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Efficiency and profits of emerging medium-scale farms in Africa

Evidence from Ethiopia's commercial horticultural sector

Fantu Nisrane Bachewe and Bart Minten

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ABSTRACT

We study production practices of larger and more capital-intensive farmers ("horti-preneurs") in horticultural commercial clusters in the central Rift Valley of Ethiopia. Attracted by profitable vegetable markets, more educated farmers rent in land for vegetable production from a large number of smallholders to meet rapidly growing urban vegetable demand. We find that these horti-preneurs obtain more than double the profit per unit of land compared to smallholders. Compared to smallholders, horti-preneurs grow different vegetables – particularly those that require more upfront investments – and in the case that they grow the same crops as smallholders, we find that they use significantly more inputs, such as fertilizer, agro-chemicals, and labor; have higher production costs; and obtain better yields. Moreover, they are also more efficient and able to produce better quality vegetables and obtain better prices. This increasing emergence of more efficient medium-scale farmers in supplying local urban markets challenges the traditional smallholder model in Africa, at least for horticulture.

1. INTRODUCTION

Upscaling is seen as part of the transformation process in economies overall and in agriculture in particular. It has been argued that increasing factor costs (especially of labor) and economies of scale – as well as changing demands by customers for uniform quality and food safety – lead to more capital-intensive agriculture and to larger farms. Such transformation processes have been documented in both developed and developing countries (Rozelle and Swinnen 2004; Hayami and Ruttan 1971; Cochrane 1979; Eastwood et al. 2010). These processes are often also seen in other parts of the agri-food system, such as in the wholesale and retail sectors (e.g. Reardon et al. 2003, 2012).

Some have argued that such upscaling might be a desired development in Africa as bigger farms might be able to achieve higher productivity and be more efficient. They might, therefore, be crucial to assure that enough food is available for the ever-growing population of the continent (Collier and Dercon 2014; Dercon and Gollin 2014). However, evidence in developing countries, and in Africa in particular, on upscaling is thin (e.g. Reardon et al. 2009). This might be because of a lack of incentives for upscaling given presumed inverse relationships between productivity and farm size in these settings (e.g. Hazell et al. 2010). However, new evidence is emerging that upscaling is happening rapidly in selected areas in Africa (Jayne et al. 2016, 2019; Sitko and Jayne 2014), driven by rapidly increasing urban demand (AGRA 2019) and by inverse relationships that do not hold for larger farm operations (Muyanga and Jayne 2019).

We look at this issue in Ethiopia, the second most populous country in Africa. Ethiopia has a smallholder dominated agricultural economy. The average farm size is estimated to be around one hectare, with average farm sizes having rapidly declined over the last decades due to rural population growth and limited land expansion possibilities (Dorosh and Minten 2020). While attracting large-scale investors in the agricultural sector in the country has been a stated objective of the Ethiopian government, successes have been limited with little evidence of successful investments in large-scale farming in the country (Ali et al. 2019).

In this paper, however, we document the production practices of larger and more capital-intensive farmers ("horti-preneurs") in horticultural commercial clusters in the central Rift Valley of Ethiopia. Attracted by profitable markets in Ethiopia's cities and towns, they rent in land from a large number of smallholders to meet the rapidly growing urban vegetable demand (see Minten et al. 2020). Compared to smallholders, horti-preneurs tend to grow different vegetables – particularly those that require more upfront investments. When they do grow the same crops as smallholders, we find that they use significantly more and more expensive (better) inputs, including fertilizer, agro-chemicals, and labor; obtain higher yields, have higher production costs per unit of output; are more efficient, achieve better product quality, and obtain better prices.

This increasing emergence of capital-intensive medium-scale farmers in supplying urban markets in Ethiopia adds to the growing evidence of rising numbers of medium-scale farmers across sub-Saharan Africa. However, in this case, it is happening in land-scarce settings where land markets were thought to be prohibitive for the emergence of larger farms (Holden and Ghebru 2016). We further show that these horti-preneurs outperform smallholders as measured by a number of indicators, including yields, technical efficiency, and profits, while they also receive higher output prices, possibly because of their better access to required capital and greater ability to take risk. Their emergence may challenge the traditional smallholder model for agricultural development in Africa, at least for commercial horticulture.

