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The Impact of Market Access on Input Use and Agricultural Productivity: Evidence From Machakos District, Kenya

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ABSTRACT
With increasing land scarcity, efforts to increase agricultural production in the past decades have been concentrated on agricultural intensification. Recent studies have shown that improvement in market access increases agricultural productivity, firstly by facilitating specialization and exchange transactions in rural areas, and secondly through intensification of input use. The extent to which specialization and intensification contribute to agricultural productivity, and how this increase is distributed across farmers of different farm sizes and resources will be presented in this paper. The output generated from a variance analysis is used to develop and estimate a three stage least square regression model. The model is used to assess the effects of market access on agricultural productivity, and the distribution of market-generated benefits among small and large farmers. Data collected from 100 farmers in Machakos District is used for the analysis. The results indicate that aggregate physical productivity increases with improvement in market access, but that there is a disparity in the distribution of market-generated efficiency gains between small and large farmers (large farmers benefit more than small farmers), and between farmers with different access options to markets – easy access farmers benefit for than farmers with difficult access.

INTRODUCTION
With only an estimated 17% of its total land area classified as having high potential for agricultural production, Kenya has, in past decades, implemented agricultural policies that gear towards intensification and liberalization of agricultural markets so as to create incentives in the agricultural sector (Makanda, 1987; Kamara & von Oppen, 1999; Freeman and Salim, 2002). Incentives in the agricultural sector, especially price incentives give positive signals for production decisions, resource allocation and market orientation in ways that may contribute to eradicating rural poverty through welfare increases and subsequent adoption of farm innovations (Boserup, 1981; Coleman & Young, 1989; Tiffen & Mortimore, 1994; Hayami, 1997). On the strength of this, marketing issues and market-oriented interventions have been supported as a basis for stimulating smallholder agricultural production. The theory of comparative costs, which is the primary background to the discussion, recognizes that with a divergence in natural production conditions and differences in market access, farmers will specialize in the production of crops for which they have a higher comparative advantage and exchange them with those for which their comparative advantage is relatively lower. The increase in farm income that results from the comparative advantage and rents from economies of scope and scale may facilitate the

[1] The views expressed by the author in this paper are purely that of the findings of this piece of research, and do not represent, in any way, the views of the African Development Bank on the issues discussed, nor does it reflect the views of the author's previous institutions of affiliation.

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purchase of more farm inputs to intensify production and improve human welfare. In the above context, the study is designed to estimate the impact of market access on input use and aggregate agricultural productivity of farmers in the Machakos district of eastern Kenya, and to examine the distribution of efficiency gains resulting from improvements in market access across rural households with different farm sizes and access to markets.
The impact of market access on agricultural productivity is estimated by means of a simultaneous system of equations that accesses the relationships between market access, agricultural productivity and input variables. The analysis builds on previous findings that the impact of market access on aggregate agricultural productivity is observed at two levels: the direct effect through market-induced allocation of land to high value crops (specialization), and the indirect effects through the intensification of input use to raise productivity (Ijaimi, 1994; von Oppen *et al.*, 1997; Kamara and von Oppen, 1999; Freeman & Salim, 2002). A common limitation of most of these discussions is the failure to recognize and separately quantify the direct and indirect effects of market access on rural farmers, which is crucial for policy formulation and implementation. The current study seeks to address these issues, and to further examine equity implications in terms of the distribution of market-generated efficiency gains among small and large farmers.

The approach utilizes mean values of aggregate productivity, market access and input variables from the results of a partial analysis. The study is organized into five main sections. The second section briefly introduces the study area, the data set, the socio-economic characteristics of the sample farmers and a summary of the results of the partial analysis. The third section introduces the model. The identification and specification of the model as well as the variables used in the estimations and their proxies are discussed in this section. The fourth part presents the results of the estimations while the fifth section summaries conclusions drawn from the study and discusses their implications.

