# MARKET SEGMENTATION STRATEGIES AND SEED PURCHASING DECISIONS AMONG SMALLHOLDERS: PRELIMINARY FINDINGS FROM KENYA

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## Abstract[1]

Efforts to increase agricultural productivity in sub-Saharan Africa require innovative approaches to improve smallholder access to new technologies. One increasingly popular approach is the use of market segmentation schemes to target smallholders with subsidized inputs. This paper presents results from an evaluation of the impact of a discount voucher scheme designed to encourage the purchase of improved maize seed by smallholders in two districts in Kenya. The study uses a randomized experiment to rigorously establish the counterfactual, i.e., "what would have happened in the absence of the scheme?" Findings suggest that while the scheme generated a significant displacement effect, higher discounts on the price of seed did have a positive impact on seed purchases. The findings are relevant to government and corporate decision-makers interested in disseminating genetically modified crops to smallholders in sub-Saharan Africa through the use of discount vouchers tied to humanitarian use exemptions and royalty-free licenses.



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## INTRODUCTION

Efforts to enhance agricultural productivity in Africa will rely significantly on increases in the use of agricultural inputs. For maize, a staple crop in many parts of eastern and southern Africa, these increases will likely result from the increases in the use of chemical fertilizers and improved seed. To date, efforts to disseminate improved maize to small-scale, resource-poor farmers have been limited across the region due largely to farmers' constrained purchasing power, their risk-averse behavior, limited market and physical infrastructure, and weak extension and advisory services. Innovative market incentives and other mechanisms are needed to make new maize technologies more available to smallholders.

This study asks whether subsidized inputs can be targeted effectively to smallholders, a question that is particularly relevant to government and corporate decision-makers seeking to deliver new technologies such as genetically modified (GM) crops to smallholders who are otherwise unable to afford them. To answer this question, the study tests one class of targeting mechanism—market segmentation. The specific mechanism tested here combines alternative methods of identifying the poor (i.e., of segmenting the market) with the distribution of discount vouchers (i.e., an implicit subsidy on the price of seed) and the sale of small seed packs (i.e., a marketing strategy designed to specifically reach smallholders).

To estimate the impacts of this market segmentation mechanism on smallholder seed purchasing behavior, the study applies a randomized evaluation design that rigorously establishes the counterfactual, i.e., "what would have happened in the absence of the project?" In answering this question, the study attempts to determine what specific type of market segmentation mechanisms increase the adoption of improved seed while also minimizing the costs of distributing seed, the leakages associated with a voucher-based intervention, and the distortions to the maize seed market.

## BACKGROUND AND MOTIVATION

Investment in the development of new agricultural technologies has largely stagnated across sub-Saharan Africa, even declining in several countries (Beintema and Stads 2006). The causes are well documented, and include diminishing and volatile funding; depreciation of physical infrastructure and equipment; flight of scientists and other essential human resources; poor incentives for staff in terms of salaries, benefits, and support services; and other resource constraints that impede teaching, research, and extension (Byerlee 1998; Pardey 2006).

However, there are signs that these trends may be reversing to some degree (Pardey 2006). Donors are committing new resources to agricultural research and development and channelling them through international programs and organizations such as the Alliance for a Green Revolution in Africa (AGRA), the Consultative Group on International Agricultural Research (CGIAR), and the Forum for Agricultural Research in Africa (FARA). Multinational crop-science companies, local seed companies, industry associations, and others private concerns are making new investments in the development and delivery of new technology products that are adaptable to African farming systems and agroecologies. And governments are introducing new public policies that loosen restrictions on private enterprise activity in both input and commodity markets. Taken together, these factors suggest that the pipeline of improved cultivars and other agricultural technologies may expand during the next several decades in sub-Saharan Africa.

But these positive signs should not imply that all smallholders will enjoy greater access to inputs and technologies in the immediate future. Where poverty traps and market failures persist, smallholders will still have difficulties in accessing many of these productivity-enhancing solutions. This may be particularly true with respect to biotechnology (Pingali and Traxler 2002; Spielman 2006). To address this reality, researchers and policymakers are exploring a variety of mechanisms aimed at subsidizing modern inputs and technologies to improve smallholder access and boost agricultural productivity.

A new favorite among many is the use of "smart" input subsidies, or subsidy programs that are more efficiently targeted to smallholders than the pan-territorial, state-dominated input subsidy programs that were popular through the 1980s (Kherallah et al. 2002). This new generation of subsidies include both several small-scale projects and large-scale programs.

**Recent experiences with subsidy programs in Sub-Saharan Africa**

Under Malawi's Agricultural Inputs Subsidy Program, for example, nearly 175,000 metric tons of fertilizer and 4,500 tons of improved maize seed were distributed in 2006/07 to targeted households through the use of 3 million fertilizer coupons and 2 million seed coupons, at a price of US$73 million (Ricker-Gilbert and Jayne 2009; SOAS 2008). Estimates from the Government of Malawi indicate that the scheme increased total maize production by more than 30 percent against the previous year's record harvest. Further analysis suggests that incremental maize production attributable to the subsidy scheme amounts to between 500,000 and 900,000 tons depending on estimates of the subsidy's displacement effects. Meanwhile, the scheme's costs and leakages have been substantial, as have its (negative) impact on private sector participation in the fertilizer market (Ricker-Gilbert and Jayne 2009).

Kenya, on the other hand, offers evidence suggesting that alternatives to these subsidy schemes can work quite well in improving smallholder access to inputs. The liberalization of fertilizer and maize markets during the early 1990s, combined with steady public investment in the expansion of market infrastructure, resulted in significant decreases in fertilizer marketing costs and distances traveled by farmers to purchase fertilizer, and significant increases in fertilizer use (Ariga and Jayne 2009; Ariga, Jayne, and Nyoro 2006; Freeman and Kaguongo 2003; Freeman and Omiti 2003; Omamo and Mose 2001). However, many smallholders in Kenya remain underserved by input markets, suggesting that there remains a role for more targeted approaches (Ariga and Jayne 2009).

One example of a targeted approach is the promotion and distribution of improved seed and fertilizer in small packages as implemented in Kenya under the Farm Inputs Promotions (FIPS) program (and replicated in several other countries in the region). The FIPS program, which is operated by a local nongovernmental organization, promotes free or low-cost “mini-packs” (vegetable and maize seed packages of 150g or less, combined with fertilizer packages of 100-200g) through stockists, schools, churches, and market places. The program relies on the private sector for both materials and packaging (Thangata, Blackie, and Seward 2009; Minde et al. 2008).

Common across many of these programs is the notion that implicit subsidies (typically in the form of discount vouchers) can be effectively targeted to smallholders, particularly those who are most in need of short-term financial support to purchase inputs. Another commonality is the belief that such programs can simultaneously promote private sector development and smallholder productivity growth. By requiring that smallholders redeem their vouchers with private input suppliers, these programs can help suppliers realize scale economies, reduce market risks, and encourage the growth of distribution and marketing networks. And for governments, the use of private sector supply channels can reduce the need for, and fiscal costs of, operating cumbersome state-owned distribution systems (Gregory 2006; Minot and Benson 2009).