However, the rise in labor and rental markets in agricultural production in these settings raises issues about inclusiveness and the welfare implications of such trends. While positive effects have been shown from increased upscaling in agricultural production in some areas in Africa (Maertens and Swinnen 2009), the implications for welfare in such cases is unclear, even though important multiplier effects within the rural economy have been documented (Minten et al. 2020).

The structure of the paper is as follows. In Section 2, we describe the data collection process. Section 3 relies on farmer level data to characterize vegetable production in the study area, focusing mainly on the distinctive characteristics of smallholder and horti-preneurs. In section 4 we present results of stochastic frontier analyses conducted to study vegetable production, particularly to investigate whether there exist differences in productivity and efficiency among smallholder and horti-preneurs. We finish with conclusions in section 5.

2. DATA AND DESCRIPTIVE STATISTICS

This study uses a survey dataset purposively collected to investigate commercial vegetable farming. The survey was conducted in January and February 2020 in the East Shewa Administrative Zone in the Central Rift Valley of Ethiopia. In order to inform the sample selection and development of survey instruments, we collected preliminary information on the types of crops cultivated, input use, labor arrangements, use of irrigation, land rental, and other aspects of vegetable production from four *woredas* (districts): Dugda, Adame Tulu, Bora, and Lume. From each of these four woredas we then selected those *kebeles* (the lowest administrative unit) that had more than 100 hectares of irrigated land. This resulted in a total of 37 *kebeles*. For each *kebele*, a list of all vegetable cultivators was prepared, along with, among other information, the vegetable area they cultivate, their tenure status, and use of irrigation. Farmers in the list were divided into two groups: medium-scale tenant farmers, the horti-preneurs, that rented-in more than 0.5 hectares of land; and smallholder farmers, that cultivated vegetables mostly on their own land. Out of all farmers in each *kebele* 22 farmers were randomly selected, out of which about one-quarter were horti-preneurs.

Minten et al. (2021) report the major trends in vegetable cultivation in the surveyed villages. They estimate that the area under irrigation more than doubled over a ten-year period, that more than 60 percent of this land was rented in by horti-preneurs, and that the value of production from this commercial cluster was approximately 200 million USD in 2019, close to the value of the much-heralded flower exports from Ethiopia. Hirvonen et al. (2021) further show how the majority of the vegetable produce from the study area is marketed towards Addis Ababa, the capital and largest city in the country.

Table 2.1 uses the household level data to characterize smallholder and horti-preneur vegetable farmers. We interviewed 809 farmers. Out of these, 633 (78 percent) are smallholders. Relative to smallholder vegetable farmers, horti-preneurs are younger and better educated. Since smallholder farmers generally cultivate vegetables on their own land, while horti-preneurs temporarily rent in most of their land, we expected smallholders to be more experienced in vegetable farming. However, there exist no significant differences in experience in vegetable farming between smallholders and horti-preneurs. Similarly, we expected that horti-preneurs would have better access to credit since, as discussed later, they conduct much larger operations and use capital-intensive production techniques. However, the data reveal no statistically significant differences between smallholders and horti-preneurs in terms of access to credit, possibly because horti-preneurs, who are considerably wealthier than smallholders, can draw from their own savings, as seen in the large differences for the value of assets between smallholders and horti-preneurs.

Table 2.1: Characteristics of smallholder and horti-preneurs, averages

	unit	Smallholders	Horti-preneurs
Farmers in survey	number	633	176
Characteristics			
Age	years	41.5	38.0
Education	years	5.2	7.5
Experience in vegetable farming	years	10.3	10.3
Use of credit	%	18.8	18.8
Value of assets	Birr	120,415	492,526

Source: Vegetable Producers' Household Survey.