2. STUDY AREA AND DATA

The study is a case study of smallholder farmers in Machakos District in the Eastern Province of Kenya. The district is located about 70 km northwest of Nairobi and covers an area of about 5 820 km^2, with a population of about 900 000 people, largely subsistence farmers. Data was collected from a random sample of 100 farmers from three village groupings around Mua, Iveti and Kangundo. These are the high potential areas in terms of agricultural production. Other parts of the district are mostly semi-arid and dominated by extensive livestock production or pastoralism (Zöbisch, 1986; Government Press, 1996). Farmers in the selected areas also differ in terms of farm sizes and access to the periodic and daily markets in the nearby towns of Machakos and Tala, the reference markets of the study. Farm size was a major criterion for the selection of farmers. In order to increase intra-group homogeneity and inter-group heterogeneity, the sample frame constitutes 55 small farmers with farm sizes of less than 10 acres, and 45 large farmers with farm sizes greater than 15 acres. The dominance of small farmers in the sample is justified by the preponderance of small farmers in the study area.

2.1 Characteristics of the sample farmers

As highlighted in Table 1, the average household size is about seven people including children. The major source of income is crops, providing over 70% of income. The limited sources of off-farm income include wage labour, sand mining, quarrying, charcoal production and firewood fetching. There is a strong correlation between household size and number of permanent farm workers. Permanent workers are almost entirely constituted of family members while seasonal wage labour is common during peak ploughing, weeding and harvesting seasons. Farm mechanization is uncommon and is limited almost entirely to large farmers. Major crops grown in the area include maize, beans, coffee, vegetables and to a lesser extent Persian fruits, avocados and sugarcane. Most of the farmers are subsistence oriented, combining

Table 1: Socio-economic characteristics of sample farmers

Variable	*Farm category*		
	Small (n=55)	*Large (n=45)*	*All (n=100)*
Farm size (acres)	5.16 (2.47)	21.88 (14.47)	12.69 (12.88)
HH size (people)	6.06 (2.87)	8.93 (3.85)	6.88 (3.46)
Age: HH head (years)	48.89 (16.22)	61.04 (15.04)	54.24 (16.84)
Education: HH Head (years)	5.61 (4.14)	7.31 (4.69)	6.37 (5.57)
Permanent labour (persons)	5.39 (2.51)	8.91 (3.02)	6.87 (3.27)
Market access (minutes)	84.78 (59.64)	45.68 (30.91)	67.58 (52.81)
Market orientation (% marketed)[b]	54.48 (24.27)	70.04 (20.49)	61.33 (23.96)
Farm income (in 000 KSh)[a]	23.39 (21.10)	121.54 (120.56)	66.56 (95.53)
Off-farm income (in 000 KSh)	8.42 (12.17)	68.62 (98.67)	34.91 (72.52)
% Farm income (% of total)	78.61 (25.38)	72.91 (22.87)	76.05 (24.45)

( ) = standard deviation; HH = household; [a] annual farm income in Kenyan Shillings (Ksh) [b] marketed output

Source: Own survey

subsistence agricultural production with off-farm activities while others produce on a comparatively larger scale both for consumption and marketing. Crops produced for the domestic markets include maize (the staple food), bean and to a lesser extent wheat and sugarcane. Coffee is the major cash crop grown in the area.

2.2 The proxies for market access and aggregate productivity

The proxy for market access is 'time taken' to the market, which was more appropriate than physical distances, due to differences in wealth and farm resources, and hence different means of transportation[2]. The measurement of agricultural productivity is based

[2] Based on this proxy, the sample was stratified into easy, medium and difficult market access, corresponding to 30, between 35 and 65, and above 70 minutes respectively from the reference markets. The representation of these categories in the sample was fairly even, giving rise to 33, 35 and 31 farmers respective categories.

on the concept of input-output relations. That is, the relationship between output and traditional inputs (land, labour and capital), while the application of complementary inputs such as fertilizer, pesticides, and high yielding seed varieties are assessed as determinants of productivity. Land being a major constraint to agricultural production in Kenya, increase in land productivity has long been identified as a major constraint to Kenya's agricultural development (Makanda, 1987). Agricultural productivity in this study therefore refers specifically to productivity per unit area, expressed in monetary terms. Aggregate productivity is thus estimated from the average yields of all the major crops grown in the study area, including maize, beans, coffee, vegetables and to a lesser extent Persian fruits, sugarcane and avocados. The aggregate productivity of these crops is estimated by obtaining the product of the yields of each of the crops and their average market prices, adding these up and then dividing by the total crop area. This is expressed in Kenyan shillings (KSh) per acre[3].