**Potential drawbacks of subsidy programs**

The downsides of voucher-based subsidy programs are not trivial. First, vouchers entail high administrative costs that can increase dramatically with the degree of targeting undertaken by the program. Second, leakages through the transfer of vouchers or discounted inputs can be substantial, potentially resulting in allocations of scarce public resources to those who may not stand to benefit most from the transfer. Third, vouchers can displace input purchases that smallholders would have otherwise made from their own resources, thus limiting the program's impact on private sector development and wasting public resources. Additional downsides include the potentially distortionary use of vouchers on a one-off basis, which may do little for improving agricultural productivity in the long run; the use of vouchers in areas where smallholders may not have access to input suppliers; or the use of vouchers with state-owned input suppliers that crowd out private suppliers (Minot and Benson 2009).

**Subsidies and the private sector: Market segmentation**

In spite of the potential downsides of voucher-based subsidies, the idea behind smart subsidies seems appealing when it comes to the delivery of new technologies such as GM crops to smallholders. Consider, for example, the hypothetical case of a private firm that develops (and holds exclusive rights over) a maize hybrid conferred with a GM trait such as insect resistance, drought tolerance or nitrogen-use efficiency. Under conventional market conditions, the rational profit-maximizing firm will sell its GM hybrid seed to farmers who are willing and able to pay the price of the seed plus a technology fee or royalty that remunerates the company for its investment in research and development of the GM trait. But in a market characterized by high fragmentation, information asymmetries, high transaction costs, and limited purchasing power among farmers, the same firm may instead choose to leverage public subsidies as a means of promoting the technology.

One way of doing this is for the firm to supply the technology on a royalty-free basis (for example, in the form of humanitarian use exemption or non-exclusive licensing agreements) in market niches that do not displace sales in their primary markets. In exchange for this royalty-free contribution, public agencies collaborate with the firm to promote the technology. This provides the company with potentially larger sales volumes (albeit at lower margins), a foothold in a new or emerging market, and an appreciable quantity of good will, all of which can translate into larger profits in the long-run.

Byerlee and Fischer (2002) describe such arrangements in the context of market segmentation schemes where public agencies negotiate humanitarian use exemptions or non-exclusive licenses that reduce the cost of a technology for specific markets. This market segmentation idea has been mooted for several GM crops and traits, including beta-carotene enriched "golden" rice in Asia, and drought tolerant maize in Africa. In the case of Bt eggplant in India, Kolady and Lesser (2008) conclude from an *ex ante* analysis that that a humanitarian use exemption is economically viable for Mahyco (the principal private firm involved in developing the GM crop in India) by segmenting the market between open pollinated varieties which would be sold with the discount to poorer farmers, and hybrids which would be sold without the discount to wealthier farmers.

However, Lybbert (2002) cautions that the complexities in implementing market segmentation schemes are non-trivial. Key issues include (a) the difficulties in establishing the ownership of intellectual property (IP) embodied in a given GM technology, which creates difficulties in calculating (forgone) royalties for the various IP owners, (b) and the long-run displacement caused by market segmentation schemes operating in markets that would otherwise become lucrative opportunities for private firms.

For the purposes of the present study, however, it is the issues of leakages and information asymmetries described by Lybbert (2002) that are worth closer examination. Leakages of the discounts on the technology to unintended beneficiaries such as large or wealthy farmers erode the firms' revenue stream and return on investment. Yet efforts to minimize these leakages are necessarily constrained by information asymmetries—public agencies or private firms rarely have sufficient information to determine who is "poor" and therefore who should be targeted.

Methods of identifying the poor can be broadly categorized into direct and indirect methods. Direct identification includes means-based testing, where potential beneficiaries are interviewed or screened by program implementers, independent assessors, or their own community to ensure that they meet specific criteria. However, direct identification methods tend to be costly, bureaucratic, and prone to rent-seeking behavior or political manipulation.

Thus, the alternative method is indirect identification, for example self-selection by geography, technology preference, or pricing. In geographic targeting, the target beneficiaries are identified based on their association with a particular geographic area characterized by high levels of poverty, marginal agroecological conditions, or similar properties. In technology targeting, target beneficiaries are identified based on their demand for a particular technology package that would not appeal to the non-poor, for example, smaller input packages, open pollinated varieties, or varieties adapted to low potential agroecologies. In tiered pricing, the target beneficiaries are identified based on their preference for lower prices, such that a technology is offered at a lower price in a limited quantity such that the poor will be able to enjoy the lower price while the non-poor will have to purchase a limited quantity at a lower price tier, and the remainder at the full price tier.

Given the accumulating evidence from projects and programs mentioned above, and given the well-documented issues and limitations of voucher-based input subsidy and market segmentation schemes, this paper attempts to shed light on the extent to which specific targeting mechanisms influence the purchase of improved maize seed by smallholders in two districts in western and central Kenya.

## PROJECT IMPLEMENTATION

### MARKET SEGMENTATION MECHANISMS

This study focused on evaluating the two segmentation mechanisms described in the preceding section —direct identification and tiered pricing. Under direct identification, the market segment of interest was identified as a group of households that are most likely to require financial assistance in purchasing inputs. Identification of this market segment was conducted by a third party—representatives of each community undertook a wealth categorization exercise and selected the poorest households to participate in the study. Community representatives included village elders, local administrative officials, other respected members of the community such as retired teachers, and representatives of some households in the community.

Under tiered pricing, the market segment of interest was identified as all individuals within a geographic or administrative area, based on an a priori assumption that most of the population required financial assistance in purchasing inputs.

### STUDY SITES

Communities were drawn from two pilot sites – Embu District in central Kenya and Kisii District in western Kenya. Each site has two major seed markets – Manyatta and Runyenjes in Embu, and Marani and Mosocho in Kisii. These markets serve communities within 15-20 km. Project participants were drawn from these communities.

In Embu district, based on number of stockists, the market towns of Manyatta and Runyenjes were selected (Figure 1). The four sublocations around each town were identified, and randomly allocated to either direct or indirect identification.

<<Figure 1 about here>>

In Kisii district, farmers in the higher areas had already started planting in mid-February, so markets higher up could not be included. After discussions with agricultural extension officers, the market towns of Mosocho and Marani (both the centers of the divisions with the same name) were identified as having a small number of stockists each (Figure 2).

<<Figure 2 about here>>

Marani market serves the sublocations of Mwagichana and Mwamonari, each with two sublocations. In Mwagichana, the sublocations Igemo and Kiomoncha were selected randomly for direct identification, while the sublocations Nyakeiri and Rioma were selected randomly for indirect identification (Table 2). In similar fashion, two sublocations were selected for direct and indirect identification each in Mosocho (see details in Table 3).