Table 2.2: Vegetable plot characteristics, by type of farmer

	unit	Smallholders	Horti-preneurs
Vegetable area cultivated by all farmers, total	hectare	502.8	831.0
Size farm			
Total area of vegetables cultivated	hectare	0.8	4.7
Share rented in	%	21.8	82.6
Number of plots cultivated	number	1.5	2.6
Size of plots	hectare	0.5	1.8
Vegetables area			
Tomato	hectare	1.10	3.48
Onion	hectare	0.72	2.54
Cabbage	hectare	0.41	0.96
Green pepper	hectare	0.35	1.60
Ethiopian kale	hectare	0.37	0.58
Soil fertility			
Fertile	%	67.8	48.9
Moderate	%	30.4	48.9
Infertile	%	1.8	2.3
Characteristics of land			
Distance from lake	minutes	38.9	28.0
Distance from river	minutes	40.4	28.6
Distance from road [dry season]	minutes	9.1	6.7
Distance from road [all-weather]	minutes	11.9	8.4
Distance from road [asphalt/tar]	minutes	28.3	12.1
Type of irrigation used			
Irrigated from lake	%	39.0	40.6
Irrigated by river	%	23.9	16.1
Irrigated from pond	%	1.6	0.9
Irrigated by well	%	35.5	42.5

Source: Vegetable Producers' Household Survey.

In Table 2.2 we present data on size and quality of land, and the proximity of the plots under production to irrigation water sources and to different types of roads. The vegetable area cultivated by horti-preneurs accounted for over 62 percent of the total vegetable area cultivated by our sample of farmers – a share nearly three times larger than the share they make up of the total number of farmers. The vegetable area cultivated by an average horti-preneur (4.7 hectares) is nearly six times the vegetable area cultivated by an average smallholder (0.8 hectares). Over four-fifths of the land cultivated by horti-preneurs is rented in, while this proportion is only about one-fifth for smallholders (Table 2.2).

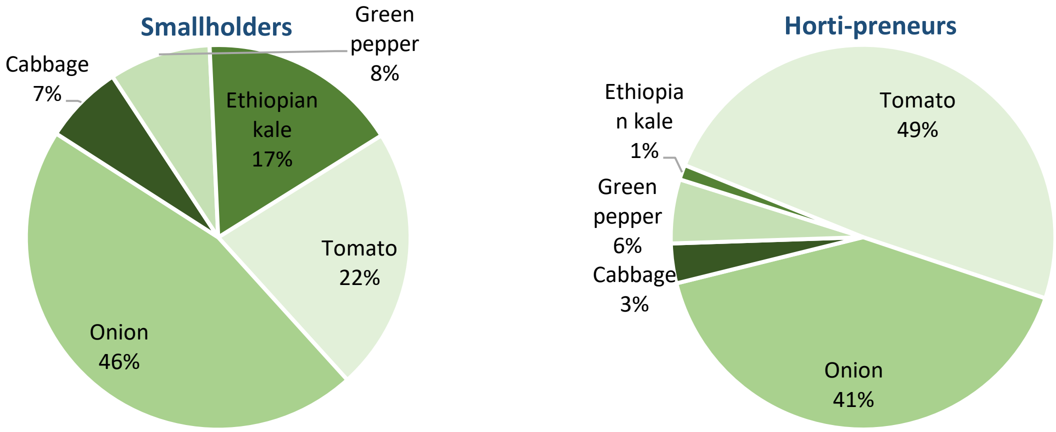
Furthermore, an average horti-preneur cultivated 2.6 plots with an average size of 1.8 hectares. Not only do horti-preneurs cultivate more plots, but the average size of the plots they cultivate is over three times the average size cultivated by smallholders.[1] That horti-preneurs cultivate considerably larger plots/parcels has important implications on land management, input use, and time needed to travel between plots/parcels.

According to the subjective evaluation of the farmers, horti-preneurs do not rent in better quality land. The proportion of smallholders' land that is considered fertile (68 percent) is considerably higher than for horti-preneurs (49 percent). That horti-preneurs cultivate less fertile lands together with their higher productivity, which we discuss below, indicates the considerable gap in productivity between horti-preneurs and smallholders in this vegetable production cluster.