2.3 Results of the partial analysis

A variance analysis was conducted so as to generate input variables of the model. As presented in Table 2, results indicate that variable inputs increase with increasing market access, though in some cases the differences are not statistically significant. Variations in the use of fertilizer, pesticides and high yielding seed varieties across market access groups exhibit statistical significance at 1% probability level. A similar trend was observed across farm size groups. These observations are largely due to the direct effect of market access or easy access to input markets, as well as decreasing 'per unit transportation cost' in areas of easy market access, especially in the case of fertilizers and high yielding varieties which are bulky to transport. In the case of pesticides, the high frequency of visits of extension workers to farmers with easy market access may have accounted partly for this observation.

Table 2: Input use and aggregate productivity by farm size and market access

	mean values of input use by market access				
Input	easy access	medium	difficult	sample	F-value
Fertilizer (kg/acre)	31.01 (23.80)	21.49 (17.27)	17.50 (9.55)	24.40 (18.71)	7.92***
Pesticides & herbi -cides (KSh/acre)	155.46 (104.36)	134.09 (91.61)	101.29 (58.03)	133.22 (92.04)	6.78***
HYV (% of area)	47.76 (20.16)	32.77 (20.45)	19.42 (20.78)	33.44 (22.47)	8.99***

[3] The official exchange rate at the time of the study was US$ 1.00 to KSh 55.94. The estimation of aggregate productivity (AP) can be mathematically expressed as:

$$AP = \sum_{i=1}^{n} Y_i X_i / A$$

Where Y_i=yield from the i-th crop; X_i= average price of the i-th crop; A = area for n crops

Credit (KSh/acre)	305.00 (362.52)	272.87 (378.33)	246.59 (549.21)	275.06 (436.04)	1.28
	Mean values of aggregate productivity in KSh/acre				
farm category	easy access	medium	difficult	sample	F-value
Small farmers	4,783.88 (1,802.01)	4,413.17 (1,942.25)	4,405.66 (1,386.25)	4,534.20 (2,421.17)	1.02
Large farmers	7,425.21 (3,406.23)	5,960.26 (1,719.91)	5,516.52 (2,354.00)	7,369.89 (2,811.54)	2.41*
All farmers	6,746.57 (3,276.34)	5,625.21 (5,171.78)	4,599.98 (1,813.07)	5,841.83 (3,834.76)	5.88***
F-value	0.94	0.85	2.86**	9.64***	

( ) = standard deviation; *, **, *** = significant at 10%, 5% and 1% probability levels respectively
Source: own survey

The acquisition of credit does not show significant (F = 1.28) variation across farm size and market access groups. Credit acquisition in the study area does not seem to depend on market access. It depends primarily on membership in farmers' organizations like marketing cooperatives, and whether or not the farmer grows coffee (the main cash crop in the area), which is associated with some credit facilities. In general, credit is received in the form of improved seeds, fertilizers, pesticides and on rare occasions physical money in exchange for products after harvest. This is usually granted by village merchants but mostly to large farmers.

Aggregate productivity also varies across farm size and market access groups (Table 2), with large farmers achieving higher productivity than small farmers, and easy access farmers experience greater productivity than those with difficult access to markets. The differences across market access groups are statistically significant at the 1% probability level. The trend holds true for both small and large farmers in the different categories of market access. These observed differences are attributed to the specialization and intensification effects of market access on agricultural productivity. That is, improved market access facilitates land allocation to crops of higher comparative advantage and hence higher profit margins (specialization), as well as facilitates easy access to inputs to intensify production (intensification). Since a separate quantification of these two effects (from which small and large farmers may benefit differently) lies beyond the scope of this partial method, a further analysis is undertaken using regression techniques.