<<Tables 2 and 3 about here>>

## METHODOLOGY

The study used a randomized experimental design to estimate the differences in seed purchases between treatment and control groups (voucher recipients and non-recipients). Randomized designs have traditionally been used to evaluate the effectiveness of nutrition, education programs, and other development interventions. More recently, randomized designs have been used to evaluate the adoption of agricultural technologies in circumstances that are somewhat similar to those being proposed in this project (Duflo, Kremer, and Robinson 2008).

In a randomized design, individuals (or other units of observation) are randomly assigned to either a treatment group which receives the intervention, or a control group which does not receive the intervention. The impact of the intervention is the mean difference in outcomes between the two groups. In the context of this proposed project, if the mean seed use of farmers in the treatment group is denoted by ($Y_t$) and the mean seed use of farmers in the control group is denoted by ($Y_c$), then the impact of the project (I), in terms of seed use, would be measured as:

$$I = Y_t - Y_c$$

The key assumption underlying the use of a randomized design follows from the random assignment of individuals to the two groups. Under random assignment, the two groups have no pre-existing differences, the only difference between the two groups is the intervention, and therefore without the intervention, both groups would have achieved the same outcomes. Thus, there is no selection bias under this assumption, and the estimate above provides a statistically robust measure of the project's impact.

The advantage of this approach over other evaluation methods is that it allows us to attribute any observed impacts to the project. For example, one of the questions we wish to investigate is whether market segmentation led to an increase in the use of improved seed by smallholder farmers. Simply comparing the input use of participating farmers before and after the market segmentation scheme is implemented will likely not provide a reliable measure of the project's impact. Other intervening or endogenous factors, such as changes in economic trends or external shocks, may influence input use among the target group. Thus, to correctly measure the project's impact, one would also need to compare changes in input use between the target group of farmers and a comparison group of farmers who are similar to the target group, but who do not participate in the project. The randomized evaluation design enables us to construct such a statistically similar comparison group.

As noted earlier, if the comparison group is *not* similar to the target group, selection bias may occur, since changes in input use may be due to the pre-existing differences between the two groups, invalidating any observed impacts. This can be addressed by a randomized trial design, isolating the impacts of an intervention from the contemporaneous impacts of other factors (Duflo, Glennerster, and Kremer 2006).

The randomized experimental setup allows for testing of the following hypotheses. Market segmentation mechanisms affect the seed purchasing decisions of smallholders, with purchases

(a) increasing with the size of the discount, (b) varying with the quantity of the seed packet, and (c) varying with the type of mechanism through which the subsidy is provided.

### RANDOM ASSIGNMENT

All participants were voluntarily assigned to treatment or control groups. The treatment in this context is defined as receiving a voucher for a discount on maize seed. The control group consists of farmers who were eligible for receiving a voucher, but instead received a benefit that is unrelated to agricultural inputs or yields. Farmers were randomly assigned to four treatment groups and two control groups, depending on the outcome of throwing a standard 6-sided die (Table 1). If the farmer threw a 1 on the die, the farmer received 0.5 kg of cooking fat and was assigned to the control group. A farmer throwing a 2 on the die received 1 kg of sugar and was also assigned to the control group. If a farmer threw a 3, 4, 5, or 6 on the die, the farmer received maize seed vouchers and was therefore assigned to a treatment group. Each farmer in the treatment groups received either 2 or 5 vouchers, and each voucher was valid for a discount of KSh 60 (approximately USD 0.86) or KSh 120 (approximately USD 1.71) on a 2-kg packet of maize seed. The permutations and treatment group assignments are presented in Table 1. The vouchers could be used to purchase maize seed at participating agro-dealers in the district, and they were valid until the end of the planting season.

### HOUSEHOLD SURVEY DESIGN

A total of 5,337 farmers participated in the project, 3,087 from Embu and 2,250 from Kisii. The breakdown of treatment and control group assignment for each sub-location is presented in Table 2.

After the planting season (July 2009) a sample of the farmers who participated in the project were surveyed. The sampling strategy was designed to select a representative sample that reflects the differences in market segmentation mechanisms, treatments, and project sites. The rationale behind this strategy is that a representative sample of project participants will allow for a rigorous estimation of (a) the impacts of the two different types of market segmentation; (b) the impacts of each type of treatment; and (c) the impacts in each of the two project sites.

Each of the two ‘sub-total’ rows in Table 2 represents a sampling pool (the sub-total of farmers within a group assignment for each market segmentation mechanism). From each of these sampling pools, survey samples of 100 per treatment group and 120 farmers per control group were randomly selected for each mechanism. Therefore, the final survey sample comprised 800 treatment observations and 240 control observations. About 90.5 percent of the survey sample was interviewed by the study’s enumerators. Due to some missing respondents, the final sample has 941 observations, of which 208 are control observations.

## RESULTS AND DISCUSSION

### IMPLEMENTATION COSTS

To analyze the efficiency of reaching farmers with vouchers through both market segmentation mechanisms, detailed records of their costs were kept, to calculate the cost per beneficiary. Unfortunately, in Embu, some of the costs could not be split over the different methods, so detailed analysis was only possible for Kisii.

The direct identification was typically organized in two meetings. The first meeting took place with a small committee to identify the poor in the village. The project team typically managed to do two meetings per day, and these meetings cost about KShs 15,000 (or US$200) per day (Figure 3a). Most of this cost covered project staff and collaborators’ time, followed by transport costs and allowances for staff from the Provincial Administration, to help and check the identification of the beneficiaries and to make sure only one person per family participated. There were also some costs for the officers of the Ministry of Agriculture, refreshments for the participants, and fees for the community elders. During the second meeting, those identified as poor were invited to participate in the randomization and distribution of the vouchers. The cost of these second meetings was very similar to those of the first meetings.

<<Figure 3a about here>>

For the tiered pricing mechanism, there was typically a preparatory meeting to explain the system to the staff of the Provincial Administation and the Minitry of Agriculture, but this meeting was much smaller and cheaper than the direct identification exercise. The voucher distribution, on the other hand, needed a lot more staff because of the large number of people who would show up. Especially at the beginning, project staff were overwhelmed, and the identification of beneficiaries and the distribution of the vouchers had to be split over two days in several places.

Because of the uneven number of activities and number of people reached per day, the cost per day is less important, but the cost per beneficiary is of interest (Figure 3b).

<<Figure 3b about here>>

Clearly, it was more expensive to identify the poor directly, about KShs 51/beneficiary, since this involved a separate meeting and takes substantial time. The second meeting, for the actual randomization and distribution of the vouchers, cost about the same, KShs 53/beneficiary.

The preparation cost for the tiered pricing was much cheaper, since it just involved a preparatory meeting with a smaller number of people. Its cost was spread over the number of beneficiaries reached, and came to only 13 KShs/beneficiary. The actual distribution of the vouchers was also cheaper, since any interested person could sign up. Many people came, and officers worked long days, and in the end the cost came down to KShs 28/beneficiary. The total cost can be estimated at KShs 105/beneficiary (US$1.4) for the direct identification and KShs 40/beneficiary ($0.5) for the tiered pricing.

