omitted zone, which is the Marginal Rain Shadow agro-region.

There appears to be no effect on crop net income overall (not shown), although there is some indication that off-farm income is greater among households targeted by the programs in 2010. Results for net livestock income are similar to those of total income, although location in the Coastal Lowlands is also associated with lower incomes. Again, the education of the household head plays an important role, and households in the High Potential Maize zone earn more off-farm income than in the Marginal Rain Shadow. One interpretation of this finding is that programs may have improved the capacity of program participants to generate income from non-farm sources, through raised farm productivity and re-allocation of labor. Estimation of the model using the common statistical distribution for USAID program participants and the independent, broadly representative Tegemeo sample as the control group reinforces these findings.

Results shown in Table 8 demonstrate the impact of programs on total net household income and on off-farm income, for both targeted and indirect beneficiaries, at the 10% level of significance. Thus, program participants fare well not only when compared to a relatively small sample of nearby households who did not participate (the USAID control group, as in Table 7), but also when compared to a nationally representative, independent statistical sample of Kenyan farm households with similar characteristics. (The balanced panel model results did not concur, but that model was based on a sample of only 111 treatment households.) The impact on livestock income that was estimated in the USAID sample did not hold in the comparison of the treatment group with the Tegemeo sample. This finding either raises doubts concerning the result presented in Table 7, or suggests that impacts on net livestock income were localized.

Table 7. Impacts of all Programs on Income ('000 KSh), USAID Sample, 2004-2010

	Income			Income/CPI			Net livestock income			Net off-farm income		
	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|
2006	19.14	24.30	0.4310	-8.14	25.93	0.7540	-15.86	18.20	0.3830	4.93	18.76	0.7930
2008	14.87	23.44	0.5260	3.13	25.94	0.9040	-14.64	18.26	0.4230	6.49	16.98	0.7020
2010	59.62	23.86	0.0130	16.82	24.96	0.5000	-20.03	15.63	0.2000	-0.64	17.19	0.9700
target	-38.26	40.38	0.3430	-20.77	40.73	0.6100	-28.30	16.31	0.0830	-23.98	33.34	0.4720
indirect	-16.67	28.45	0.5580	-11.62	31.76	0.7140	-28.58	16.99	0.0930	4.89	27.10	0.8570
target 2006	74.41	37.66	0.0480	53.48	39.40	0.1750	34.30	19.79	0.0830	27.54	31.83	0.3870
target 2008	125.32	44.23	0.0050	123.21	48.39	0.0110	61.87	21.73	0.0040	55.01	37.35	0.1410
target 2010	124.07	51.17	0.0150	97.29	50.30	0.0530	37.01	16.88	0.0280	77.21	43.26	0.0740
indirect 2006	16.30	35.78	0.6490	9.34	38.24	0.8070	23.64	20.09	0.2390	-3.37	32.62	0.9180
indirect 2008	91.84	45.19	0.0420	93.92	49.64	0.0590	80.29	33.77	0.0180	27.45	35.33	0.4370
indirect 2010	162.71	93.48	0.0820	145.11	88.92	0.1030	42.55	17.90	0.0180	142.30	94.96	0.1340
Male-headed household	24.89	18.10	0.1690	23.20	17.90	0.1950	2.67	4.73	0.5730	17.17	14.09	0.2230
Education of head	16.46	1.85	0.0000	16.87	1.85	0.0000	1.41	0.51	0.0060	14.70	1.59	0.0000
Farm land owned	24.30	9.54	0.0110	24.71	9.32	0.0080	3.23	0.92	0.0000	9.69	6.96	0.1640
Km to market	-0.38	0.62	0.5430	-0.33	0.63	0.6020	0.09	0.26	0.7210	-0.43	0.73	0.5540
Coastal lowlands	-52.32	43.66	0.2310	-49.08	43.63	0.2610	-86.02	12.60	0.0000	90.04	61.37	0.1420
Western lowlands	-90.14	30.44	0.0030	-92.73	31.70	0.0030	-84.97	13.32	0.0000	39.57	26.62	0.1370
Western transitional	-84.87	31.74	0.0080	-86.13	33.12	0.0090	-66.88	13.83	0.0000	5.62	25.99	0.8290
High potential maize	51.66	32.77	0.1150	56.20	34.22	0.1010	-27.58	13.56	0.0420	79.20	26.30	0.0030
Western highlands	44.51	71.24	0.5320	53.80	74.09	0.4680	-14.96	19.31	0.4390	49.72	58.22	0.3930
Central highlands	35.27	32.47	0.2780	40.08	33.54	0.2320	-22.72	13.35	0.0890	39.33	27.47	0.1520
Constant	-57.95	44.17	0.1900	-36.30	45.37	0.4240	79.63	20.84	0.0000	-123.03	37.06	0.0010
F(21, 1732)=14.54				F(21, 1732)=15.12			F(21, 1800)=25.48					
Prob>F=0.0000				Prob>F=0.0000			Prob>F=0.0000					
n=1754				n=1754			n=1754			n=1745		
Omitted zone=Marginal rainshadow												

Table 8. Impacts of All Programs on Income ('000 Ksh), 2004 and 2010, USAID and Tegemeo Samples

	Income			Income/CPI			Net livestock income			Net off-farm income		
Variables	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|
2010	92.30	18.19	0.00	-2.26	14.84	0.88	18.76	4.23	0.00	23.78	11.08	0.03
target	26.44	19.29	0.17	44.30	20.94	0.03	6.52	4.54	0.15	-6.48	15.04	0.67
indirect	-10.78	23.12	0.64	-3.50	25.89	0.89	4.53	6.16	0.46	-13.53	17.70	0.45
target 2010	75.65	42.01	0.07	21.11	34.02	0.54	7.16	7.14	0.32	64.87	33.63	0.05
indirect 2010	166.50	95.04	0.08	106.40	70.08	0.13	13.55	9.89	0.17	154.70	81.10	0.06
Male household head	12.00	11.91	0.31	15.17	11.09	0.17	7.23	2.52	0.00	1.40	9.31	0.88
Education of head	13.32	1.52	0.00	12.95	1.32	0.00	0.65	0.26	0.01	10.40	1.28	0.00
Farm land owned	13.40	2.09	0.00	14.43	2.16	0.00	2.25	0.25	0.00	5.05	1.63	0.00
Km to market	-0.27	0.18	0.13	-0.30	0.21	0.16	-0.08	0.05	0.14	0.02	0.02	0.47
Coastal lowlands	-4.09	23.24	0.86	4.40	23.61	0.85	-16.00	6.31	0.01	32.27	18.51	0.08
Western lowlands	-50.42	14.81	0.00	-48.54	15.72	0.00	-12.39	3.09	0.00	-9.11	11.81	0.44
Western transitional	-51.11	13.77	0.00	-49.26	14.38	0.00	-7.05	2.94	0.02	-42.30	9.48	0.00
High potential maize	16.60	14.34	0.25	17.70	15.44	0.25	14.73	3.16	0.00	-9.05	11.10	0.42
Central highlands	30.63	18.35	0.10	40.50	16.09	0.01	13.71	3.97	0.00	-13.04	15.53	0.40
Constant	-7.56	19.05	0.69	11.21	16.85	0.51	1.38	2.87	0.63	-15.30	15.87	0.34
Marginal rainfall shadow is excluded zone												
F(14, 2443) = 24.64				F(14, 2443) = 26.59			F(14, 2464) = 31.37			F(14, 2464) = 13.14		
Prob > F = 0.0000				Prob > F = 0.0000			Prob > F = 0.0000			Prob > F = 0.0000		
Observations	2458			2458			2479			2479		
R-squared	0.218			0.269			0.208			0.087		
Target	594			594			608			608		
Indirect	204			204			208			208		
Control(total)	1660			1660			1663			1663		
Control (tegemeo)	1388			1388			1388			1388		
Control (USAID)	272			272			275			275		

Note: observations are double the number of households (households are observed in 2004 and 2010)

5. IMPACTS BY PROGRAM

5.1. Kenya Maize Development Program

KMDP program participants grow maize in the Western Transitional, High Potential Maize, and Western Highlands zones, which are well-favored for maize production relative to other agro-regional zones in Kenya. In 2010, Tegemeo panel data indicate that 82%, 96%, and 72% of households in the three zones, respectively, grew hybrids, of which only a negligible percentage had retained (recycled) seed from the previous season. The overall percentage of farmers growing hybrid during the 2009-10 season in the full panel was 82%. Farmers in these areas have also grown maize hybrids since the earliest releases of improved maize in Kenya, in the late 1960s-early 1970s.

There are only eight cases of indirect beneficiaries in the pooled sample, which is too few to analyze separately. The trajectories of maize yields in the four survey years are shown for target and control groups below. While there is a yield advantage among KMDP program participants in each survey year relative to the control group, mean yields among participants are not substantially greater than that measured in 2004 except in 2006.

Considering either the full sample of farmers (all programs) or the KMDP groups only, the highest observed yields by far were reported for the 2006 survey year. This survey year was the best of the four years for maize production. By contrast, farmers experienced depressed rainfall in the 2009/2010 cropping year. Nonetheless, all groups of farmers managed to obtain average yields in 2009/2010 that were no lower than either those obtained in the 2000/2004 or the 2007/2008 cropping years (Figure 3).