3. MODEL DEVELOPMENT

This section attempts to assess the effects of market access on input use and agricultural productivity. A three stage least square regression model is developed and estimated. The model specification draws largely on the relationship between market access, aggregate productivity and input use as highlighted in the previous section, as well as in previous studies (Ijaimi, 1994; von Oppen et al., 1997; Kamara, 1997). The model enhances a separate estimation of the specialization and intensification effects of market access on agricultural productivity. A further step is taken to estimate the elasticity or degree of responsiveness of agricultural productivity to input use, thereby overcoming the inferential limitations of the partial methods. The application of the three stage least square method to the estimation of a system of equations requires that the model be identified in such a unique way that allows the estimation of the correct coefficients of the parameters (Koutsoyiannis, 1977; Greene, 1993; Gujarati, 1995). The problem of identification requires that two conditions be satisfied[4]. These conditions are taken into consideration in the formulation of the reduced from equations.

3.1 Variables in the model

The input variables for the estimation of the analytical equations consist of estimated means and standard deviations of the dependent and explanatory variables obtained from the results of the partial analysis. A synoptic description of these variables and their descriptive statistics is presented in Table 3. The model consists of a total of four basic equations, specified according to the empirical relationships between the respective variables as suggested by the results of the partial analysis.

Table 3: Variables in the model and their proxies

Variable, Description, Proxy	*Mean*	*Std. Dev.*
AP (aggregate productivity in KSh/acre)	5,841.00	3,834.00
FERT (mineral fertilizers in kg/acre)	24.40	18.71
PEST (pesticides and herbicides in KSh/acre)	133.22	92.04
HYV (high yielding varieties: area in %)	33.44	22.47
CRED (formal and informal credit in KSh/acre)	275.06	436.04
MA (market access: time taken to/from in minutes)	84.78	59.64
LA (cultivated area in acre)	12.69	12.88
FYM (farm yard manure in tons/acre)	19.86	32.01
LBR (labour input per acre in mandays)	51.98	30.17
EXTN (extension services in number of visits/year)	51.30	50.24

Std. Dev = standard deviation

[4] The first condition, the 'order condition' requires that the total number of variables excluded from a particular equation but included in the other equations must be at least equal to the number of equations of the system less one. Mathematically, this is expressed as follows:

$$(K\text{-}M) \geq (G\text{-}1)$$

[*excluded variables*] ≥ [*total number of equations -1*]

G = total number of equations (= total number of exogenous variables).
K = total number of variables in the model, and
M = number of variables (endogenous and exogenous) included in a particular equation

The second, the 'rank condition' requires that in a system of *G* equations, any particular equation is identified if, and only if, it is possible to construct at least one non-zero determinant of order (*G-1*) from the coefficients of the variables excluded from the model; and that a system of equations is identified if all of its equations are identified.

3.3 The reduced form equations

The dependent variable in the first equation is aggregate agricultural productivity expressed in KSh/acre. As revealed by the partial analysis the most important input variables that influence agricultural productivity in the area include the application fertilizers, pesticides, high yielding varieties, market access and labour input. Aggregate productivity is accordingly specified as follows:

$$AP = f_1(\hat{FERT}, \hat{PEST}, \hat{HYV}, MA, LBR) \quad (1)$$

Where

FÊRT, PÊST, HŶV are predicted values estimated from FERT, PEST, HYV equations respectively and entered in AP equation.