Out of the plots cultivated by horti-preneurs and smallholders, about the same proportion use lake water as their irrigation source. Using the usual form of transportation, it takes about 40 minutes from an average plot cultivated by smallholders to get to a water source, while this is less than 30 minutes for plots cultivated by horti-preneurs. Furthermore, it takes 26, 29, and 57 percent less time for horti-preneurs to get to the nearest dry weather, all weather, and asphalted road, respectively. Horti-preneurs cultivate plots that may not be more fertile than those cultivated by smallholder, but the plots are better located with respect to water resources and to roads. The distance of plots to these irrigation sources have important implications on the initial investments needed for irrigation systems and on their running costs. Moreover, the location of farms relative to roads has possible implications on costs of production or on output prices.

Finally, medium scale horti-preneurs grow different vegetables than do smallholders. Figure 2.1 shows the share of different vegetables out of the total area cultivated for each group. Half of the total horti-preneurs' area is sown to tomatoes, which, as discussed below, is one of the costliest vegetables to produce. In contrast, the share of tomato in the total area in which smallholders produce vegetables is only 22 percent. The proportion of smallholders' and horti-preneurs' area cultivated to onion are close to each other at 41 percent and 46 percent, respectively, while green pepper is the other vegetable allocated similar proportions of the vegetable area of smallholders and horti-preneurs. With 17 percent of smallholders' vegetable area under Ethiopian kale, which is the least costly vegetable to grow and is mostly considered as a 'poor people's' food in Ethiopia, smallholders allocate more than 10 times the share of their land under vegetables than do horti-preneurs for the crop.

Figure 2.1: Share of vegetables in total vegetable area, by type of farmer



Source: Vegetable Producers' Household Survey.

[1] A plot is roughly defined as a piece of land under the same crop, mix of crops, or any other form of land use, while a parcel is any landholding entirely surrounded by land not held by the landholder. A parcel may consist of one or more plots adjacent to each other. In this respect, an average horti-preneur cultivated 2.1 parcels with an average area of 2.2 hectares, while an average smallholder cultivated 1.3 parcels with an average area of 0.6 hectares.

3. PRODUCTIVITY AND PROFITS

3.1. Total production, productivity, and costs of production

Table 3.1 summarizes the data on aggregate vegetable production among farmers surveyed. About 43,600 metric tons of vegetables was produced during the 12 months prior to the survey, out of which tomato accounted for 58 percent, followed by onion at 27 percent. Aggregate tomato output is higher than double the onion outputs, despite the larger area under onion, implying that tomato yields are considerably higher. Each of the remaining three vegetables accounted for 6 percent or less of total vegetable output

Table 3.1: Vegetable production, by type of vegetable and farmer

	Total output (thousand MT)			Share out of vegetable output (%)			Share out of farmer output (%)		
	Small-holders	Horti-preneurs	All farmers	Small-holders	Horti-preneurs	All farmers	Small-holders	Horti-preneurs	All farmers
All vegetables	13.3	30.3	43.6	30.5	69.5	100.0	100.0	100.0	100.0
Tomato	4.8	20.6	25.3	18.8	81.2	100.0	36.0	67.9	58.2
Onion	4.5	7.4	11.9	37.9	62.1	100.0	34.1	24.5	27.4
Cabbage	1.2	1.2	2.4	49.0	51.0	100.0	8.8	4.0	5.4
Green pepper	0.5	0.8	1.3	37.6	62.4	100.0	3.7	2.7	3.0
Ethiopian kale	2.3	0.3	2.6	88.9	11.1	100.0	17.4	0.9	6.0

Source: Vegetable Producers' Household Survey.

Horti-preneurs, who account for 22 percent of farmers in the study and for 62 percent of the area under all vegetables, accounted nearly 70 percent of total vegetables produced. This suggests that horti-preneurs' yields are higher than those of smallholders.