## TARGETING

Figures 4ab illustrate the characteristics of the participants, disaggregated by segmentation mechanism. Figure 4a compares the total land owned by participants in each segmentation mechanism, and 4b compares the participants in terms of wealth classes. The poverty classes are based on a wealth index, which was computed using the methods developed by Filmer and Pritchett (1998), and extended and applied by Skoufias et al. (2001), and more recently by Langyintuo (2008). The method involves using principal components analysis to determine the linear combinations of variables that best determines wealth levels, ranking the variables, and aggregating the variables to form the index, based on their weighted contribution to wealth levels. The variables used to generate the wealth index for this study are listed in the appendix.

<<Figures 4a and 4b about here>>

The figures indicate that direct identification led to the selection of participants in lower wealth categories compared with the tiered pricing mechanism. For example, the first pair of columns in Figure 4a represents farmers who own less than one acre of land. The columns show that direct identification led to the inclusion of a little more than 200 farmers in the project, compared to about 150 farmers for the tiered pricing. In Figure 4a, the first two pairs of columns represent farmers in the bottom two quintiles of the wealth index. The number of directly-identified farmers in these two categories is clearly larger than the farmers who participated through the tiered pricing mechanism. The number of directly-identified farmers in the lowest wealth category is almost double the number of farmers in the tiered pricing group.

However, the Figures 4a-b also indicates that there were only minor differences between the two market segmentation mechanisms in terms of farmers in higher income groups. The number of participating farmers with 1-2 acres of land (second column pair in Figure 4a) is almost identical for direct identification and tiered pricing. There are only slightly more farmers with 2-3 acres in tiered pricing compared with direct identification (Figure 4a, third column pair), and slightly more directly-identified farmers than tiered pricing farmers with land sizes greater than 3 acres (Figure 4a, last pair of columns). These findings are corroborated by the last three pairs of columns of Figure 4b, which represent the top three wealth index categories: Although the numbers of directly-identified farmers in these categories are lower than the corresponding numbers of tiered pricing farmers, these differences are not large.

Taken together, these findings suggest that direct identification was more successful than tiered pricing in selecting the poorest households in the community to be included in the project. However, the identification exercise did not appear to be successful in screening out wealthier households. A large number of wealthy farmers and farmers with large landholdings were included in the list of farmers identified by the community.

### VOUCHER USE

The second set of findings addresses the question "what did farmers do with the vouchers?" Findings indicate that voucher use was similar for both the directly identified farmers and the farmers who participated in the tiered pricing mechanism. In the direct identification, 55.04 percent of the respondents reported that they used their vouchers to purchase seed, while the corresponding figure for the tiered pricing was 55.59 percent. This is a somewhat surprising result: One would hypothesize, *a priori*, that the farmers who participated in the tiered pricing would have a higher use than the farmers who were identified by the community and asked to participate. One explanation for this finding may be drawn from the fact that the findings on targeting indicate that there was not much difference in the numbers of wealthier households participating in each type of mechanism. Thus, to the extent that the direct identification was not successful in screening out wealthier households, it is possible that the same types of households (in terms of propensity to use the vouchers) were included in each mechanism.

Figures 5a and 5b disaggregate these percentages by treatment, and also report other uses of the voucher such as selling or exchange for other items. These figures implicitly measure the diversion of vouchers from their intended use, or the extent of leakage from the project. These leakage levels do not seem to be particularly high, especially compared to the percentage of respondents who reported that they used the vouchers. The figures indicate that there was a small secondary market for the vouchers, but the price or coverage of the market was not enough to mop up a large percentage of the vouchers.

<<Figures 5a and 5b about here>>

Figure 6 plots the percentage of farmers who reported that they did not use the vouchers. These figures implicitly measure the extent to which the discount offered with each voucher was appropriately targeted. As illustrated in Figures 5a, 5b, and 6, voucher use increases as the quantity and value of vouchers increases, and this trend is more pronounced for the tiered pricing mechanism than for direct identification. Thus, in the tiered pricing mechanism, where all households could participate, small changes in the quantity and value of vouchers led to improvements in the use of the vouchers. In contrast, for the direct identification, which included predominantly lower income households, such changes had no effect on voucher use.

<<Figure 6 about here>>

### SEED PURCHASING BEHAVIOR

The second set of findings addresses the question "did vouchers affect farmers' seed purchasing behavior?" To address this question, the outcome of interest is the amount of maize seed (in kilograms) purchased by the household in the main season of 2009 (after voucher distribution). A simple comparison of means is used to measure this. Recall that the randomized evaluation design ensures that there is no selection bias, and therefore the difference in means between any of the treatment groups and the control groups is the estimate of the average treatment effect.

Figures 7a and 7b show the mean maize seed purchase by treatment assignment for both types of market segmentation mechanisms. As indicated in Figure 7a, the differences between maize seed purchased by farmers who received vouchers and the control group are not significantly different from zero in the direct identification. Figure 7b shows that for the tiered pricing mechanism seed purchases were significantly higher for some the farmers who received vouchers compared with the control group of farmers. For farmers who received five vouchers with a discount of 120 KSh, the mean maize seed purchase was 4.7 kg (Figure 7a, first bar), while the corresponding figure for the control group was 3.03 kg (Figure 7b, last bar). This means that giving farmers five of the 120 KSh vouchers led to an average 1.67 kg increase in the purchase of maize seed per farmer ($p<0.05$). The second bar in Figure 7b indicates that giving farmers five of the 60 KSh vouchers led to an increase in seed purchase of 1.75 kg per farmer ($p<0.01$).

<<Figures 7a and 7b about here>>

These findings may imply that the vouchers had a positive effect on seed purchasing decisions where the recipients of the vouchers were most able to pay for their share of the seed purchase (i.e., the seed price less the discount). Under direct identification, fewer were able to do this because the identification mechanism resulted (by design) in a greater concentration of poorer households receiving vouchers—households that were least likely to be able to pay for their share of the seed cost. Under tiered pricing, the distribution is less skewed toward poorer households (again, by design), likely resulting in a larger proportion of relatively wealthier households receiving vouchers and being able to pay for their share of the seed cost.

### HETEROGENEOUS IMPACTS

The third set of findings addresses the question of whether there are heterogeneous impacts within and across communities. This question requires further probing to determine whether the observed impacts hold across all segments of the communities being studied. To do this, households are segmented by wealth categories using the wealth index (described earlier), and impacts of the project on the lowest wealth categories are examined. Impacts for households in the first three quintiles of the wealth index are analyzed here, implying a focus on the least wealthy 60 percent of the sample.