Figure 3. Comparison of Average Maize Yields, KMDP Program, by Group and Survey Year, USAID Sample

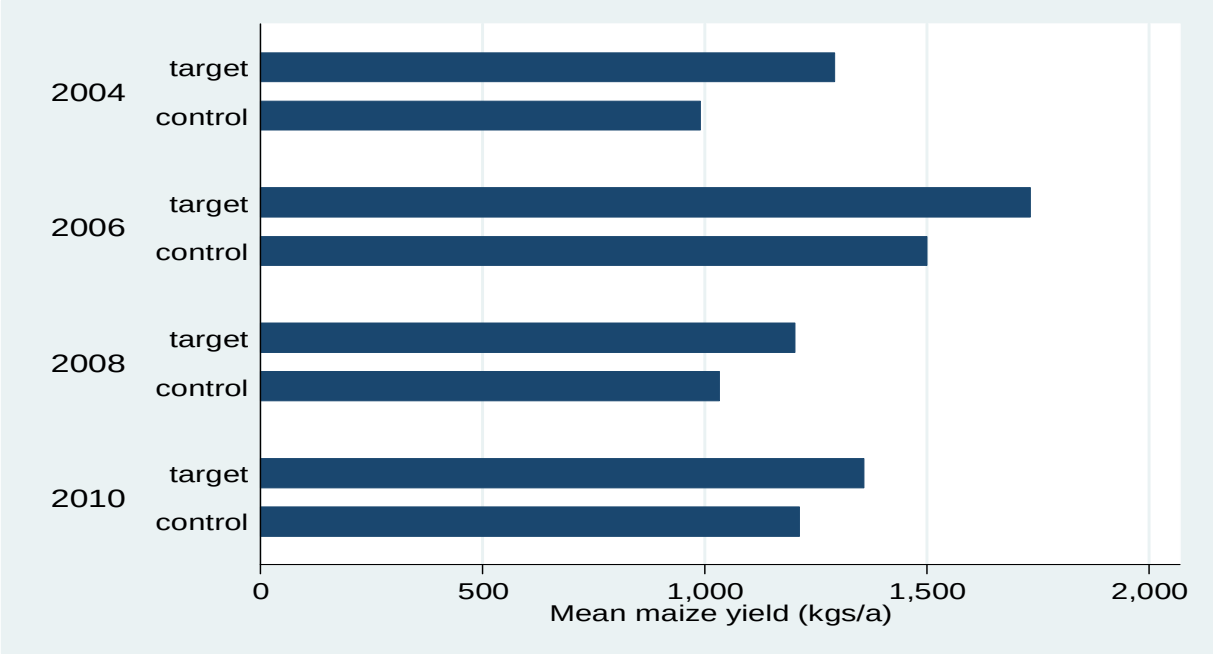


Figure 4. Comparison of Average Maize Production, KMDP Program, by Group and Survey Year, USAID Sample

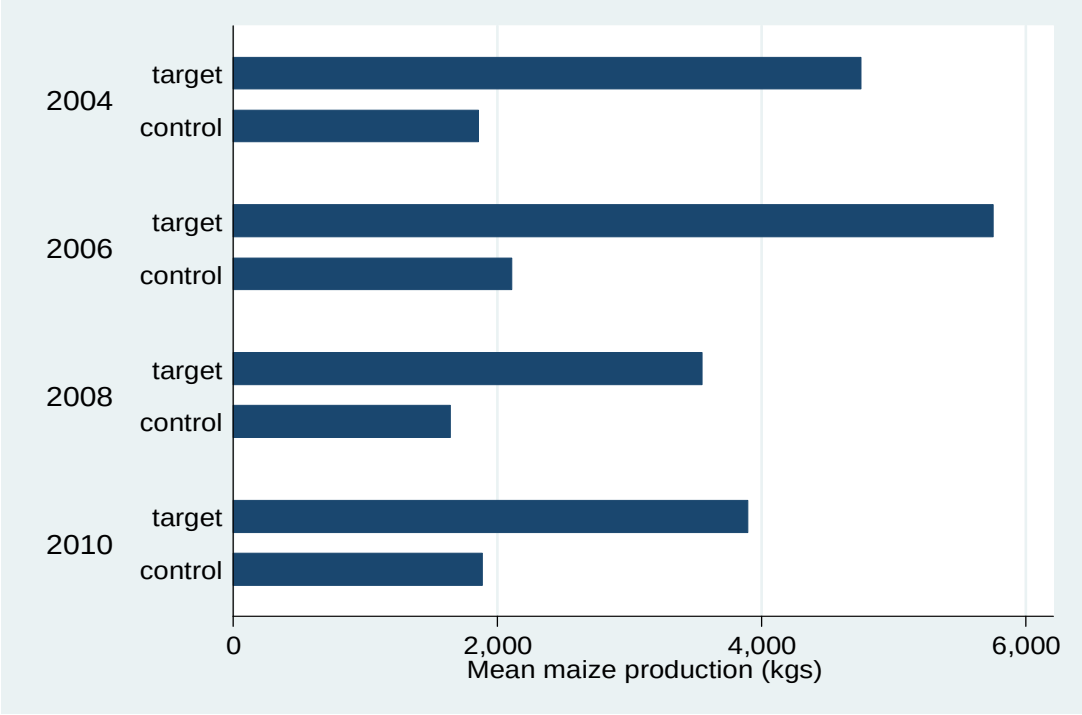
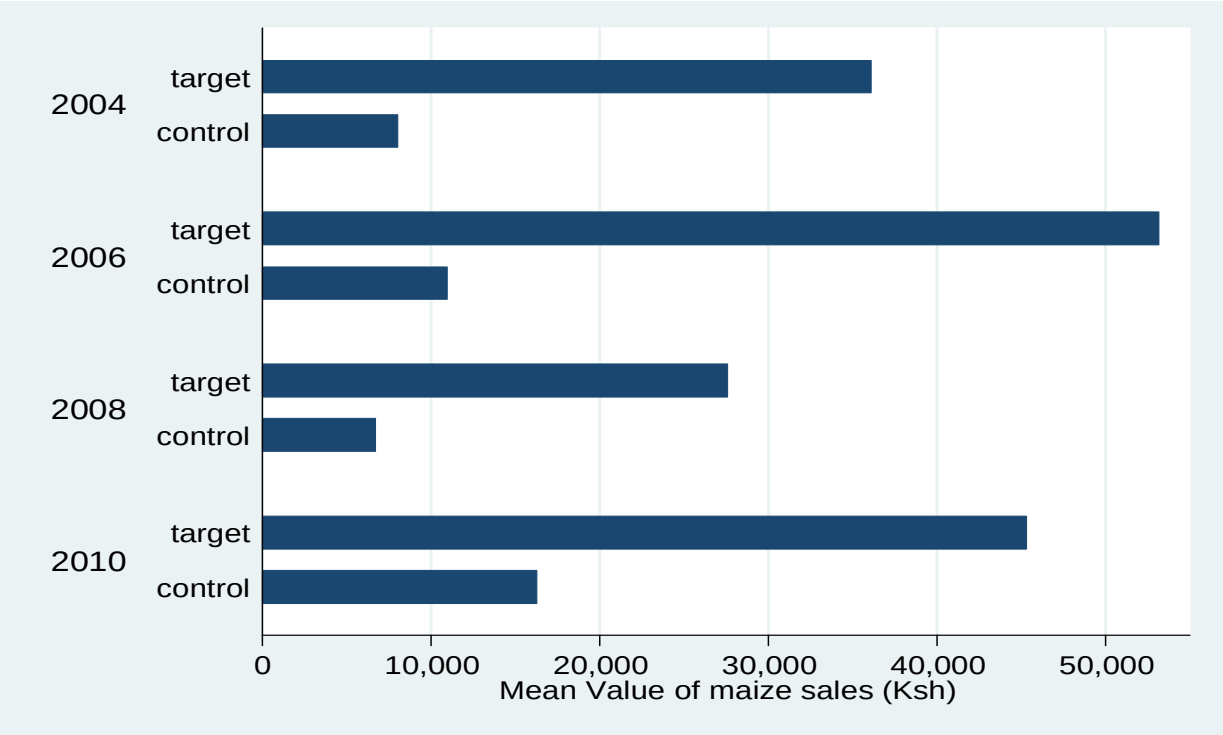


Figure 5. Comparison of Average Value of Maize Sales, KMDP Program, by Group and Survey Year, USAID Sample



As suggested above, econometric analysis indicates that the impact of the program on maize yields per acre was not statistically significant in any of the survey years compared to the initial year of 2004 (Table 9). Even when controlling for other factors, maize yields rose for both control and target groups in 2006. This finding confirms that the 2005/2006 cropping year had an effect in and of itself on maize yields.

Rain-fed maize yields are highly variable from year to year and location to location, and although they are less so in the favorable areas of Kenya relative to other areas of Sub-Saharan Africa, we would not necessarily expect to see an impact on yields without having used a randomized, controlled design.

The one socio-economic variable that is statistically significant in this regression, and the only variable that is statistically significant other than 2006 and initial sample selection, is male household head. On average, male-headed households produce 264 kg/acre more than female-headed households. Only 30 of the 331 households included in the KMDP groups are female-headed. For purposes of comparison, this percentage (under 10%) is less than half the percentage of maize-growing, female-headed households in the more nationally representative Tegemeo sample (24% in Western Transitional, 25% in High Potential Maize, and 23% in the Western Highlands zones in 2010). Thus, the data indicate that households headed by women appear to be under-represented in the KDMP. However, operational aspects of the program may be more important than representation in terms of measuring gender impacts.

The impact of the program in terms of maize production and the value of maize sold is visible in 2006. One interpretation of this finding is that maize growers in the program were better able to respond well to a good season than those outside the program, given the range of new services to which they had access. Farm land owned and location in the High Potential Zone also have significant and large effects on production and sales relative to other zones.

There is no impact of the program, however, on the decision to sell maize or on the proportion of maize produced that is sold. Of the parameters included in the regression, only farm land owned and growing maize in the best zone in Kenya influence these decisions. In interpreting any of these results, however, it is important to remember that the sample sizes are small and the socio-economic covariates are few.

In terms of overall indicators of KMDP impact, there is no discernible impact of the program on total household net income (Table 10), nominal or deflated, in any of the survey years. Larger farmers who live closer to markets in either the Western Highlands or the Higher Potential Maize zones earned significantly more than those in the Western Transitional zone from 2004 to 2010.