Fertilizer use is, a priori, influenced by credit, area under high yielding seed varieties, physical market access and the use of farmyard. Farmers generally acquire mineral fertilizers in the form of credit from cooperatives. Credit in cash form from farmers associations and/or village merchants is also used to purchase mineral fertilizers by farmers. As fertilizer application in the study area comprises both organic and mineral fertilizers, the availability and application of farmyard manure also influences the level of application of mineral fertilizers. High yielding seed varieties are known to have a relatively higher demand for mineral fertilizers. Based on these assumptions, the equation for fertilizer use is specified as follows:

$$\hat{FERT} = f_2(HYV, MA, CRED, FYM) \quad (2)$$

The use of pesticides is hypothesized to be influenced by market access, acquisition of credit to purchase pesticides, visits of extension agents and the area under high yielding varieties. Extension services that enlighten farmers about the relevance of pesticides and herbicides are strongly posited to be crucial in the adoption of the input. The area under high yielding varieties is hypothesized to be a determinant since high yielding varieties are relatively more vulnerable to pests and weeds. Therefore the equation for pesticides and herbicides is derived as follows:

$$\hat{PEST} = f_3(MA, CRED, EXTN, HYV) \quad (3)$$

The area under high yielding varieties (in % of total farm area) is hypothesized to be influenced by market access, availability of credit to purchase the input, farm size and extension services. The equation for area under high yielding varieties is therefore specified as follows:

$$\hat{HYV} = f_4(MA, CRED, LA, EXTN) \quad (4)$$

Each of the equations of the above specification obeyed the restriction posed by the econometric identification condition (see Section 3). The model was thus identified for simultaneous estimation and hence solvable by the three stage least square method. FÊRT, *PÊST* and *HŶV* are estimated from equations 2, 3 and 4, and the predicted values entered in

Equation 1. The *LIMDEP-software* (Limited Dependent Variables) was used to estimate the coefficients of the parameters. The estimated coefficients are reported together with their t-values, which are shown in Table 4. A derived elasticity (at the mean) was estimated from the coefficients of the explanatory variables in each equation, and reported along with the coefficients and t-statistics in the same table[5].

4. RESULTS AND DISCUSSION

As indicated in Table 4, most of the explanatory variables carry the expected signs. In some equations however, certain variables carry unexpected signs and raise interesting questions about a priori expectations. These observations are explained in the detailed discussion of results in the subsequent sections.

4.1 The specialization effects of market access (direct effects)

As highlighted in Table 4, the use of fertilizers, high yielding seed varieties and labour input are positive determinants of aggregate agricultural productivity. The coefficients of labour and fertilizer use are significant at the 5% and 10% probability levels respectively, while that of high yielding varieties is not statistically significant. The coefficient for the use of pesticides bears a negative sign, which is unexpected, but is statistically insignificant. As it is not clear whether this is due to multicollinearity among the explanatory variables, variance inflation factors are calculated, but the VIF values (reported with each coefficient in Table 4) do not reveal any significant multicollinearity. Thus, one possible explanation of the unexpected result for pesticides may relate to untimely application or inappropriate use of pesticides. As the yields of the high yielding varieties depend very much on pesticide use, this observation could also be an explanation for the observed weak correlation between the use of high yielding varieties and productivity, which is not statistically significant. Market access (time taken to the market) has a negative effect on productivity, which indicates that aggregate productivity increases with 'decreasing time to markets' (or improving market access). This means that improved market access increases agricultural productivity. The derived elasticity estimate shows that a 10% improvement in market access, *ceteris paribus*, will lead to about 1.7% increment in aggregate productivity in the study area. The derived elasticity of aggregate productivity to fertilizer use, all else equal, is about 7.9%, indicating that fertilizer use is one of the key determinants of productivity in the area, which is quite consistent with the agro-ecological profile of the area. Also, it further relates to the fact that high yielding varieties of maize, beans and vegetables that are widely grown in the area respond well to fertilizer.

The effects of the explanatory variables in the aggregate productivity equation measure the direct influence of market access on agricultural productivity, and can thus be interpreted directly. In practice, these direct effects are observed through the specialization of farmers in the production of particular crops or crop mixtures for which they have a better comparative cost advantage, which are exchanged through market mechanisms to acquire those they do not produce.

[5] Elasticity was calculated at the mean level (see means presented in Table 3) for each explanatory variable.