Table 3.2: Productivity and costs, by type of vegetable and farmer

				t-test	
	Unit	Smallholders	Horti-preneurs	t-value	Prob()
Productivity					
Overall vegetables	MT/ha	23.6	34.6	-8.3	0.00
By vegetable					
Tomato	MT/ha	36.9	51.5	-4.4	0.00
Onion	MT/ha	18.6	22.3	-4.4	0.00
Cabbage	MT/ha	31.8	41.4	-2.0	0.05
Green pepper	MT/ha	10.1	18.5	-4.9	0.00
Ethiopian kale	MT/ha	29.1	29.2	0.0	0.99
Average costs					
Overall vegetables	Birr/ha	91,116	158,640	-16.5	0.00
By vegetable					
Tomato	Birr/ha	190,614	235,785	-6.9	0.00
Onion	Birr/ha	119,208	131,537	-4.9	0.00
Cabbage	Birr/ha	63,136	71,862	-1.6	0.11
Green pepper	Birr/ha	63,008	128,480	-8.2	0.00
Ethiopian kale	Birr/ha	32,199	40,667	-2.3	0.02

Source: Vegetable Producers' Household Survey.

We present average vegetable yields and costs of production in Table 3.2.[2] Horti-preneurs' yields are shown to be higher than yields of smallholders for all vegetables. At 51.5 MT/ha, tomato

[2] Data on gross production costs summarized in Table 3.2 were collected by asking for information on gross production costs from each farmer, as opposed to summing different reported components of their production costs.

yields of horti-preneurs are nearly 40 percent higher than those of smallholders, while onion and cabbage yields are 20 and 30 percent higher, respectively. Horti-preneurs' green pepper yields are 82 percent higher than smallholders' yields, while there was no statistically significant differences in Ethiopian kale yields.

The lower panel of Table 3.2 presents data on production costs per hectare for the different vegetables. It shows significant differences in production costs for horti-preneurs and for smallholders as well as between vegetables. Average per hectare production costs of horti-preneurs are almost 75 percent higher than the production costs of smallholders. This is partly driven by the different crop mix of horti-preneurs than of smallholders. Production costs are highest for tomato and onions, products that horti-preneurs specialize in, and lowest for Ethiopian kale, which is mostly grown by the smallholders.

However, differences are substantial and often significant when comparing the same vegetables. Tomato producing horti-preneurs on average spend nearly 236,000 birr (8,105 US dollars)[3] per hectare, which is about 24 percent higher than the average spending of smallholders. Similarly, per hectare costs of production of horti-preneurs are 10 to 26 percent higher than that of smallholders for onions, cabbage, and Ethiopian kale, while green pepper production costs are more than two times higher for horti-preneurs than for smallholders.

3.2. Profits

In Table 3.3, we summarize total and per hectare profits and vegetable prices for smallholders and horti-preneurs.

Table 3.3: Prices, profits, and profitability, by type of vegetable and farmer

				t-test	
		Smallholders	Horti-preneurs	t-value	Prob()
Price obtained					
Tomato	Birr/kg	9.2	10.2	-2.0	0.04
Onion	Birr/kg	11.3	12.7	-3.8	0.00
Cabbage	Birr/kg	4.6	4.0	1.3	0.20
Green pepper	Birr/kg	16.4	18.6	-1.6	0.12
Ethiopian kale	Birr/kg	4.1	4.8	-0.4	0.70
Profits					
Overall vegetables	Birr	58,326	528,301	-14.3	0.00
By vegetable					
Tomato	Birr	180,136	847,983	-5.6	0.00
Onion	Birr	61,088	484,609	-8.9	0.00
Cabbage	Birr	24,890	82,555	-5.0	0.00
Green pepper	Birr	32,504	178,644	-2.6	0.01
Ethiopian kale	Birr	25,810	37,689	-1.3	0.20
Profitability					
Overall vegetables	Birr/ha	79,917	180,439	-12.0	0.00
By vegetable					
Tomato	Birr/ha	121,160	273,593	-5.5	0.00
Onion	Birr/ha	78,131	148,735	-8.4	0.00
Cabbage	Birr/ha	56,219	76,189	-1.3	0.18
Green pepper	Birr/ha	82,871	125,859	-1.3	0.19
Ethiopian kale	Birr/ha	70,913	63,822	0.4	0.69

Source: Vegetable Producers' Household Survey.