Table 9. Impacts of KMDP on Maize Yield, Production, Sales, Sales Share of Production, and Decision to Sell Maize

	Maize yield (kgs/a)			Maize production (kgs)			Value of maize sold (Ksh)			Share of production sold			Sell maize or not		
	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|
2006	846.4	430.9	0.0500	158.7	394.1	0.6870	-2690.6	5711.1	0.6380	0.106	0.095	0.2650	0.391	0.321	0.2230
2008	75.7	165.4	0.6470	-153.9	367.8	0.6760	-12488.9	9062.5	0.1700	-0.046	0.104	0.6590	-0.239	0.334	0.4750
2010	215.4	169.3	0.2040	-51.2	464.0	0.9120	17557.0	14428.7	0.2250	-0.004	0.093	0.9690	-0.029	0.301	0.9230
target	244.4	128.9	0.0590	1106.1	695.7	0.1130	3943.2	9352.7	0.6740	0.190	0.084	0.0250	0.360	0.300	0.2300
target 2006	-406.8	520.7	0.4350	1373.8	810.3	0.0910	26883.7	11887.5	0.0250	-0.029	0.114	0.8000	-0.132	0.418	0.7520
target 2008	-169.5	210.2	0.4210	-282.1	632.8	0.6560	13958.5	11222.0	0.2150	0.039	0.129	0.7640	0.030	0.448	0.9470
target 2010	-148.4	206.3	0.4720	-74.5	746.9	0.9210	1042.1	17317.4	0.9520	0.066	0.114	0.5650	0.346	0.405	0.3940
Male-headed household	263.6	125.7	0.0370	283.4	472.6	0.5490	-628.2	9954.5	0.9500	0.047	0.078	0.5460	0.374	0.297	0.2080
Education of head	16.2	11.7	0.1660	46.6	32.8	0.1560	730.5	543.3	0.1800	0.003	0.004	0.4280	0.006	0.017	0.7280
Farm land owned	-7.65	9.18	0.4050	315.13	161.61	0.0520	3372.88	2082.33	0.1070	0.022	0.003	0.0000	0.178	0.030	0.0000
Km to market	13.2	20.9	0.5290	3.4	127.6	0.9790	1413.2	2172.7	0.5160	-0.008	0.006	0.2150	-0.032	0.024	0.1690
High potential maize	137.1	225.9	0.5440	1683.4	350.7	0.0000	28109.4	6935.3	0.0000	0.207	0.060	0.0010	0.318	0.199	0.1110
Western highlands	158.3	275.3	0.5660	357.8	595.2	0.5480	17161.2	10927.5	0.1180	0.142	0.079	0.0750	-0.223	0.292	0.4460
constant	532.0	228.5	0.0210	-912.6	779.2	0.2420	-23193.4	14041.1	0.1000	-0.213	0.113	0.0600	-1.096	0.395	0.0050
F(13, 321)=2.48				F(13, 358)=12.24			F (13,232)=19.19			LR chi2(13)=142.02			LR chi2(13)=94.54		
Prob > F=0.0031				Prob > F=0.0000			Prob > F=0.0000			Prob > chi2=0.0000			Prob > chi2=0.0000		
n=335				n=337			n=246 (only for maize sellers)			n=372 (121 left-censored at 0)			n=373		
OLS (robust s.e.)				OLS (robust s.e.)			truncated regression			Tobit			probit		

Table 10. Impacts of KMDP on Income and Value (Ksh) of Livestock Assets, 2004-2010

	Income (Ksh)			Value of livestock assets (Ksh)		
	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|
2006	33933	41052	0.4090	20973	16419	0.2020
2008	28275	34218	0.4090	206885	34919	0.0000
2010	97082	48547	0.0460	49465	17548	0.0050
target	7851	45342	0.8630	-58166	21694	0.0080
target 2006	-27857	57603	0.6290	12150	22840	0.5950
target 2008	42698	62834	0.4970	328635	117317	0.0050
target 2010	-14682	67604	0.8280	6150	25723	0.8110
Male-headed household	24504	56074	0.6620	31139	33655	0.3550
Education of head	4254	3228	0.1880	-4412	1899	0.0210
Farm land owned	12189	7290	0.0950	6244	2907	0.0320
Km to market	-6767	3185	0.0340	-1957	3750	0.6020
High potential maize	69063	24092	0.0040	52476	21259	0.0140
Western highlands	234883	54172	0.0000	262049	61098	0.0000
constant	39087	58847	0.5070	10249	36258	0.7780
F(13, 358)=5.73				F(13, 359)=7.76		
Prob>F=0.0000				Prob >0.0000		
n=372				n=373		
OLS (robust s.e.)				OLS (robust s.e.)		

KMDP appears to have influenced the value of livestock assets enumerated in 2008 (two years after the impact on maize production). It will be important to explore this finding more thoroughly. Again, location in the High Potential Maize and Western Highlands zones is positively associated with the value of livestock assets.

Estimation of the model using the common statistical distribution for USAID program participants and the independent, broadly representative Tegemeo sample as the control group does not show significant impacts on maize yields, production, or value of sales, income, or livestock assets. This result is not surprising, given the fact that virtually all households in Kenya grow maize, but do so with tremendous heterogeneity in objectives and conditions that leads to wide ranges in yields, production, and sales.

Regressions using both samples do confirm the overwhelming weight of higher education of the household head, larger farm size, and favorable agro-ecological conditions in attaining

higher maize productivity, production, sales earnings, and income. They also underscore the statistical significance of a male household head, and an initial positive bias in maize outcomes for the target group. Interestingly, R-squared statistics are high for independently sampled target and control groups (from 21% for maize yields to 38% for value of livestock assets).

5.2. Kenya Horticulture Development Project

Yield and production for specific horticulture crops were not examined for KHDP because of the wide range of horticultural crops grown, and the relatively small sub-sample sizes for each. The sample without indirect beneficiaries was used for estimation, given the distortions mentioned above. KHDP participants reside in the Coastal Lowlands, the Western Lowlands, the Western Transitional Zone, the High Potential Maize Zone, and the Central Highlands.

Figure 6. Comparison of Average Production of Horticultural Crops, KHDP Program, by Group and Survey Year, USAID Sample

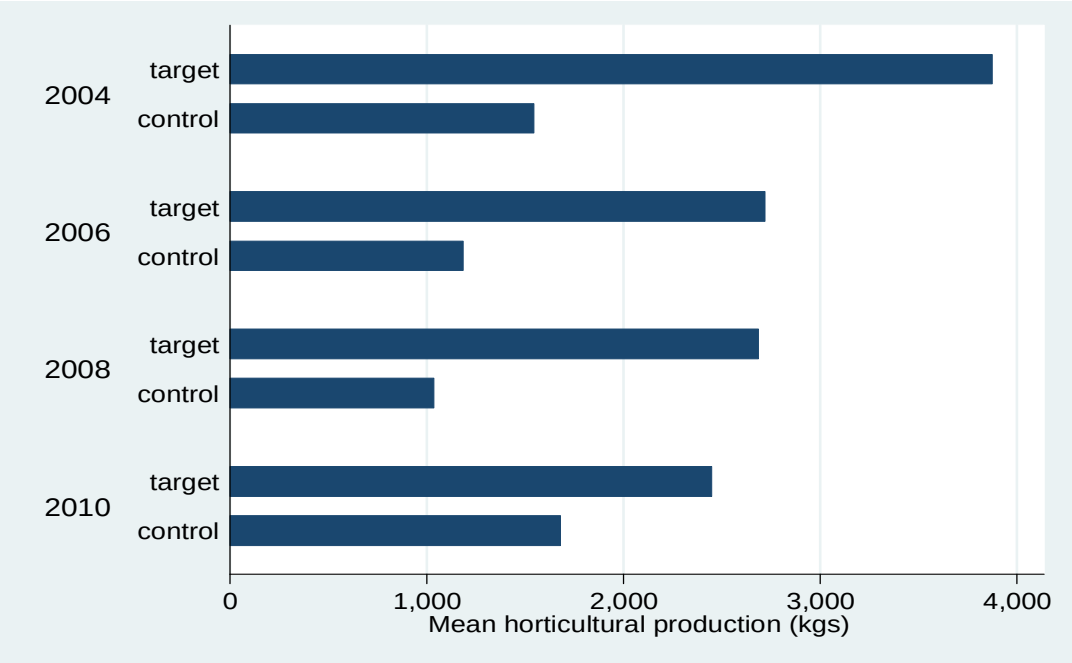
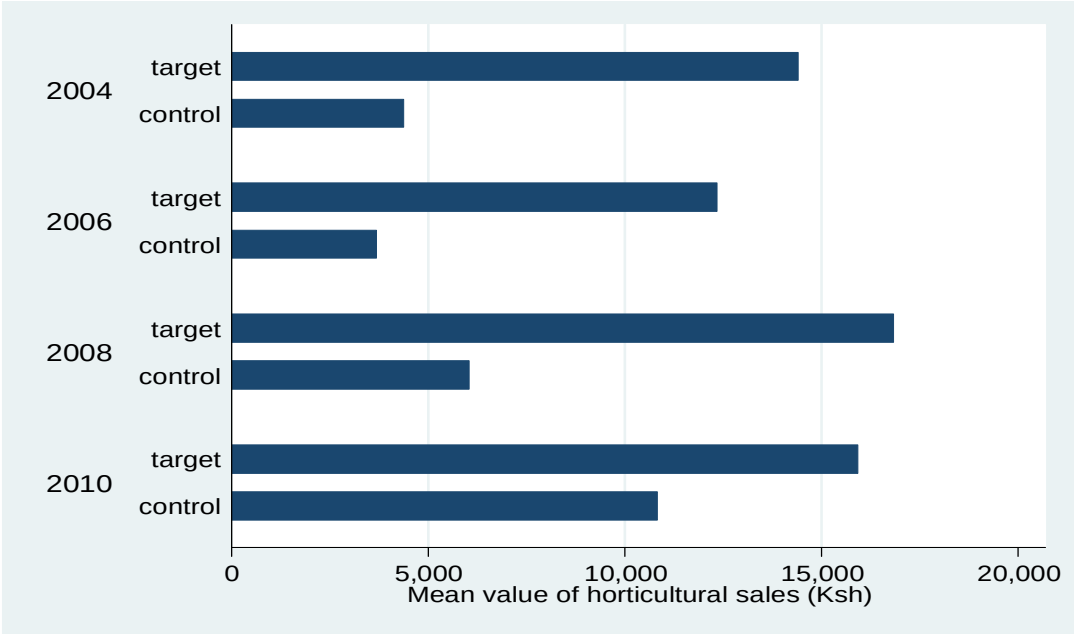


Figure 7. Comparison of Average Sales Value of Horticultural Crops, KHDP Program, by Group and Survey Year, USAID Sample



As suggested by Figures 6 and 7, KHDP does not seem to have had an impact on horticultural production per se. In fact, the effect in 2006 appears to be negative relative to 2004. However, estimating production has been complicated by shifting focus from one crop to another, shifting of the locus of activities from one area to another, the broad scope of crops considered and the measurement error associated with estimating production in each of them individually and in the aggregate. Only zone effects are significant in the regression—negative in the Coastal Lowlands and positive in the Central Highlands (Table 11).

The value of horticultural crop sales, however, was substantially affected by program participation in 2010 relative to 2004. Year effects are of large magnitude, as well as location in the Coastal Lowlands (negative) and the Central Highlands (positive). Of the 353 households, 41 did not sell their horticultural produce. Tobit and probit regressions show no effect of the program on the share of sales or the decision to sell, although zone effects are statistically significant. All are negative relative to the Western lowlands, except the effect of location in the Central Highlands.