The estimates for this subgroup are presented in Figures 8a and 8b. Figure 8a indicates that the average treatment effects are still not significantly different from zero for the directly identified households. For the tiered pricing mechanism (Figure 8b), all treatment groups had significantly higher purchases of maize seed than the control group, with the exception of farmers who received 2 vouchers for the 60 KSh discount.

The findings from this analysis of the lower wealth subgroups implies that the impacts observed for the entire sample were not driven entirely by wealthier households in the tiered pricing group: poorer households in the tiered pricing mechanism also changed their seed purchasing behavior when the received vouchers. This suggests that beyond the resource constraints faced by poorer households in each mechanism, there may be other reasons why the directly identified households did not increase their seed purchasing behavior. However, these findings should be interpreted with some caution as they are based on a non-randomized sub-sample of the study's random sample of households.

<<Figures 8a and 8b about here>>

## CONCLUSION

This paper presents findings from a study of market segmentation study for maize seed in the Embu and Kisii District of Kenya. The study uses a randomized evaluation design to estimate the average treatment effects of two different types of market segmentation, direct identification and tiered pricing, which represent two different approaches to identifying farmers and providing voucher-based subsidies on the purchase of improved maize seed.

The results indicate the use of vouchers is a relatively cheap and efficient way of distributing subsidies for agricultural inputs. The costs are substantially higher for direct identification (KShs 105/beneficiary) than for the tiered pricing mechanism (KShs 40). Direct identification, on the other hand, is a better mechanism than tiered pricing for including the poorest households in market segmentation schemes. Still, direct identification did not lead to the exclusion of wealthier farmers.

The findings on targeting suggest that direct identification is a better mechanism than tiered pricing for including the poorest households in market segmentation schemes. For interventions which have poverty reduction as their main goal, direct identification may thus be the right mechanism. However, this conclusion needs to be tempered in light of the fact that the study finds minimal impacts on seed purchases among directly identified farmers. In view of this, it is doubtful that market segmentation through direct identification alone will have much impact on crop yields, much less on food security. The analysis of targeting also indicates that direct identification did not lead to the exclusion of wealthier farmers.

Most recipients of the vouchers (50 – 60 percent) used them to purchase maize seed. Other farmers sold the vouchers or exchanged the vouchers for other items, or did not use the vouchers at all. Findings also suggest that voucher use increased slightly as the value and quantity of vouchers increased.

The observed impacts, in terms of increased seed purchase, were small and substantially lower than the amount of subsidy that the intervention offered to farmers. This implies some displacement effects: market segmentation had some impact on seed purchasing decisions, but many farmers used part of the discount to purchase seed that they would have purchased anyway in the absence of the intervention. These results, based on an experimental study, support the recent findings from the observational study of Malawi's voucher program (Ricker-Gilbert and Jayne 2009). There is some evidence of heterogeneous impacts when wealth subgroups within the communities are taken into consideration. A lower discount led to higher seed purchases among households in lower wealth categories, although this discount had no impact for the entire sample.

In conclusion, findings suggest that a market segmentation scheme must offer a significant discount on the price of seed in order to have impacts on seed purchases. These findings point to the need for careful targeting of market segmentation schemes and the need for more in-depth analysis of these segmentation mechanisms. In future research, further insights can be gained by extending the experiment to geographic areas with low adoption rates, and to a wider set of inputs, in particular fertilizer.

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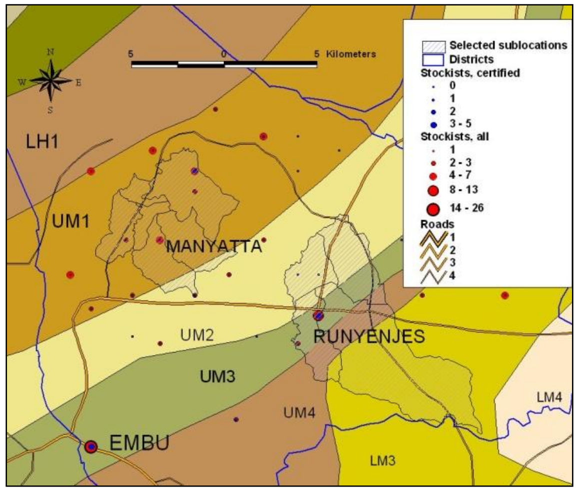
## APPENDIX

**Table A1. Variables used to compute wealth index**

| **Household characteristics** |
|---|
| Household size |
| Age of the household head |
| Household head's primary education |
| Gender |
| Literacy |
| Household adult equivalents |
| Dependency ratio |
| Adult's farm time |
| Ownership of savings account |
| Total household land holding |
| Total cultivated land |
| Total tropical livestock units |
| Value of the main house |
| Value of oxcart |
| Value of wheel barrow |
| Value of hoes |
| Value of stores |
| Value of livestock structures |
| Value of bicycles |
| Value of motorcycles |
| Value of car/truck |
| Value of radio |
| Value of television |
| Value of mobile phone |
| Value of solar |
| Roofing material (Grass, Iron-sheet, or Tile) |
| Floor material (Earthen, Cemented, Wooden, or Tiled) |
| Wall material (Brick, Mud, Iron-sheet, Plastered) |

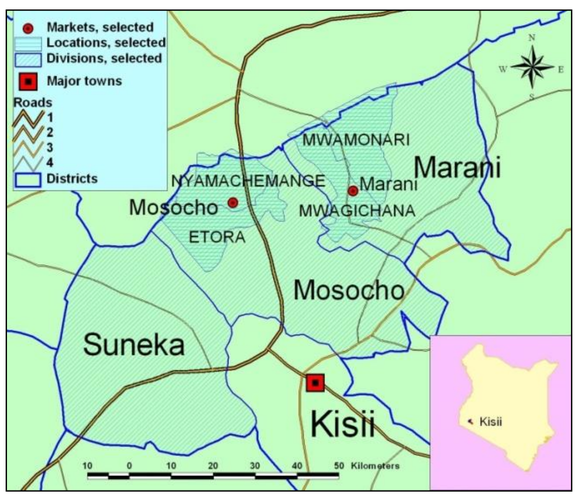
**FIGURES AND TABLES**

**Figure 1. Selected markets in Embu district (Manyatta and Runyenjes)**




Source: Authors.

**Figure 2. Selected markets in Kisii district (Marani and Mosocho)**




Source: Authors.

**Table 1. Random assignment of farmers to treatment and control groups**

| ***Number on die*** | ***Benefits received*** | ***Group assignment*** |
|---|---|---|
| 1 | Cooking fat (0.5 kg purchased at KSh 60) | Control |
| 2 | Sugar (1 kg purchased at KSh 75) | Control |
| 3 | Maize seed vouchers (2 for KSh 60 discount on 2-kg packet) | Treatment #1 |
| 4 | Maize seed vouchers (2 for KSh 120 discount on 2-kg packet) | Treatment #2 |
| 5 | Maize seed vouchers (5 for KSh 60 discount on 2-kg packet) | Treatment #3 |
| 6 | Maize seed vouchers (5 for KSh 120 discount on 2-kg packet) | Treatment #4 |

Source: Authors.