Table 4: Three stage least square (3SLS) regression coefficients and their derived elasticities

Explanatory variables	DEPENDENT VARIABLES: (1) productivity (Ksh/acre) coefficient	t-statistics	elasticity[a]	(2) fertilizer use (kg/acre) coefficient	t-statistics	elasticity[a]	(3) pesticide use (Ksh/acre) coefficient	t-statistics	elasticity[a]	(4) High yielding varieties (area %) coefficient	t-statistics	elasticity[a]
FERT	189.80 (1.123)	1.668*	0.7927	--	--	--	--	--	--	--	--	--
PEST	-15.064 (1.818)	-0.442	-0.3435	--	--	--	--	--	--	--	--	--
HYV	50.384 (1.250)	0.900	0.2884	0.69150 (1.333)	9.065***	0.9476	3.5747 (1.064)	7.146***	0.8973	--	--	--
CRED	--	--	--	0.12414 (1.020)	0.646	0.2720	0.30102 (1.134)	0.135	0.6215	0.06490 (1.009)	3.166***	0.5338
MA	-11.928 (1.002)	-1.166	-0.1730	-0.21760 (1.076)	-1.860*	-0.7568	0.65961 (1.025)	0.938	0.4197	-0.20161 (1.003)	-4.148***	-0.5145
LA	--	--	--	--	--	--	--	--	--	1.2876 (1.193)	8.962***	0.4959
FYM	--			-0.10541 (1.086)	-2.835**	-0.0858	--	--	--	--	--	--
LBR	18.387 (1.010)	2.198)**	0.1632	--	--	--	--	--	--	--	--	--
EXTN	--	--	--	--	--	--	0.56720 (1.123)	0.181	0.2184	0.49162 (1.111)	5.182***	0.7541
Adjusted R^2	0.46			0.57			0.38			0.63		

*, **, *** = significant at 10%, 5% and 1% probability levels respectively; [a] = derived elasticity; -- = variable excluded from equation;
( ) = in parentheses are VIF values (variance inflation factors), given by $(1-R_i^2)^{-1}$, where R_i^2 is the R^2 from regressing the ith explanatory variable on all other explanatory variables, which is a standard test for multicollinearity (cf. Kennedy, 1998:190; Gujarati, 1995:328); The 3SLS procedure first estimates Equations 2, 3 and 4, and then substitute the predicted values into Equation 1 for the estimation of aggregate productivity.

4.2 The intensification effects of market access (indirect or input effect)

The remaining three equations – fertilizer use, pesticides use and area under high yielding varieties – assess the variables that determine input use. In other words, the explanatory variables in these equations are crucial factors that explain the intensification of input use in the study area. Variables in the second equation are determinants of fertilizer use, all of which carry the expected signs. Credit availability, the use of high yielding varieties, access to market and the use of farm yard manure are important factors that determine fertilizer use. Of these, market access, application of farmyard manure and the use of high yielding varieties bear coefficients that are statistically significant. The derived elasticity estimates indicate that a 10% increase in the use of high yielding varieties will, all else equal, increase fertilizer use by 9% while a 10% improvement in market access (*ceteris paribus*) leads to about 7.6% increase in fertilizer use. These observations can be attributed to the relatively high fertilizer demand of high yielding varieties and the already discussed advantages associated with improvements in market access. The use of farmyard manure has a significant negative effect on fertilizer use due to the substitution relationship between the two inputs. Though the coefficient for credit is not statistically significant, it bears the expected sign, which indicates the importance of credit for fertilizer use (at least for some of the farmers) in the study area.

As indicated in the third equation, the use of pesticides in the study area is crucially determined by proportion of land area under high yielding varieties and extension services – visits by extension workers[6]. The derived elasticity of pesticide use to changes in area under high yielding varieties (*ceteris paribus*) is about 9%. This can be attributed to the relatively low resistance of high yielding varieties to pests and diseases, and their general vulnerability compared to traditional species, as documented by agronomic studies (cf: Montagnini *et al.*, 1995). Credit acquisition does not significantly affect pesticide use. There is no clear relationship between market access and pesticide use, perhaps due to the fact that pesticide is far less bulky compared to other inputs, and that pesticide bottles can even be carried in a farmer's pocket. This is further confirmed by the coefficient of market access variable in the pesticide equation, which is statistically insignificant.