Table 11. Impacts of KHDP on Horticultural Production, Sales, and Share of Production Sold

	Horticultural production (kgs)			Value of horticultural sales (Ksh)			Share of production sold		
	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|
2006	1457.91	643.99	0.0240	9146.74	3880.31	0.0190	0.054	0.0602	0.3710
2008	661.68	588.22	0.2610	6260.90	4321.60	0.1480	0.121	0.0723	0.0950
2010	1390.99	556.49	0.0130	15838.36	5060.91	0.0020	0.127	0.0629	0.0450
target	1783.83	485.34	0.0000	12767.81	4813.47	0.0080	0.235	0.0606	0.0000
target 2006	-1353.23	761.96	0.0770	-4062.90	5374.70	0.4500	-0.078	0.0838	0.3510
target 2008	-430.69	676.91	0.5250	-209.33	5059.27	0.9670	-0.054	0.0972	0.5780
target 2010	291.39	856.52	0.7340	28113.12	11103.71	0.0120	-0.023	0.0825	0.7830
Male-headed household	465.20	372.26	0.2120	1983.12	4974.84	0.6900	0.029	0.0454	0.5170
Education of head	6.77	37.22	0.8560	331.56	440.61	0.4520	0.002	0.0032	0.5350
Farm land owned	78.70	51.39	0.1270	608.61	562.30	0.2800	-0.002	0.0032	0.5030
Km to market	-40.33	62.54	0.5190	-538.57	672.38	0.4240	-0.005	0.0041	0.2010
Coastal lowlands	-1353.87	685.85	0.0490	-31100.75	10044.18	0.0020	-0.290	0.0819	0.0000
Western transitional	225.20	310.27	0.4680	-2506.23	3230.49	0.4380	-0.176	0.0457	0.0000
High potential maize	139.60	307.45	0.6500	6565.29	5522.84	0.2350	-0.146	0.0413	0.0000
Central highlands	3815.31	760.72	0.0000	30604.55	8538.05	0.0000	0.115	0.0462	0.0130
Constant	-672.54	429.90	0.1190	-12679.74	5139.50	0.0140	0.304	0.0597	0.0000
Western lowlands omitted									
n=353				n=353			n=353		
F(15, 337)=3.46				F(15, 337)=3.34			LR chi2(15)=89.04		
Prob>0=0.0000				Prob>0=0.0000			Prob > chi2=0.0000		
OLS (robust s.e.)				OLS (robust s.e.)			Tobit (41 left-censored at 0)		

Regressions also demonstrate that there have been positive and significant impacts of KHDP on total net household income in both 2006 and 2010, in either nominal or real terms (regression income deflated by the CPI is not shown) (Table 12). No impacts on livestock assets or other household assets are discernible. Income is also strongly affected by the education of the household head and farm land owned, as well as by agro-regional zone, in various ways.

Table 12. Impact of KHDP on Income, 2004-2010

	Income (Ksh)		
	Coeff.	Robust Std. Err.	P>|t|
2006	-9,093	34,299	0.7910
2008	-4,910	38,836	0.8990
2010	43,684	36,606	0.2340
target	-70,054	29,108	0.0170
target 2006	68,247	40314	0.0910
target 2008	57,262	49,872	0.2520
target 2010	104,571	48,301	0.0310
Male household head	1,246	19,459	0.9490
Education of head	12,064	2,290	0.0000
Farm land owned	26,429	2,687	0.0000
Km to market	-4,596	3,854	0.2340
Coastal lowlands	60,187	62,784	0.3380
Western transitional	-44,615	20,407	0.0290
High potential maize	49,181	22,243	0.0280
Central highlands	130,041	32,433	0.0000
Constant	-41,048	32,397	0.2060
Western lowlands omitted			
n=353			
F(15, 336)=14.56			
Prob>0=0.0000			
OLS (robust s.e.)			

Estimation of the model using the common statistical distribution for USAID program participants and the independent, broadly representative Tegemeo sample as the control group supports these findings. Relative to the large Tegemeo sample (1,369 in the control group), the handful of horticultural producers targeted by the KHDP (129) produced more in 2010 relative to 2004, had a higher value of sales, and earned more total net household income, even controlling for higher initial incomes (Table 13) and inflation (not shown here).

Table 13. Impacts of KHDP on Horticultural Production, Sales and Income, 2004 and 2010, USAID and Tegemeo Samples

	Horticultural production (kgs)			Value of horticultural sales (Ksh)			Income (Ksh)		
	Coeff	Robust Std. Err	P> |t|	Coeff	Robust Std. Err	P> |t|	Coeff	Robust Std. Err	P> |t|
2010	-344	532	0.5180	8,326	4,748	0.0800	37,337	25,924	0.1500
Target	-683	338	0.0434	428	1,979	0.8290	-56,425	18,107	0.0019
Target 2010	2296	869	0.0083	33,519	10,266	0.0010	107,911	41,274	0.0090
Male household head	498	411	0.2260	2308	2,078	0.2670	19,421	10,445	0.0632
Education of head	49.4	21	0.0172	279	125	0.0270	10,327	1,230	0.0000
Farm land owned	32.2	23	0.1590	191	127	0.1330	11,975	2,137	0.0000
Distance to market	-9.34	7.00	0.1830	-63.31	63	0.3190	-233	183	0.2040
Coastal Lowlands	-445	625	0.4770	-4,651	4,808	0.3340	38,932	23,462	0.0972
Western transitional	-1,139	346	0.0010	-5,743	1,641	0.0000	-29,434	12,578	0.0194
High potential maize	-1,063	430	0.0136	-823	2,262	0.7160	10,374	16,827	0.5380
Central Highlands	951	399	0.0172	5,654	2,402	0.0190	76,750	11,699	0.0000
Constant	2,124	345	0.0000	4,429	1,757	0.0120	-2,101	11,094	0.8500
N	1,581			1,581			1,598		
R-squared	0.036			0.1032			0.399		
Target	129			129			129		
Control	1452			1,452			1,452		
Control USAID	83			83			83		
Control Tegemeo	1369			1,369			1,369		

5.3. Kenya Dairy Development Program

KDDP has operated in the Western Transitional, High Potential Maize, Central Highlands and Marginal Rain Shadow zones. The best year for all farmers in terms of milk per cow was 2008, and 2010 was the worst of the four years for both control and target groups (Figure 8). In terms of production and sales, variation among years is more complex (Figures 9 and 10).

Figure 8. Comparison of Average Milk Production per Cow, KDDP Program, by Group and Survey Year, USAID Sample

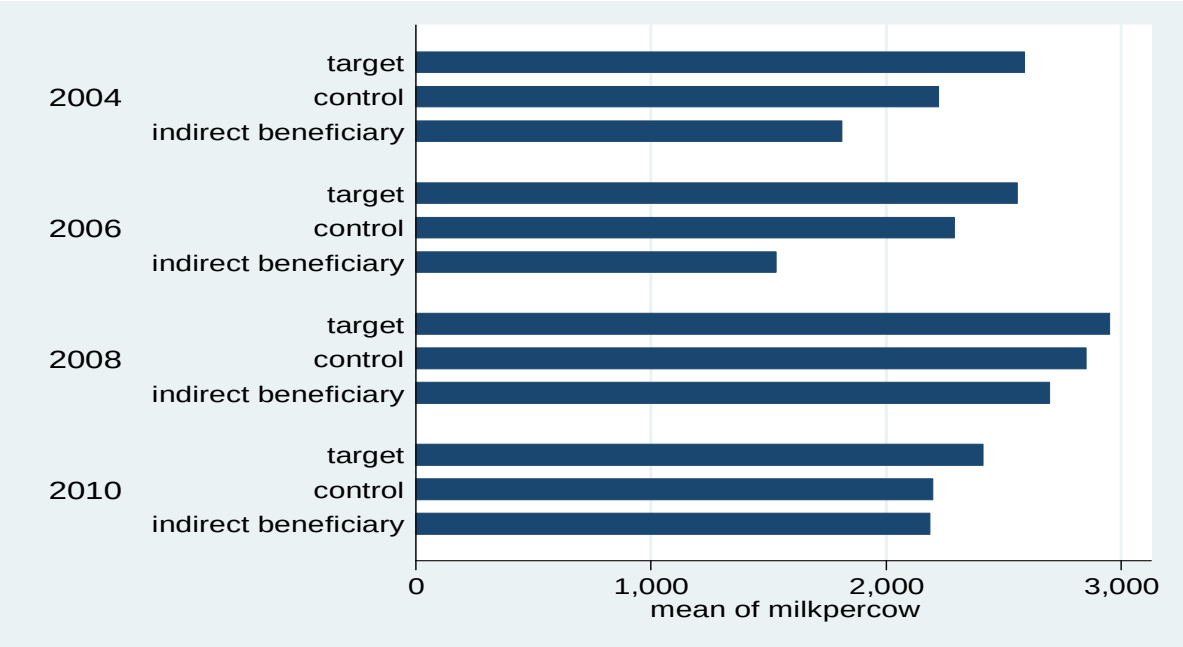


Figure 9. Comparison of Average Milk Production, KDDP Program, by Group and Survey Year, USAID Sample