[3] Calculated at average daily exchange rate in 2019 of 29.09 birr per US dollar.

We find that prices of different vegetables are markedly different, but that prices received by smallholders and horti-preneurs for a given vegetable are not far apart. For instance, cabbage prices are among the cheapest at 4.6 birr/kg for smallholders and 4.0 birr/kg for horti-preneurs, while green pepper prices are the highest at 16.4 birr/kg for smallholders and 18.6 birr/kg for horti-preneurs. Prices received by an average horti-preneur are higher for all vegetable types except for cabbage, although the difference is statistically significant only for tomato and onion.

Despite relatively small price differences, profits for horti-preneurs are considerably higher than those obtained by smallholders (Table 3.3). Farmers that cultivate tomato have the highest profits followed by those that grow onions. Both of these crops are more likely to be cultivated by horti-preneurs. Even if they grow similar crops, the results of our t-tests indicate that gross profits of horti-preneurs are statistically significantly higher than those of smallholders for all vegetables except Ethiopian kale. Between crops, smallholder (horti-preneur) farmers that cultivated tomato have nearly three (two) times the gross profits of onion farmers, who have the next highest gross profits.

An average horti-preneur had a gross profit of 528,000 birr (18,161 USD), over nine times the average profit of 58,000 birr (2,005 USD) of smallholder vegetable farmers. Profits per hectare of an average horti-preneur (180,000 birr/ha or 6,200 USD/ha) are nearly 126 percent higher than those of smallholders. These higher profits are partly driven by crop choices, as horti-preneurs focus on those crops for which profits are higher. Even if they grow the same crop, profits for horti-preneurs are generally higher, but only significantly so for tomato and onions.

Finally, in Table 3.4 we summarize the share of total output of vegetables that was graded as best, medium, or poor quality; the yields obtained for each quality grade; and the average prices received for each quality grade.

Table 3.4: Quality of harvest, by type of vegetable and farmer

	Smallholders				Horti-preneurs			
	Best	Medium	Lower	Overall	Best	Medium	Lower	Overall
Share in output (%)								
Tomato	59.2	38.6	2.2	100.0	68.6	27.9	3.5	100.0
Onion	52.1	42.6	5.3	100.0	62.7	33.9	3.4	100.0
Cabbage	55.7	40.5	3.8	100.0	49.3	46.7	4.0	100.0
Green pepper	55.7	40.6	3.8	100.0	72.1	24.3	3.6	100.0
Ethiopian kale	55.3	42.9	1.8	100.0	72.2	27.8	0.0	100.0
Yields (MT/ha)								
Tomato	26.0	11.9	0.2	37.1	39.6	15.5	1.6	52.3
Onion	11.7	7.5	0.6	18.6	16.9	8.5	0.9	22.3
Cabbage	20.7	9.9	1.1	31.2	18.9	21.0	1.0	41.3
Green pepper	6.2	4.0	0.2	10.1	13.4	4.9	0.4	18.5
Ethiopian kale	18.1	11.1	0.1	29.0	22.5	6.7	0.0	29.2
Average price (birr/kg)								
Tomato	9.8	9.4	5.0	9.2	10.7	9.5	9.0	10.2
Onion	11.6	10.9	10.0	11.3	13.5	11.5	11.1	12.7
Cabbage	4.8	4.4	3.4	4.6	3.9	3.4	1.5	4.0
Green pepper	16.9	16.0	15.6	16.4	21.0	20.3	12.0	18.6
Ethiopian kale	4.7	4.6	3.0	4.1	5.3	3.4	-	4.8

Source: Vegetable Producers' Household Survey.
Note: Vegetable yields in this table differ slightly from those in Table 5.2 due to differences in levels of aggregation.