The fourth equation in the model shows that acquisition of credit, access to markets, total farm area cultivated and extension services are all factors that significantly influence the use of high yielding varieties in the study area. The use of high yielding varieties is more elastic to market access, credit and extension services than it is to land area under cultivation. All other conditions remaining the same, a 10% improvement in market access may lead to about 5% increase in the application of high yielding seed varieties in the study area. This interrelationship between the inputs and their subsequent effect on productivity represent the indirect effects of market access, or the input effects.

[6] Herbicides are not used in the area.

4.3 The aggregate effect of a 10% improvement in market access

Table 5 summarizes the aggregate effect of a 10% improvement in market access on agricultural productivity, keeping all other conditions the same. The arbitrary reference to a 10% improvement is based on the assumption that this is a plausible target that can be practically achieved through simple road repairs and upgrading, awareness creation among farmers about quality standards, timely planting for targeted markets, etc., that may not involve huge financial and other resource requirements. The estimation of the increase in aggregate productivity from the indirect effects (Table 5) is done by multiplying the elasticity of each input (with respect to the 10% improvement in market access) by the derived input elasticity of agricultural productivity to the use of the particular input, a methodology that is relatively developed in the literature (von Oppen, 1978; Ijaimi, 1994).

Table 5: The aggregate effect of a 10% improvement in market access

category of effect	*aggregate effect*	
	on input use (%)	*on productivity (%)*
a) specialization effect (direct)	--	1.73
FERT	7.57 x (0.7927)	6.00
HYV	5.14 x (0.2884)	1.48
b) sum of intensification effects (indirect)[a]	--	7.48
Grand Total (a + b)	--	9.21

( ) = derived input elasticity; -- = not applicable;

[a] the effect of pesticide use is not estimated, as it is statistically insignificant

According to the model, the achievement of a 10% improvement in market access in the study area will increase aggregate agricultural productivity by 1.7% (direct effects), while a 7.5% increase results from indirect or input effects (Table 5). Although improvement in market access, without availing other relevant support services such as extension, may sometimes lead to inappropriate use of certain inputs (as may have been the case with pesticides in the model), the overall increase that results from the input effects is usually greater than that from the direct effects. According to the model, a 10% improvement in market access in the study area will, *ceteris paribus,* lead to a 9.2% overall increase in aggregate agricultural productivity, which may lead to a significant improvement in rural livelihoods and welfare

5. CONCLUSIONS AND IMPLICATIONS

All inputs under investigation (except pesticides) increase with improvement in the access of farmers to both input and output markets, leading to an increase in aggregate agricultural productivity. The general conclusion is that prioritising the improvement of market access is an important approach to rural development, as it gives farmers the opportunity to specialize and optimise their portfolios with respect to available resources and subsequently exploit economies of scope and scale. Benefits are observed from the increase in aggregate productivity that result from the intensification and specialization effects of market access. However, the results of the partial analysis show that large farmers generally benefit more from the input effects than small farmers as reflected by the realized increases in aggregate productivity. Since over three-quarters of the overall increase in aggregate agricultural productivity is accounted for by the input effects from which large farmers benefit more (partial analysis), small farmers find themselves at the losing end. It is therefore vital to note, especially at the policy making level, that in as much as a general improvement in market access improves the income of rural households, it can at the same time lead to inequity in the form of uneven distribution of these market generated efficiency gains between different groups: small versus large farmers; easy access versus difficult access, with the bulk of the small farmers falling into the latter category. The problems of small farmers in the study area are basically different from that of large farmers, and this distinction should be given due consideration during policy formulation. The access of small farmers especially to credit and extension, which are key determinants of the use of other inputs, is important in the study area. These results may not be very different from the situation in other parts of Kenya and other developing countries with similar production systems.

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