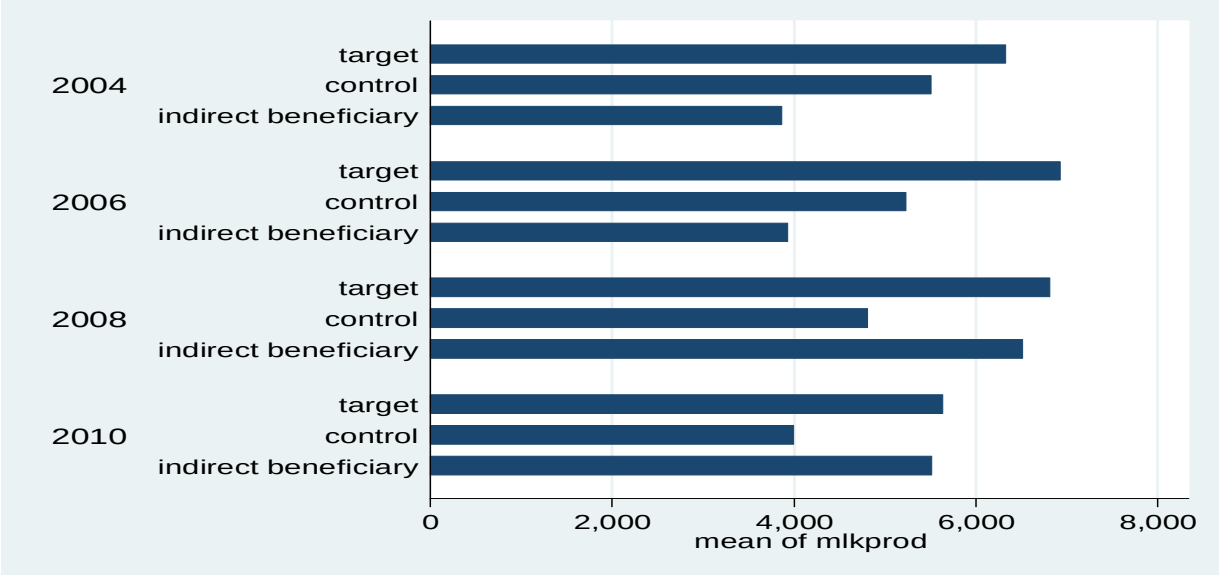
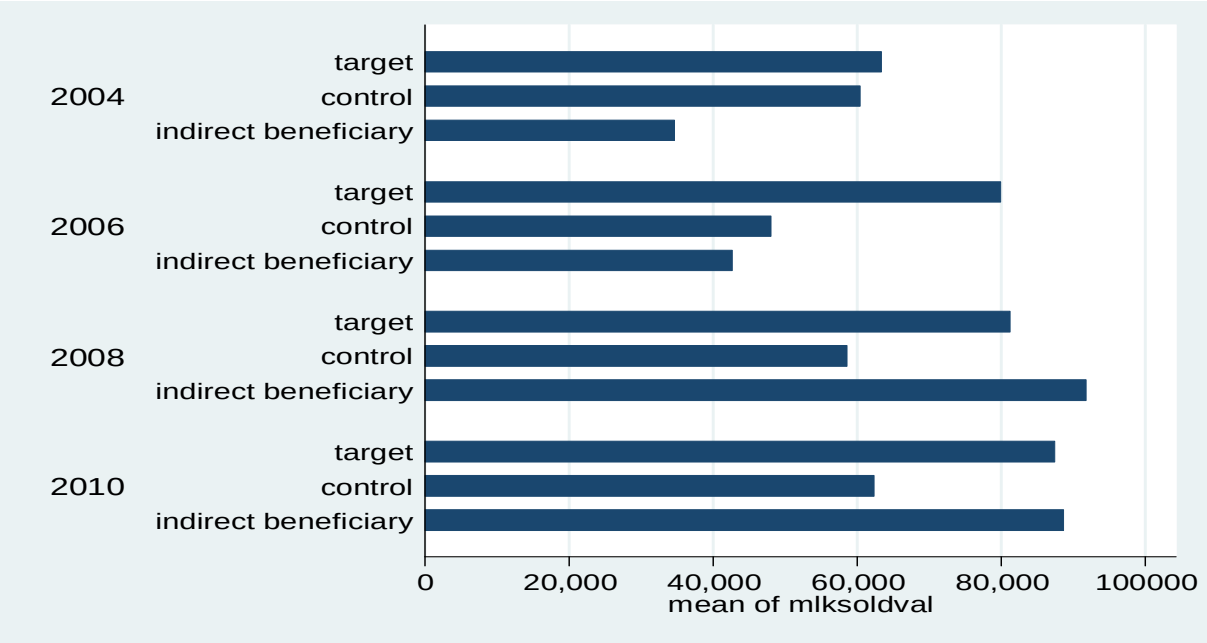


Figure 10. Comparison of Average Value of Milk Sales, KDDP Program, by Group and Survey Year, USAID Sample



The year effect in 2008 is also prominent when controlling for other factors via econometric regression. KDDP does not seem to have affected milk produced per cow relative to 2004 (Table 14). As is the case in other programs, male household head, education of the head, and farm land owned influence productivity positively and significantly. Female-headed households are better represented in the dairy than in the maize groups, and are fairly equally represented as percentages of control (13%), target (11%), and indirect beneficiary (16%) in KDDP groups. Relative to the Western transitional zone, farmers in Central Highlands and Marginal Rain Shadow zones have higher milk yield.

By 2010, however, there is evidence of significant program impact on both milk production and value of milk sales for target and indirect beneficiary households. Other socio-economic factors continue to be important, although the effects of zone are less visible. The share of milk sold is not affected by KDDP. Location in the Marginal Rain Shadow zone has the single largest impact on the share of milk sold.

Table 14. Impact of KDDP on Milk per Cow, Milk Production, Value of Milk Sold, Production Share Sold, 2004 - 2010

	Milk per cow (litres)			Milk production (litres)			Value of milk sold (Ksh)			Share of milk production sold		
	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|
2006	112.55	329.34	0.7330	-178.89	1317.21	0.8920	-9764	19166	0.6110	-0.055	0.081	0.4990
2008	667.34	352.25	0.0580	-704.53	1285.31	0.5840	-1215	20881	0.9540	-0.014	0.084	0.8710
2010	103.69	250.74	0.6790	-1284.86	1129.90	0.2560	4348	17643	0.8050	0.155	0.064	0.0160
target	245.85	245.33	0.3170	-472.56	1208.94	0.6960	-12875	18443	0.4850	0.046	0.061	0.4500
indirect	-328.15	276.11	0.2350	-1870.61	1191.20	0.1170	-25092	17735	0.1570	-0.095	0.066	0.1510
target 2006	-49.27	370.57	0.8940	1436.69	1582.13	0.3640	36209	24309	0.1370	0.086	0.087	0.3200
target 2008	-233.25	433.14	0.5900	1608.80	1544.95	0.2980	25669	24322	0.2920	-0.002	0.091	0.9820
target 2010	-49.80	293.68	0.8650	2112.17	1305.31	0.1060	41024	20299	0.04	-0.025	0.070	0.7230
indirect 2006	-361.96	397.72	0.3630	499.32	1481.82	0.7360	23765	21026	0.26	0.058	0.094	0.5390
indirect 2008	272.09	681.79	0.6900	3518.04	2160.79	0.1040	64081	33494	0.06	0.150	0.100	0.1330
indirect2010	248.21	335.36	0.4590	3201.31	1377.18	0.0200	50600	22123	0.02	0.084	0.077	0.2730
Male-headed household	253.64	110.96	0.0220	350.74	387.02	0.3650	-101	5835	0.99	-0.019	0.025	0.4590
Education of head	40.97	9.26	0.0000	173.04	53.87	0.0010	3551	947	0.00	0.004	0.002	0.0140
Farm land owned	16.89	9.42	0.0730	255.00	107.26	0.0180	3014	1448	0.04	0.004	0.001	0.0030
Km to vet	20.33	13.62	0.1360	103.91	57.01	0.0690	1559	865	0.07	0.005	0.002	0.0090
High potential maize	233.38	262.53	0.3740	979.14	797.99	0.2200	-11587	18677	0.54	-0.004	0.078	0.9550
Central highlands	518.00	268.13	0.0540	1283.31	930.85	0.1680	-3757	20193	0.85	0.082	0.079	0.3020
Marginal Rain Shadow	677.17	354.88	0.0570	3860.47	1323.42	0.0040	13447	22607	0.55	0.159	0.090	0.0770
Constant	1038.48	378.79	0.0060	1052.58	1692.55	0.5340	15196	30515	0.62	0.465	0.101	0.0000
Western transitional zone omitted												
F(18,1006)=5.49				F(18,1006)=3.69			F(18,1006)=4.73			LR chi2 (18)=133.77		
Prob>F=0.0000				Prob>F=0.0000			Prob>F=0.0000			Prob>chi2= LR chi2(18)		
n=1025				n=1025			n=1025			n=1025		
OLS (robust s.e)				OLS (robust s.e)			OLS (robust s.e)			Tobit (78 left-censored at 0)		

Table 15. Impact of KDDP on Income and Value of Livestock Assets, 2004-2010

	Value of net livestock income (Ksh)			Income (Ksh)			Value of livestock assets (Ksh)		
	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|	Coeff.	Robust Std. Err.	P>|t|
2006	-18513	20713	0.3720	49513	49813	0.3200	-2740	36736	0.9410
2008	9547	22310	0.6690	76478	48567	0.1160	401713	98571	0.0000
2010	-46414	17274	0.0070	63004	43287	0.1460	39693	31861	0.2130
target	-34323	17511	0.0500	6502	57048	0.9090	-23205	37621	0.5370
indirect	-47404	17847	0.0080	22560	45104	0.6170	-22484	31722	0.4790
target 2006	45158	23832	0.0580	97344	68375	0.1550	64015	44018	0.1460
target 2008	54737	27637	0.0480	114511	76250	0.1330	340771	163922	0.0380
target 2010	71114	19541	0.0000	164744	74266	0.0270	32573	38345	0.3960
indirect 2006	28478	23045	0.2170	-15871	60670	0.7940	35771	40718	0.3800
indirect 2008	65713	41527	0.1140	26173	71119	0.7130	160840	136883	0.2400
indirect2010	74799	20597	0.0000	164527	104801	0.1170	69220	54925	0.2080
Male-headed household	9693	6637	0.1440	40498	26462	0.1260	-77590	41541	0.0620
Education of head	1047	681	0.1240	20530	2871	0.0000	10231	3717	0.0060
Farm land owned	3207	1362	0.0190	27456	15149	0.0700	17589	8914	0.0490
Km to vet	1983	1036	0.0560	-4845	4549	0.2870	-3823	3895	0.3260
High potential maize	-44232	17846	0.0130	62932	73553	0.3920	88676	41350	0.0320
Central highlands	-57055	18530	0.0020	-9564	84248	0.9100	98903	42941	0.0210
Marginal Rain Shadow	-30185	22278	0.1760	-43317	91120	0.6350	113741	62020	0.0670
Constant	110163	27948	0.0000	-123860	134792	0.3580	-77855	94176	0.4090
Western transitional zone omitted									
F(18,1006)=5.05				F(18,946)=8.51			F(18,1005)=9.51		
Prob>F=0.0000				Prob>F=0.0000			Prob>F=0.0000		
n=1025				n=965			n=1024		
OLS (robust s.e)				OLS (robust s.e)			OLS (robust s.e)		

The impacts of KDDP on general outcome variables are most remarkable in terms of the net value of livestock income (Table 15). Livestock income rises each year in terms of both magnitude and statistical significance for the target group and indirect beneficiaries relative to the control group. There is no difference in these findings when nominal income is deflated by the CPI. KDDP impact on total net household income is also visible in 2010, and in 2008, the value of livestock assets is affected positively.

Of these findings, impacts of the KDDP on nominal income in 2010 relative to 2004 are statistically significant in the regressions using the Tegemeo sample as the control group, compared to the program target group. Again, discrepancies in results between the two estimation procedures do not invalidate either set of results. Instead, they suggest that there re differences between locally (program areas) and nationally (beyond program areas) findings.

