THE IMPACT OF MARKET ACCESS ON INPUT USE AND AGRICULTURAL PRODUCTIVITY: EVIDENCE FROM MACHAKOS DISTRICT, KENYA

AB Kamara[1]

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 specialisation and exchange transactions in rural areas, and secondly through intensification of input use. The extent to which specialisation 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 are 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 more than farmers with difficult access.

1. INTRODUCTION

With only an estimated 17% of its total land area classified as having high potential for agricultural production Kenya has, in the past decades, implemented agricultural policies geared towards intensification of production and liberalisation of markets so as to create incentives in the agricultural sector (Makanda, 1987; Kamara & Von Oppen, 1999; Freeman & Salim, 2002). Such incentives, especially price incentives, provide positive signals for production decisions, resource allocation and market orientation in ways that may contribute to eradicating rural poverty (Boserup, 1981; Coleman & Young, 1989; Tiffen & Mortimore, 1994; Hayami, 1997). As a

[1]*Policy Economist, International Water Management Institute (IWMI), West Africa Office, Accra, Ghana.*

result, market-oriented interventions have been supported as a basis for stimulating smallholder agricultural production.

The theory of comparative cost advantage 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 resulting increase in farm income may facilitate the purchase of more farm inputs to intensify production and improve human welfare. In this regard, this 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 assesses the relationships between market access, agricultural productivity and input variables. The analysis builds on previous findings, namely that the impact of market access on aggregate agricultural productivity is observed at two levels: a direct effect through market-induced allocation of land to high value crops (specialisation), and an indirect effect through the intensification of input use to raise productivity (Ijaimi, 1994; Von Oppen *et al*, 1997; Kamara & 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 the equity implications in terms of the distribution of market-generated efficiency gains among small and large farmers.

The approach uses mean values of aggregate productivity, market access and input variables from the results of a partial analysis. The study is organised 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 summarises the conclusions drawn from the study and discusses their implications.

2. STUDY AREA AND DATA

Data were obtained from smallholder farmers in the 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 were collected from a random sample of 100 farmers from three village groupings around Mua, Iveti and Kangundo, areas of high agricultural potential. 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, which were used as reference markets for 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 consisted of 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, while off-farm income sources include wage labour, sand mining, quarrying, charcoal production and firewood fetching.

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)

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

There is a strong correlation between household size and number of permanent farm workers, generally family members, while seasonal wage labour is common during peak ploughing, weeding and harvesting seasons. Farm mechanisation 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 production with off-farm activities, although some produce on a comparatively larger scale both for consumption and marketing. 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 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. As land is a major constraint to agricultural production in Kenya, an increase in land productivity has long been identified as key to agricultural development in Kenya (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, and 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 the input variables of the model. As presented in Table 2, the results indicate that variable inputs increase with increasing market access, though in some cases the differences

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[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. Farmers were evenly spread across the three groups, with 33, 35 and 31 farmers respectively in the three categories.*

[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.

are not statistically significant. Variations in the use of fertilizer, pesticides and high yielding seed varieties across market access groups exhibit statistical significance at the 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 fertilisers 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 result.

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

Input	**Mean values of input use by market access**				
	Easy	**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 & herbicides (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***
Credit (KSh/acre)	305.00 (362.52)	272.87 (378.33)	246.59 (549.21)	275.06 (436.04)	1.28
Farm category	**Mean values of aggregate productivity in KSh/acre**				
	Easy	**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***	

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

The acquisition of credit does not show significant variation across farm size and market access groups (F = 1.28), thus credit acquisition depends primarily on membership in farmers' organizations like marketing cooperatives, and whether or not the farmer grows coffee, where credit facilities are provided, rather than on market access. In general, credit is received in the form of improved seeds, fertilisers, pesticides, and on rare occasions, cash in exchange for products after harvest. This is usually granted by village merchants, 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 attributable to the specialisation 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 (specialisation), and easy access to inputs to intensify production. Since 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). 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 a manner 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.

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[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.

3.1 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.

3.2 The reduced form equations

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

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

Where

$\hat{FERT}$, $\hat{PEST}$, $\hat{HYV}$ are predicted values estimated from FERT, PEST, HYV equations respectively and entered in AP equation.

Table 3: Variables in the model and their proxies

Variable, Description, Proxy	Mean	Standard Deviation
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

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

$$F\hat{E}RT = f_2(HYV, MA, CRED, FYM) \tag{2}$$

The use of pesticides is hypothesised to be influenced by market access, acquisition of credit to purchase pesticides, number of 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 hypothesised 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:

$$P\hat{E}ST = f_3(MA, CRED, EXTN, HYV) \tag{3}$$

The area under high yielding varieties (in % of total farm area) is hypothesised 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:

$$H\hat{Y}V = f_4(MA, CRED, LA, EXTN) \tag{4}$$

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, $P\hat{E}ST$ and $H\hat{Y}V$ are estimated from equations 2, 3 and 4, and the predicted values entered in Equation 1. The LIMDEP (Limited Dependent Variables) software was used to estimate the coefficients of the parameters. The estimated coefficients are reported together with their t-values 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].

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

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.

4.1 The specialisation effects of market access (direct effects)

As highlighted in Table 4, the use of fertilisers, high yielding seed varieties and labour input are positive determinants of aggregate agricultural productivity. The coefficients of labour and fertiliser 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 multicolinearity 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 multicolinearity. 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 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 fertiliser use, all else equal, is about 7.9%, indicating that fertiliser use is one of the key determinants of productivity, which is 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 fertiliser.

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 specialisation 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.