**Table 2. Project participants, by mechanism and assignment (number)**

***Market segmentation mechanism #1: Direct identification***

| | | *Group Assignment* | | | | |
|---|---|---|---|---|---|---|
| ***District*** | ***Sub-location*** | ***Control*** | ***Treatment #1*** | ***Treatment #2*** | ***Treatment #3*** | ***Treatment #4*** |
| Embu | Kianjuki | 99 | 51 | 51 | 50 | 50 |
| | Kairuri | 46 | 25 | 19 | 28 | 25 |
| | Nthangaiya | 50 | 22 | 21 | 21 | 28 |
| | Gikuuri | 84 | 39 | 32 | 39 | 42 |
| Kisii | Igemo | 135 | 34 | 59 | 39 | 66 |
| | Kiomoncha | 70 | 35 | 33 | 25 | 46 |
| | Santa | 137 | 70 | 71 | 67 | 74 |
| | Raganga | 95 | 59 | 67 | 47 | 73 |
| | Sub-total | 716 | 335 | 353 | 316 | 404 |

***Market Segmentation Mechanism #2: Tiered Pricing***

| | | *Group Assignment* | | | | |
|---|---|---|---|---|---|---|
| ***District*** | ***Sub-location*** | ***Control*** | ***Treatment #1*** | ***Treatment #2*** | ***Treatment #3*** | ***Treatment #4*** |
| Embu | Manyatta | 180 | 93 | 100 | 84 | 85 |
| | Kawanjara | 205 | 88 | 97 | 82 | 98 |
| | Kavutiri | 189 | 94 | 95 | 96 | 100 |
| | Kigaa | 162 | 112 | 95 | 105 | 105 |
| Kisii | Nyakeiri | 84 | 44 | 35 | 44 | 40 |
| | Rioma | 69 | 37 | 39 | 37 | 41 |
| | Matieko | 93 | 40 | 37 | 44 | 42 |
| | Bigege | 94 | 45 | 39 | 33 | 31 |
| | Sub-total | 1076 | 553 | 537 | 525 | 542 |

Source: Authors.