6. POST-ESTIMATION ANALYSIS

The econometric results presented above provide estimates of impacts at the mean, using parametric tests. Another way to view impacts is to compare the distributions of the variables, with non-parametric tests. As an illustration, we used the regressions to predict the values of total net household income, based on the USAID sample. We then compared the cumulative distribution of a) predicted values, and b) regression residuals between beneficiary and control groups. According to Naschold and Barrett (2010), the non-parametric test comparing the cumulative distributions of residuals isolates the effect of the program (any effect that cannot be explained by other factors).

With respect to predicted income (Figure 11), the cumulative distributions of predicted values and residuals are statistically different at less than 1% based on the Kolmogorov-Smirnov test. Distributions for predicted values for both outcomes lie entirely to the right for the beneficiary group relative to the control group. That is, at any particular income value "*" (say, Ksh 50,000), the probability that the predicted value of income is lower than "*" is greater for a control household than for a household in the target group. This holds true across the entire range of income values. In other words, when all year effects and other covariates are taken into account, the income of target households dominates that of the control households in the first-order, stochastic sense. The position of the residuals distributions is more difficult to visualize from the graphs (Figure 12).

Figure 11. Cumulative Distribution of Predicted Values of Total Net Household Income, Beneficiaries and Non-beneficiaries, USAID Sample

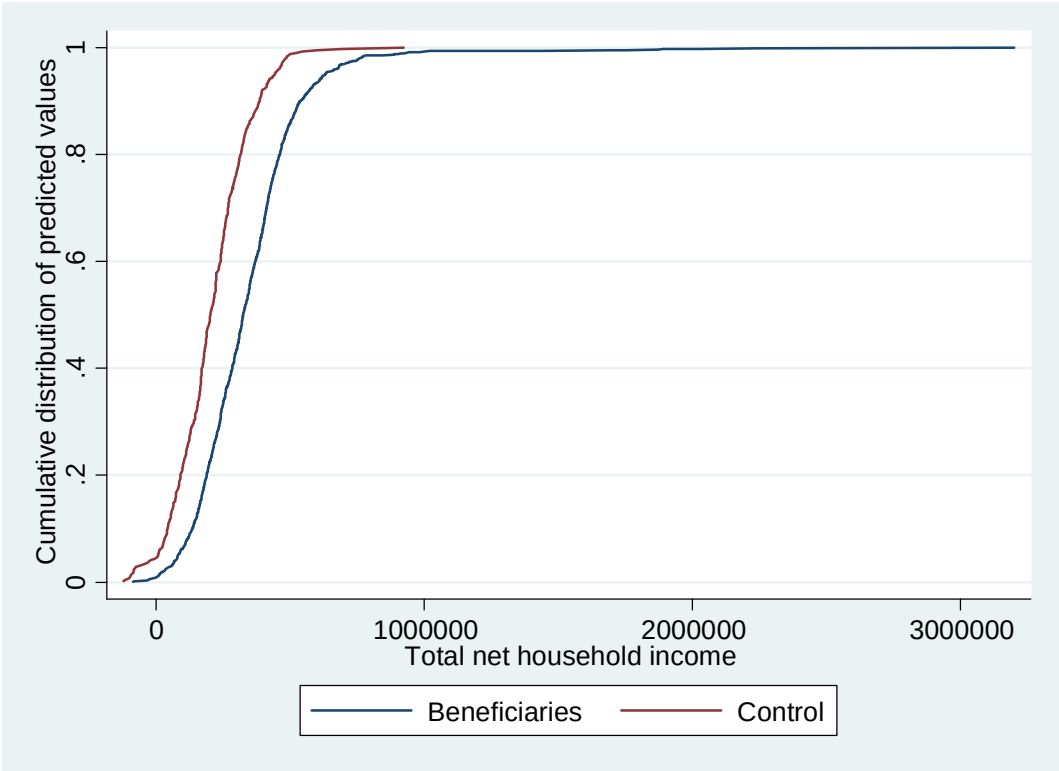
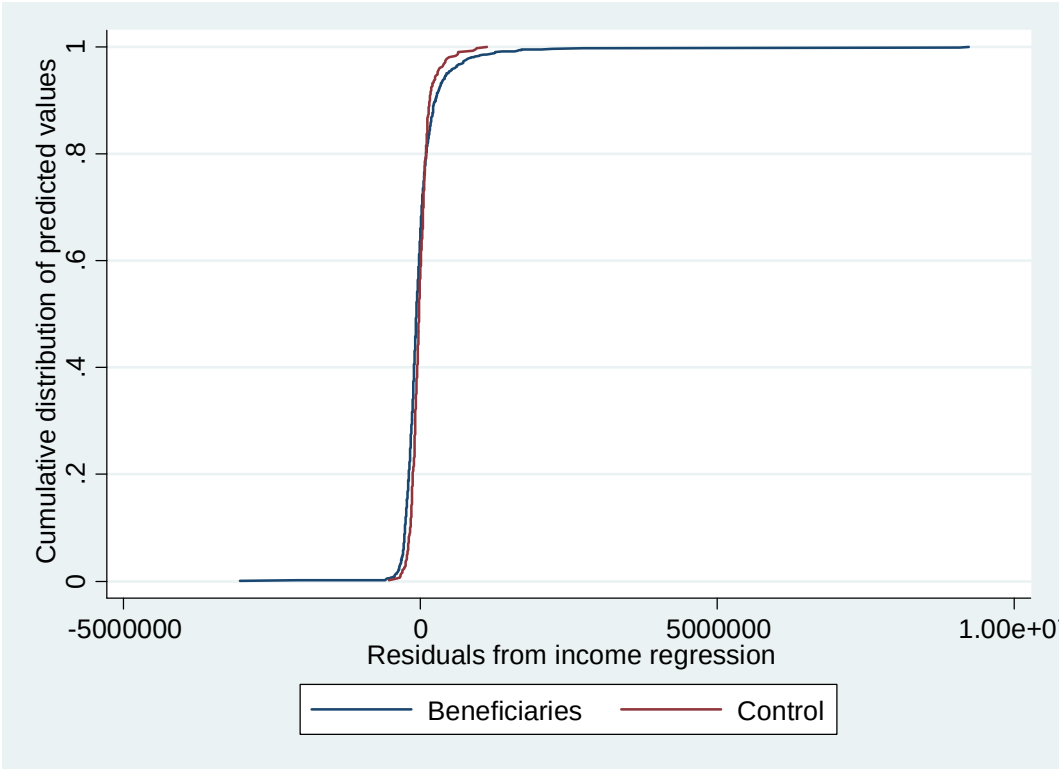


Figure 12. Cumulative Distribution of Residuals from Regression of Total Net Household Income, Beneficiaries and Non-beneficiaries, USAID Sample



7. POVERTY IMPACTS

We explored poverty impacts in a number of ways, in an effort to understand the data and concepts. Initially, we estimated probit equations to test a change in the likelihood that the average household earned income above the official Kenyan poverty line ($1.25 per capita/day) after program participation. These regressions were not statistically significant across programs, and showed weak significance for KHDP participants but not for other programs taken individually. As is well known, however, binary variables reduce information embedded in continuous variables to only two outcomes (poor, non-poor). Where feasible, use of continuous variables is therefore preferable.

With this objective in mind, we then estimated ordinary least squares regressions with the *poverty differential* (the difference between nominal income per adult equivalent and the official poverty line) as the dependent variable. Findings indicated that the average household was statistically farther from the poverty line when participating in USAID-funded programs, either directly or indirectly, in 2008 and 2010. Controlling for year, group, group and year interactions, agro-regional zone and other socio-economic factors, and comparing all beneficiary groups across all programs, we compared the predicted poverty rates among households in 2004 to 2010. Statistically, these estimates represent what would have been the change in distance from poverty due to the program alone, when all other factors that influence poverty rates are considered.

When we tested the robustness of the sample results by comparing program beneficiaries to the Tegemeo sample with a common support, the statistically significant impact held on the difference between income per capita and the poverty line at the 10% level of significance. This is a particularly important finding for USAID, because it attests to the generalizability of the result that cross-program impacts on proximity to the poverty line are positive. That is, all programs combined have, on average, distanced households farther from the poverty line.

However, the concept of poverty differential is not easy to interpret and is not recognized as a standard measure of poverty. The simplest poverty index is the headcount, or share of individuals above and below the poverty line in a sample of population. Headcounts, or any poverty index, summarize information among individuals. To estimate them systematically with a difference-in-difference approach that accounts for year, treatment, and other covariates, it is necessary to use predicted values from the income regression.

We also considered the need to address potential measurement errors in the income variable. A unique aspect of Tegemeo's survey data is that the Institute collects detailed data on actual incomes, by source, rather than expenditures. On one hand, this enables analyses of livelihoods paths and strategies over time. On the other, elicitation of income as compared to expenditure data has often been criticized on the basis of systematic underreporting or other types of measurement errors.

To handle idiosyncratic outliers in the income variable, we applied the following procedure. For the initial and final years (2004, 2010), the following points in the distribution were calculated: the first quartile (Q1), the third quartile (Q3) and the inter-quartile range (IQR). An outlier was defined as any observations for which at least one of two possibilities occur: (1) it is smaller than Q1-1.5*IQR or (2) it is greater than Q3+1.5*IQR. In an outlier-free distribution, the smallest and greatest values of the sample should equal the first and third quartiles minus/plus 1.5 times the inter-quartile range. Any observations that exceed the

range established in (1) and or (2) were removed. The distributions of the income variable in the matched USAID and Tegemeo samples before and after the procedure are shown in Appendix 4.

Table 16 shows the cross-program income regressions before and after correcting for extreme values. The impact of the program in the final year of study (2010) relative to the first year of study (2004) is highly significant in both regressions, when controlling for initial conditions and other important covariate. The education of the household head, as has repeatedly been shown in other studies in Kenya, is a strong factor. Distance to market continues to be insignificant. Aside from greater explanatory power (as evidenced in the F values and R-squared), a bias in impacts in favor of male household heads is significant in the regression with income corrected for outliers. In addition, the significance of the negative influence of household location in the Western Lowlands or Western Transitional relative to the Marginal Rain shadow zone is statistically significant in this regression.

Table 17 compares the estimates of changes in the counts of households with predicted average per (adult-equivalent) capita per day income below the World Bank poverty for the three samples. Although the statistical properties of the estimates based on the matched samples are better, the sample sizes are exceedingly small for beneficiaries. In addition, the sampling fraction is not known in the adjusted, matched samples. We concluded that while the mean statistical relationships in the regression may be better portrayed in the adjusted matched sample, and while this sample gives us an indication of the broader relevance of results, the estimates of numbers of households brought out of poverty through program participation may be more readily interpretable with the USAID sample alone.