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

Explanatory variables	DEPENDENT VARIABLES											
	(1) Productivity (Ksh/acre)			*(2) Fertiliser use (kg/acre)*			*(3) Pesticide use (Ksh/acre)*			*(4) High yielding varieties (area %)*		
	coefficient	**t-statistics**	**elasticity[a]**	**coefficient**	**t-statistics**	**elasticity[a]**	**coefficient**	**t-statistics**	**elasticity[a]**	**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		

Notes: *, **, *** = 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 *i*th explanatory variable on all other explanatory variables, which is a standard test for multicolinearity (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 – fertiliser 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 fertiliser 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 fertiliser 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 fertiliser use by 9% while a 10% improvement in market access *ceteris paribus* leads to an increase in fertiliser use of about 7.6%. These observations can be attributed to the relatively high fertiliser 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 fertiliser use due to the substitution relationship between the two inputs. Though the coefficient for credit is not statistically significant, it bears the expected sign.

As indicated in the third equation, the use of pesticides in the study area is crucially determined by the proportion of land area under high yielding varieties and 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 in agronomic studies (cf: Montagnini *et al*, 1995). Credit acquisition does not significantly affect pesticide use. There is also no clear relationship between market access and pesticide use, perhaps due to the fact that pesticides are 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

[6] *Herbicides are not used in the area.*

conditions remaining the same, a 10% improvement in market access may lead to an approximately 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 represents the indirect effects of market access, or the input effects.

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, creating awareness 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 (Von Oppen, 1978; Ijaimi, 1994).

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

Category effect	Aggregate effect	
	On input use (%)	On productivity (%)
a) Specialization effect (direct)	na	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]	na	7.48
Grand Total (a + b)	na	9.21

Notes: ( ) = derived input elasticity; na = 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 specialise 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 specialisation 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 realised 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 while 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 efficiency gains between different groups: small versus large farmers, or 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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REFERENCES

BOSERUP E (1981). *Population and technological change. Chicago*: the University of Chicago Press, USA.

COLEMAN D & YOUNG T (1989). *Principles of agricultural economics: Markets and prices in less developed countries*. WYE studies in agriculture and rural development. Cambridge University Press, UK, pp 167–262.

ELLIS F (1993). *Peasant economics: Farm household and agrarian development.* Second Edition. WYE Studies in agricultural and rural development. Cambridge University Press, UK, pp 18-44.

FREEMAN HA & SALIM SS (2002). *Commercialisation of smallholder irrigation: The case of horticultural crops in semi-arid areas of eastern Kenya*. In: Sally H & Abernethy CL (eds), Private irrigation in sub-Saharan Africa. Proceedings of the Regional Seminar on Private Sector Participation and Irrigation Expansion in sub-Saharan Africa, 22–26 October, 2001, Accra, Ghana, pp 185–192.

GOVERNMENT PRESS, REPUBLIC OF KENYA (1996). *District Development Plan, Machakos District, Eastern Province, Kenya*, pp 29-95.

GREENE WH (1993). *Econometric analysis*. Second Edition. Prentice Hall International, Inc., Englewood Cliff, New Jersey, pp 486-498.

GUJARATI DN (1995). *Basic econometrics.* McGraw-Hill International Economic Series. Third Edition. New York.

HAYAMI Y (1997). *Development economics: From poverty to the wealth of nations*. Claredon Press, Oxford, pp 35-48.

IJAIMI AAM (1994). *Efficiency and equity effects of market access on agricultural productivity in Sudan: A case study of smallholders along the River Nile, North of Khartoum.* PhD Dissertation, Department of Agricultural Economics, University of Hohenheim, Stuttgart, Germany.

KAMARA AB (1997). *Die Auswirkung des Marktzugangs auf die Landwirtschaftlice Produktivität und Inputeinsatz in Machakos Distrikt, Kenia*. MSc Thesis, University of Hohenheim, Stuttgart, Germany, pp 30-48.

KAMARA AB & VON OPPEN M (1999). Efficiency and equity effects of market access on agricultural productivity: The case of small farmers in Machakos

District, Kenya. *Quarterly Journal of International Agriculture* 38(1):65–77.

KENNEDY P (1998). *A Guide to Econometrics*. Fourth Edition. Blackwell Publishers.

KOUTSOYIANNIS A (1977). *Theory of econometrics: an introductory exposition of econometric methods*. Second Edition, Reprint 1993. Macmillan, pp 48-68; S.340-376; pp 471-478.

MAKANDA DW (1987). *Managing Kenya's agricultural sector to the year 2000 and beyond*. Workshop on Kenya's industrial and agricultural strategies towards the year 2000. Nairobi, 21-25th September 1987, pp 17-29.

MONTAGNINI F, FANZERES A & GUIMARAES DA VINHA S (1995). The potential of 20 indigenous tree species for soil rehabilitation in the Atlantic forest region of Bahia, Brazil. *Journal of Applied Biology* 32:841-854.

TIFFEN M & MORTIMORE X (1994). Population growth and natural resource use: Do we need to despair of Africa? *Outlook on Agriculture 22:241.*

VON OPPEN M (1978). *The effect of interregional trade and market infrastructure on aggregate productivity*. ICRISAT (International Crop Research Institute for the Semi-Arid Tropics), Economic Program, Pantacheru, India.

VON OPPEN M, NJEHIA B & IJAIMI AAM (1997). Policy arena: The impact market access on agricultural productivity: lessons from India, Kenya and Sudan. *Journal of International Development* 9(1):177-131.

ZÖBISCH MA (1986). Erfassung und Bewertung von Bodenerosionsprozessen auf Weideflächen im Machakos-Distrikt von Kenia. Der Tropenlandwirt. *Journal of Agriculture in the Tropics and Subtropics* 27:4–27. Special Issue. Witzenhausen, Germany.