**Figure 3a. Daily cost of operations (KShs/day)**

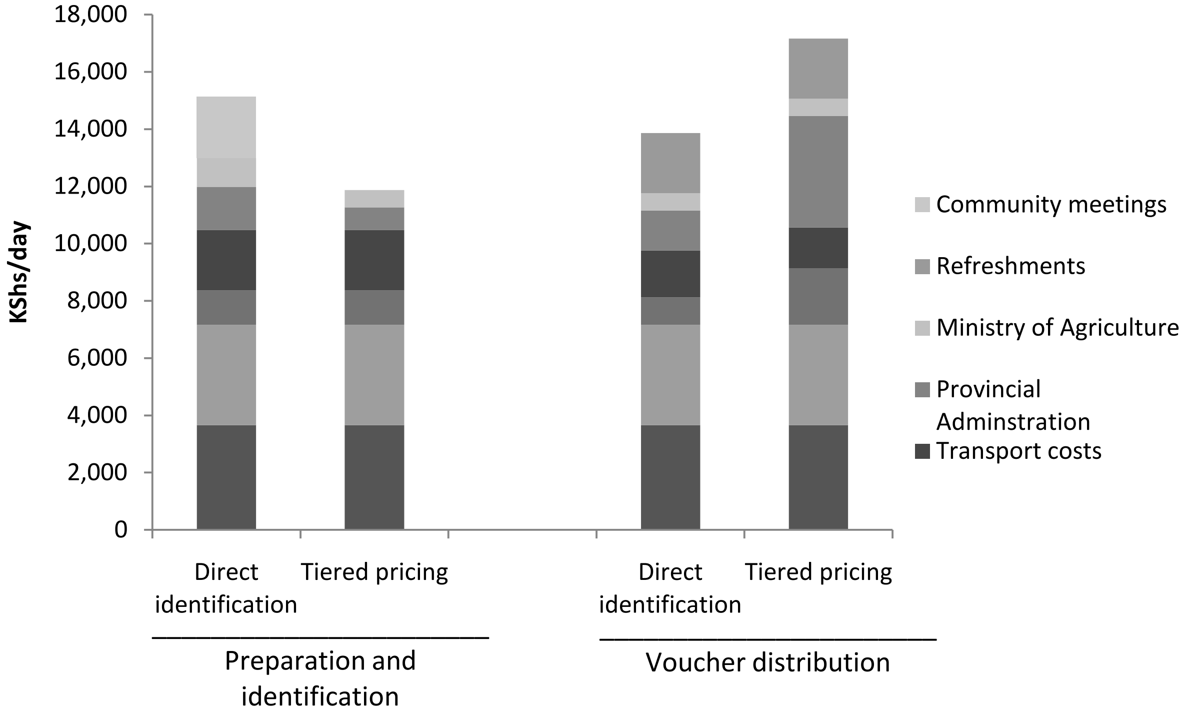



**Figure 3b. Average project implementation cost (KShs) per beneficiary, by segmentation mechanism**

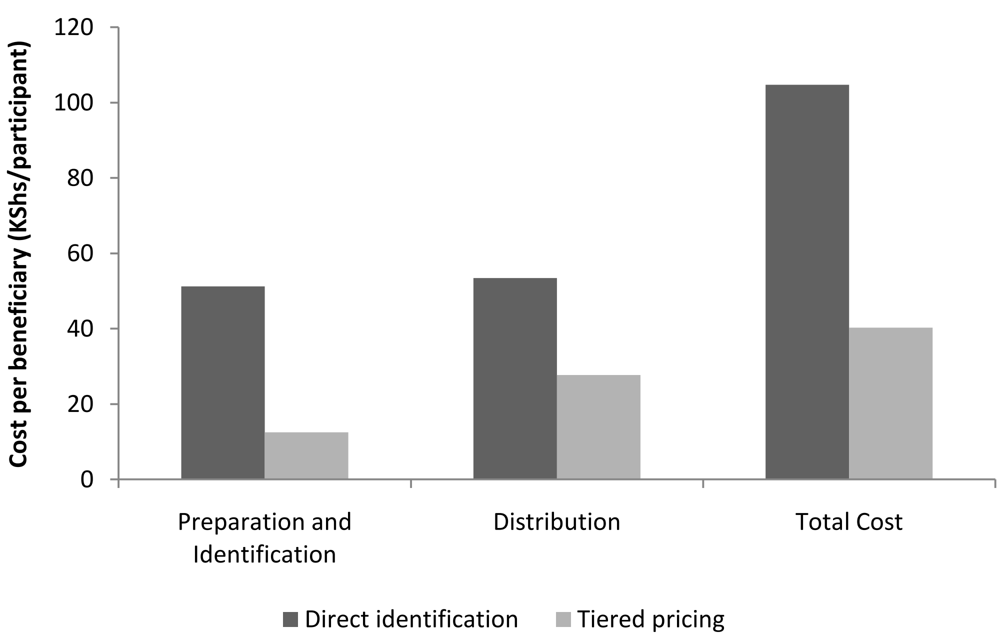
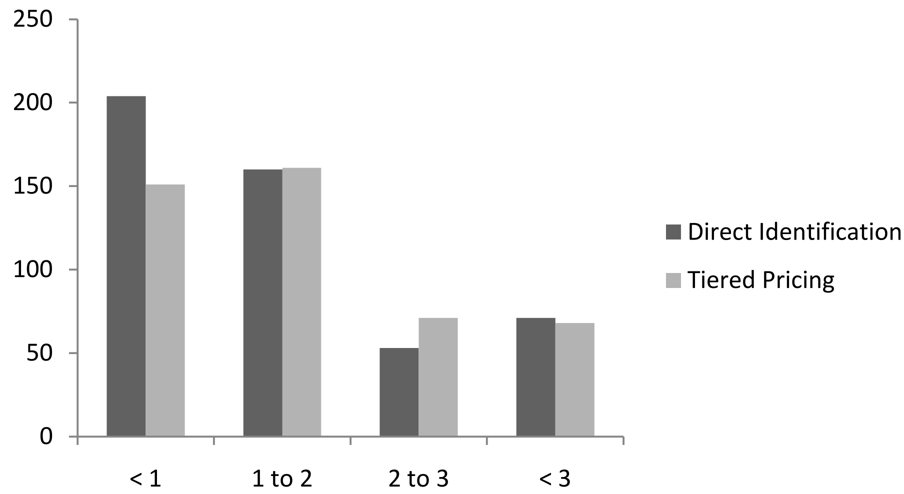
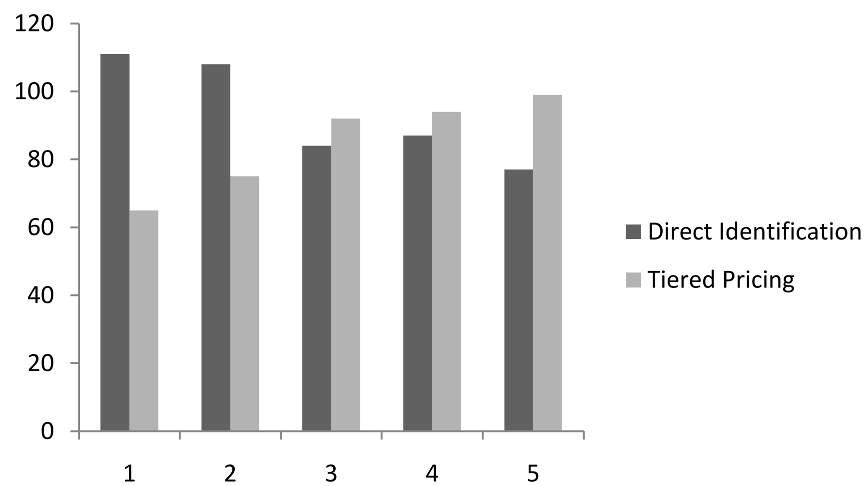


**Figure 4a. Total land (in acres) owned by households, by segmentation mechanism**



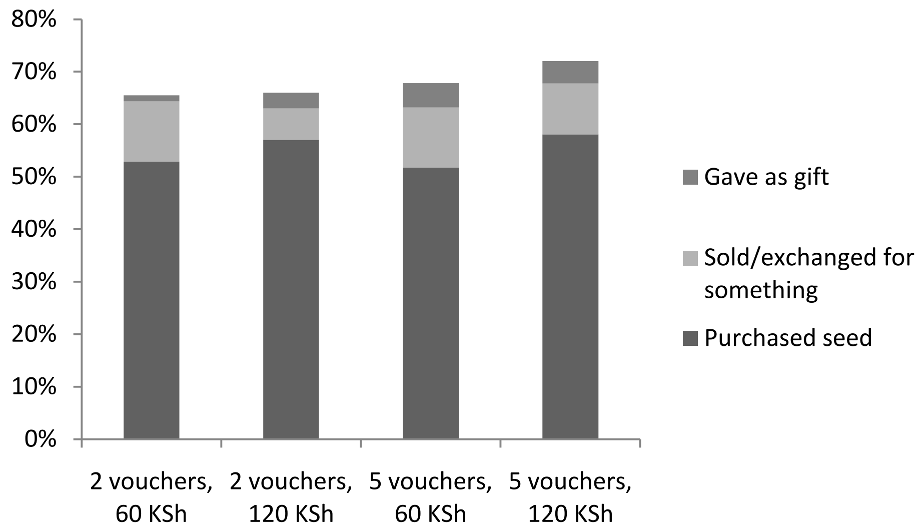

Source: Authors.

**Figure 4b. Number of participating households in each wealth index quintile, by segmentation mechanism**



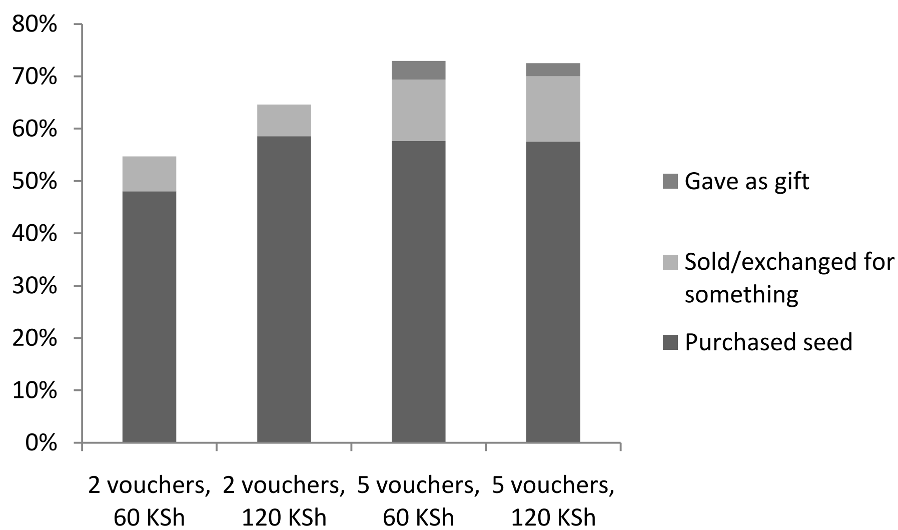

Source: Authors.