We might interpret these as evidence of local poverty impact. The figures show that individuals in households participating in programs were less likely to be poor (19% as compared 38%) at the outset than those in non-participating households. Both groups moved gradually out of poverty during the period of study, but the estimated path is more uneven among non-beneficiaries and is monotonic among beneficiaries. Less than 3% of beneficiaries were poor in 2010, as compared to 18% of non-beneficiaries. Since the panel is not balanced, to calculate the number of households lifted out of poverty by the programs is not straightforward. In addition, poverty indicators are expressed per capita, but our income estimates are household-based.

Table 16. Cross-program Impacts on Income and Adjusted Income, USAID and Tegemeo Samples

	Income			Income Adjusted for Outliers		
	Coef.	Robust Std. Err.	P>t	Coef.	Robust Std. Err.	P>t
2010	85,248	18,004	0.0000	66,554	12,278	0.0000
Beneficiary	-12,761	20,181	0.5270	9,718	7,278	0.1820
Beneficiary, 2010	118,986	38,590	0.0020	41,121	14,683	0.0050
Male household head	13,472	11,849	0.2560	14,188	6,204	0.0220
Education of head	13,713	1,595	0.0000	7,538	494	0.0000
Farm land owned	13,442	2,081	0.0000	4,871	513	0.0000
Distance to market	-264	182	0.1470	-7	20	0.7080
Coastal Lowlands	9,853	29,934	0.7420	8,354	17,621	0.6350
Eastern Lowlands	23,425	25,504	0.3580	10,921	13,853	0.4310
Western Lowlands	-33,059	25,459	0.1940	-50,851	12,906	0.0000
Western Transitional	-38,082	24,252	0.1160	-31,167	13,591	0.0220
Western Highlands	3,316	24,865	0.8940	-17,855	13,931	0.2000
High potential maize	33,875	24,558	0.1680	15,432	12,617	0.2210
Central Highlands	48,335	25,694	0.0600	23,040	12,708	0.0700
Constant	-21,944	28,839	0.4470	51,741	12,589	0.0000
Marginal Rain shadow is excluded zone						
N=2458				2282		
F(14, 2443) = 23.55				F(14, 2267) = 61.54		
Prob > F = 0.0000				Prob > F 0.0000		
R-squared = 0.2170				R-squared = 0.3143		

Table 17. Comparison of Estimates of Household Numbers and Percentages above and below Poverty Line, with and without Programs, by Year

	USAID Sample						USAID and Tegemeo Sample						USAID and Tegemeo Sample, adjusted for outliers					
	Non-beneficiary			Beneficiary			Non-beneficiary			Beneficiary			Non-beneficiary			Beneficiary		
Year	non-poor	poor	total	non-poor	poor	total	non-poor	poor	total	non-poor	poor	total	non-poor	poor	total	non-poor	poor	total
2004	63	39	102	269	64	333	1,019	471	1,490	284	61	345	1,009	481	1,490	287	58	345
	61.76	38.24	100	80.78	19.22	100	68.39	31.61	100	82.32	17.68	100	67.72	32.28	100	83.19	16.81	100
2006	64	28	92	282	21	303												
	69.57	30.43	100	93.07	6.93	100												
2008	43	23	66	167	7	174												
	65.15	34.85	100	95.98	4.02	100												
2010	140	30	170	421	11	432	490	25	515	104	4	108	465	50	515	98	10	108
	82.35	17.65	100	97.45	2.55	100	95.15	4.85	100	96.3	3.7	100	90.29	9.71	100	90.74	9.26	100
All	310	120	430	1,139	103	1,242	1,509	496	2,005	388	65	453	1,474	531	2,005	385	68	453
	72.09	27.91	100	91.71	8.29	100	75.26	24.74	100	85.65	14.35	100	73.52	26.48	100	84.99	15.01	100

Note: Average number of persons per household is 5.86. The original sampling fraction was 12%, implying that each sampled household in 2004 represented eight households. We cannot confirm constant sampling fractions in subsequent surveys.

Considering all programs combined allows for potential spillover effects among programs. For example, the geographical distribution of the sample suggests that activities across programs are concentrated in the High Potential Maize and Central Highlands Zones. Results by program were less impressive and we do not feel confident reporting them. We attribute lack of statistical significance primarily to very small sample sizes.

Declining overall poverty rates are consistent with the findings of Suri et al. (2008), who analyzed indicators of poverty and inequality with the Tegemeo panel data from 1997 to 2007. Similar to the above, their analysis of the panel data signals the importance to poverty reduction of having more than a primary education, cultivating more land, and having off-farm sources of income, especially salaries. They also found a strong spatial dimension to poverty and poverty mobility. Analyzing the same panel data with different methods and indicators, Muyanga, Jayne, and Burke (2010) concluded that over 70% of the sampled households were in roughly the same wealth position in 2007 as they were 10 years earlier, although more households experienced an increase in asset wealth than a decline. Their evidence also points to a decline in poverty rates, consistent with Government of Kenya estimates of declining national poverty rates over the same general period.

Several policy factors shaped changes in poverty rates from 2003 to 2007 on a national scale, such as better development planning and execution of the plans by the new government that was formed in early 2003. From 1997 to 2000, economic growth rates in Kenya declined, but persistent improvement in growth was observed between 2003 and 2007. The period of impressive growth (2003-2007) coincided with implementation of two development plans: Economic Recovery Strategy and Strategy for Revitalization of Agriculture. These strategies were developed in a consultative manner, receiving substantial input from the private sector, including Tegemeo, which was rare in Kenya's history. The focus of the plans was to renew the economy and redirect the agriculture sector toward a growth path. Creation of employment was emphasized and productivity growth in agriculture was given special attention. Several collapsed institutions were revived, including the Kenya meat commission (for beef processing), and Kenya cooperative creameries (for milk processing). The coffee development fund was established, among other initiatives. During this period, the government employed more staff in the Agriculture Ministry after a freeze in employment in 1997. Because agriculture forms the bulk of the rural economy, these investments in agriculture cannot be ruled out in contributing to poverty reduction during the period. Of course, another huge decline in incomes occurred in 2008 due to post-election turmoil.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Conclusions

This analysis builds on the findings of surveys conducted by Tegemeo Institute since 2004 to monitor indicators of progress in three programs funded by USAID: the Kenya Maize Development Program, the Kenya Horticulture Development Project, and the Kenya Dairy Development Program. The objectives of the analysis were to summarize quantitative evidence concerning the economic impacts of the programs, and to identify areas of improvement in research for future baselines and impact evaluations. The study team attempted to apply the most up-to-date econometric procedures for analysis of impacts. Nonetheless, the team also recommends additional, qualitative approaches to ensure holistic, comprehensive impacts analysis. Often, such approaches provide information that is not well captured in econometric analyses; they also serve to explain findings or modify the interpretation of quantitative findings.

As indicators of general program impact, we have explored total net household income and its components (net crop income, net livestock income, and net off-farm income), asset values, and the relationship of income to the poverty line. We have also examined program-specific, direct impacts, such as yields, production, and value of sales.

There is statistical evidence of impacts on total household net income when all programs are considered together, even when controlling for the advantages target households enjoyed prior to program implementation relative to the control group. Not only are the average differences-in-differences statistically significant in nearly most survey years relative to 2004 for both target and indirect beneficiary households, but also non-parametric analysis confirms that the distributions or predicted income for the target group dominate in the first-order stochastic sense. In other words, at any chosen level of real net household income, the probability that a target household has a lower income is always lower than it is for a control household.

Within-program impacts are also visible, although these differ by indicator and are not as statistically robust—in part because of small sample sizes. For example, ascertaining maize yield impacts on farms is particularly challenging without more precise measurement techniques, larger samples, or controlled conditions. In the best year in terms of weather and decision-making context, 2006, we do observe an impact on total maize production and the value of maize sold. Measuring both productivity and production gains in horticultural crops is rendered more difficult by the range of crops, and the changing geographical focus of activities. Yet, we also see signs of significant, positive impacts on the value of horticultural sales particularly in 2010 relative to the base year, as well as on total net household income in either nominal or real terms.

Of the three programs, impacts of the dairy program are the most apparent in statistical terms. It is useful to recall that dairy production is a daily rather than a seasonal activity, and that sample sizes were larger for this program than for other programs. As in the case of maize, no productivity effect on milk per cow is evident in the regressions, although the impact on total milk production and particularly its value is apparent by 2010. What is most remarkable, however, is the visible, growing impact on the value of net livestock income and total household income with each survey year.

Many of these conclusions stand up to an even more rigorous test that compares outcomes for the relatively small beneficiary group and Tegemeo's independent, nationally representative sample of households with multivariate regression. In addition, across all programs combined, there is

some evidence of impact on the difference between net household income per capita and the poverty line, both in the original sample, and between the original sample and the Tegemeo sample. Analysis of impacts on the headcount and share of households under the World Bank poverty line indicate movement of beneficiaries out of poverty, but the statistical analysis suggests that impacts may be localized, and it is not altogether clear the beneficiaries moved out of poverty more rapidly than non-beneficiaries did.

Of policy relevance is some evidence not only of initial program targeting among households with a lower poverty rate than is found in the general population, but also of greater impacts among male-headed households. These findings may warrant further discussion and monitoring in future surveys.

8.2. Recommendations for Future Design

We propose a number of improvements in the design of future research to measure impacts of USAID-funded programs in Kenya.

First, a more expeditious sample design would nest the sample drawn from target and indirect beneficiary groups within a nationally representative frame so that a combination of matching and difference-in-differences approaches can be rigorously applied. Attention should be given to the statistical power of the sample by experts. To gird the statistical rigor, beneficiary and non-beneficiary groups should be more carefully defined, taking into account potential dynamics of the programs. To minimize financial costs incurred and time effort put in conducting the surveys, and reinforce statistical rigor, one option would be to select a larger sample of participants, or several types of participants, more comprehensively defined, and compare these to the full, independent Tegemeo sample as a control group.

Secondly, related to the improvement in sample design is an improvement in the definition of indicators to measure. Priority indicators may need special measurement techniques. For example, if maize yields are a priority indicator, greater attention must be paid to how these are measured on farms. Rainfall, soils, and other factors need to be considered at a micro-climate, rather than agro-region, scale.

How to operationally define program participation and the nature of the expected impacts is a generalized problem. For example, each new seed variety has an incremental but often imperceptible impact, although the cumulative impact over a number of new seed varieties is larger. Adoption itself is ill-defined because the technique or practice it refers to undergoes continual change, with both adopters and non-adopters adjusting (Sadoulet and de Janvry 2011).

A third recommendation with respect to quantitative measurement is to conduct surveys with a longer than the current two-year time lag.

Finally, in addition to the quantitative approaches, other qualitative survey approaches such as focus group discussion and histories, can be anchored to the statistical design to form a mixed methods, qualitative-quantitative methodology.

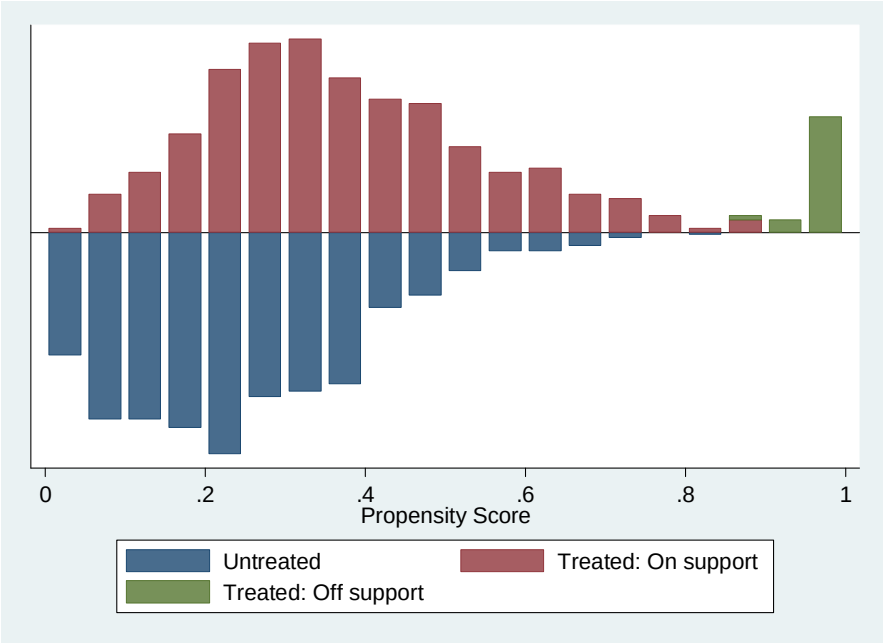
APPENDICES

APPENDIX A1. CONVERSION FACTORS TO COMPUTE ADULT EQUIVALENTS

	Adult Equivalence	
Age	Males	Females
Under 1 year	0.33	0.33
1 - 1.99	0.46	0.46
2 - 2.99	0.54	0.54
3 - 4.99	0.62	0.62
5 - 6.99	0.74	0.70
7 - 9.99	0.84	0.72
10 - 11.99	0.88	0.78
12 - 13.99	0.96	0.84
14 - 15.99	1.06	0.86
16 - 17.99	1.14	0.86
18 - 29.99	1.04	0.80
30 - 59.99	1.00	0.82
60 and over	0.84	0.74

Source: World Health Organization, for use in southern Africa.

Appendix A2. Graph of Common Support Estimated with Propensity Score Matching, with 5% Trimming of Target Groups in USAID Sample, USAID and Tegemeo Samples, 2004



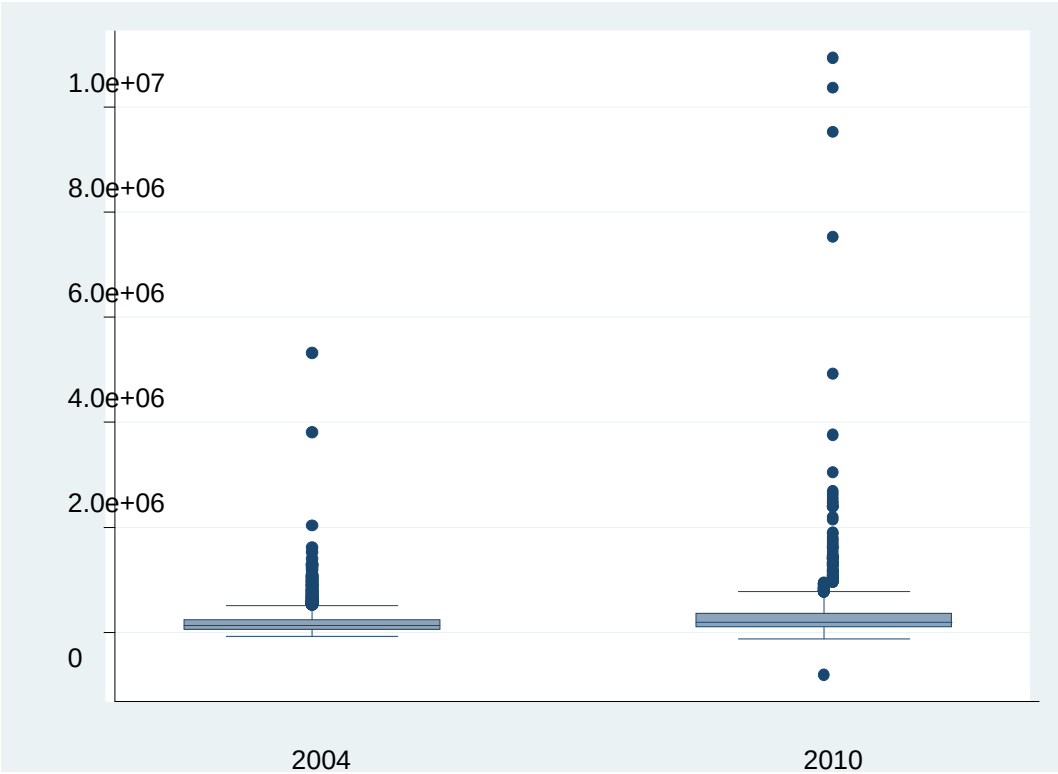
Appendix A3. Means of Outcome Variables by Program, Group, and Year

	Group	Maize yield (kgs/a)	Maize production (kgs)	Value of maize sales (Ksh)	Income (Ksh)	Poverty differential
2004	target	1,292	4,751	36,120	300,332	39,383
	control	992	1,885	8,032	160,918	13,809
2006	target	1,733	5,759	53,142	277,285	37,697
	control	1,501	2,111	10,989	199,609	22,050
2008	target	1,205	3,557	27,631	327,274	45,273
	control	1,032	1,649	6,695	183,558	19,406
2010	target	1,360	3,895	45,276	351,140	61,828
	control	1,214	1,891	16,268	274,580	44,559
		Horticultural production (kgs)	Horticultural sales (Ksh)		Income (Ksh)	Poverty differential
2004	target	2,039	8,943		136,032	10,669
	control	1,253	3,481		150,249	23,822
2006	target	2,095	13,666		193,900	17,255
	control	2,614	11,211		131,250	23,187
2008	target	1,987	11,760		150,203	2,012
	control	1,695	6,341		101,189	2,550
2010	target	4,135	51,355		260,183	23,320
	control	2,540	17,219		174,515	28,540
		Milk per cow (liters)	Milk production (liters)	Value of milk sales (Ksh)	Income (Ksh)	Poverty differential
2004	target	2,589	6,330	63,404	355,101	65,923
	control	2,227	5,509	60,489	219,775	37,175
	indirect	1,814	3,872	34,701	238,400	39,491
2006	target	2,559	6,924	79,952	421,833	89,759
	control	2,291	5,230	48,149	257,139	54,205
	indirect	1,536	3,927	42,779	228,283	28,696
2008	target	2,953	6,811	81,292	504,749	97,283
	control	2,855	4,813	58,680	303,938	77,732
	indirect	2,700	6,519	91,926	291,263	38,963
2010	target	2,414	5,643	87,504	452,257	114,474
	control	2,198	4,007	62,330	278,852	31,030
	benefic	2,186	5,519	88,709	480,972	83,367

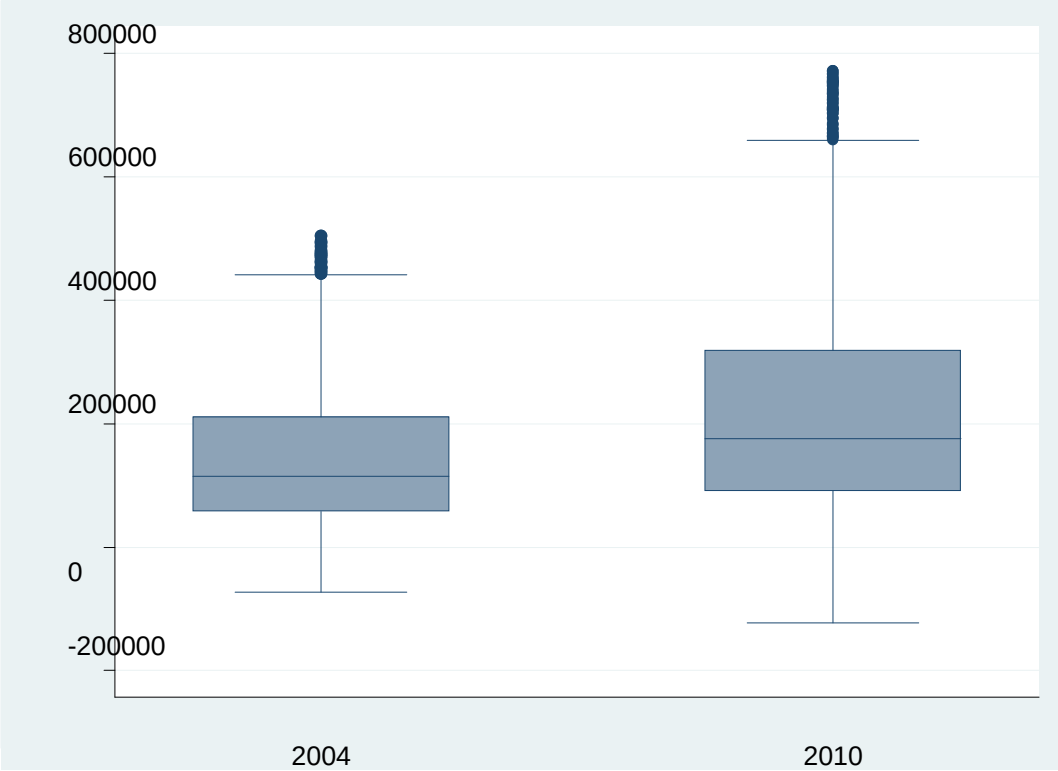
Note: Group sizes are too small by year for indirect beneficiaries in maize and horticulture.

Appendix A4. Means of Outcome Variables by Program, Group, and Year

Distribution of Total Household Net Income 2004, not Corrected for Outliers, Matched USAID and Tegemeo Samples



Distribution of Total Household Net Income 2004, Corrected for Outliers, Matched USAID and Tegemeo Samples



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