**Figure 5a. Voucher use: Direct identification**



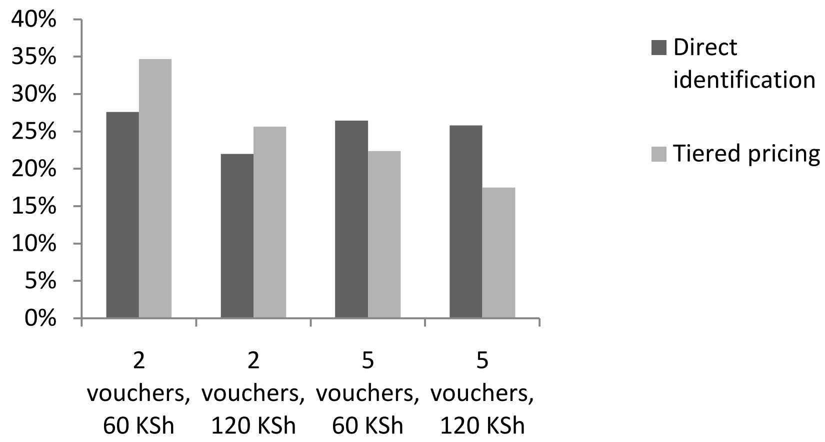

Source: Authors.

**Figure 5b. Voucher use: Tiered Pricing**



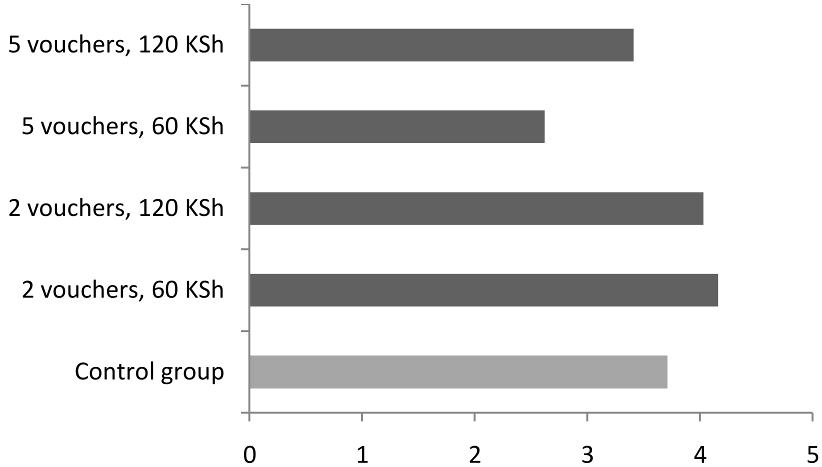

Source: Authors.

**Figure 6. Percentage of farmers who did not use vouchers**



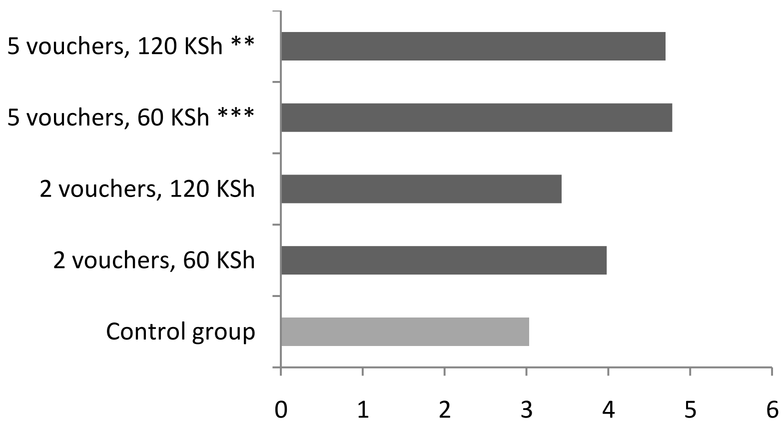

Source: Authors.

**Figure 7a. Maize seed purchased in main 2009 season: Direct identification**



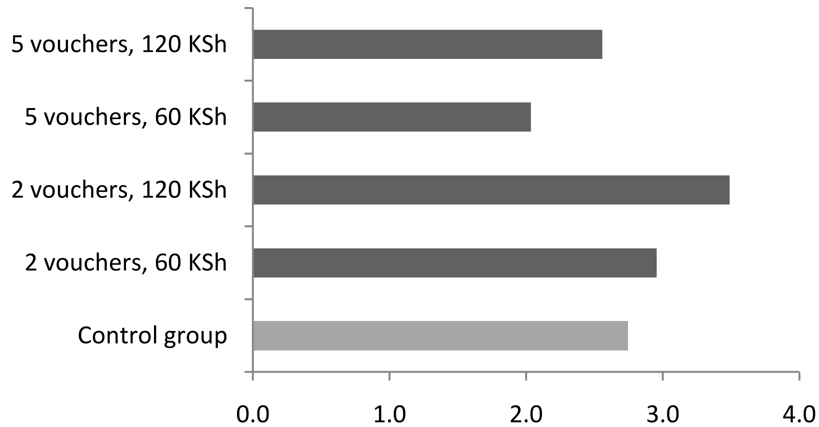

Source: Authors.
Note: A t-test for difference in means between mean seed purchase between each treatment group and the control group. ***, ** indicate statistical significance at 1 percent and 5 percent respectively.

**Figure 7b. Maize seed purchased in main 2009 season: Tiered pricing**



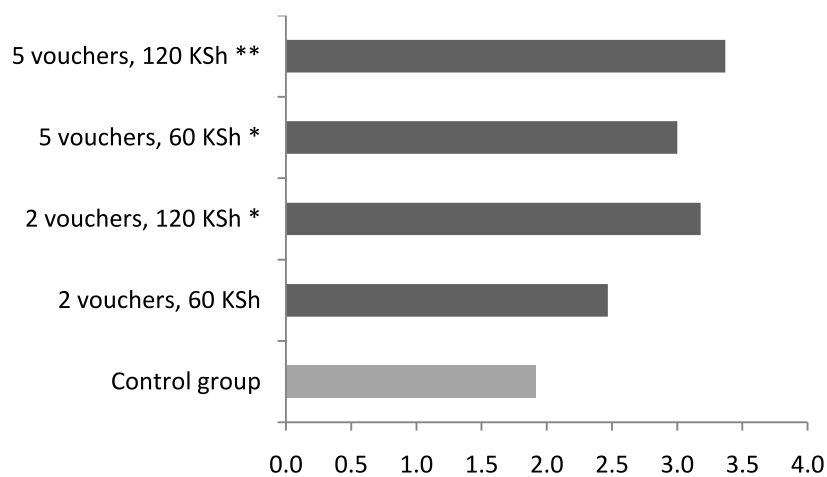

Source: Authors.
Note: A t-test for difference in means between mean seed purchase between each treatment group and the control group. ***, ** indicate statistical significance at 1 percent and 5 percent respectively.

**Figure 8a. Maize seed purchased in main 2009 season: Direct identification, lowest wealth categories**




Source: Authors.

**Figure 8b. Maize seed purchased in main 2009 season: Tiered pricing, lowest wealth categories**




Source: Authors.
A t-test for difference in means between mean seed purchase between each treatment group and the control group. *, ** indicate statistical significance at 5 percent and 10 percent respectively.