Three findings can be highlighted. First, most of the produce of both smallholders and horti-preneurs is graded as best quality. Second, a relatively higher proportion of horti-preneurs' produce is graded as best quality – shares in total outputs of vegetables graded as best quality are higher for horti-preneurs than for smallholders for all vegetables except cabbage. Third, as expected, prices generally increase with the quality of the produce. The average vegetable prices received by horti-preneurs, and consequently their profitability, are relatively higher than for smallholders because most of their produce is of higher quality.

The higher prices received by horti-preneurs and the greater profitability they realize compared to smallholders reflects in part differences between horti-preneurs and smallholders in the quantity and the quality of inputs used as well as in the efficiency in the use of these inputs. We turn to this issue now.

4. PRODUCTIVITY AND TECHNICAL EFFICIENCY: ECONOMETRIC ANALYSES

In this section, we present results of a stochastic frontier analyses (see Kumbhakar and Knox Lovell 2000) conducted to investigate factors associated with vegetable yields (value of output per hectare), farmers' level of technical efficiency, and factors associated with technical efficiency. Consider a stochastic vegetable production frontier:

$$Y_{hp} = F\left(X_{hp}, T_h, \beta\right) = f(X_{hp}, T_h, \beta) \cdot exp\ (V_{hp} - U_{hp}) \tag{1}$$

where Y_{hp} is vegetable type p yields of farmer h produced using a vector of inputs represented by X_{hp}. T_h represents a vector of locational and farmer specific factors, including a *woreda* dummy as well as a dummy variable that takes a value of 1 if the farmer is an horti-preneur. β is a vector of production function parameters. The *composed error term*, $\exp\left(V_{hp} - U_{hp}\right)$, captures the underlying hypothesis of stochastic frontier analyses on the two causes of differences in yields/value of output. In equation (1), the *deterministic component*, $f(X_{hp}, \mathrm{T}_h, \beta)$, is uniform, while $\exp\left(V_{hp} - U_{hp}\right)$ varies across *h* and *p*. According to this method, farmer *h*'s technical efficiency (TE_{hp}) relative to farmer *k* that produces the optimal yield, Y^*, is given as

$$TE_{hp} = \frac{Y_{hp}}{Y^*} = \frac{f(X,T,\beta) \cdot exp\ (V_{hp} - U_{hp})}{f(X,T,\beta) \cdot exp\ (V_{kp} - U_{kp})} = exp\ (-U_{hp}) \tag{2}$$

$TE_{hp} \leq 1$ and declines with increases in the technical inefficiency component, U_{hp}, which is assumed to be a function of crop, household, and location specific variables, Z_{hp}, and a vector of unknown parameters, δ. The technical inefficiency effects model associated with (1) is then specified as:

$$U_{hp} = Z_{hp}\delta + W_{hp} \tag{3}$$

Under certain assumptions on V_{hp} and U_{hp}, the parameters of equations (1) and (3) as well as TE_{hp} can be estimated simultaneously using a maximum likelihood approach. We provide estimates of the production function parameters in Table 4.1. We estimate the stochastic production frontiers using as dependent variables the value of output per hectare and physical yields (quantity of output per hectare) using the aggregate (pooled) data as well as separately for smallholders and horti-preneurs.

Table 4.1: Estimates of stochastic vegetable production frontiers, by type of farmer

Variable	Dependent variable: Value of output/ha			Dependent variable: Yield		
	Aggregate	Smallholder	Horti-preneur	Aggregate	Smallholder	Horti-preneur
Labor, person days per ha (log)	0.088***	0.100***	0.064***	0.058***	0.065***	0.048***
	(0.016)	(0.024)	(0.021)	(0.011)	(0.014)	(0.015)
Fertilizer, kgs per ha (log)	0.042***	0.048***	0.002	0.027***	0.035***	-0.021
	(0.010)	(0.011)	(0.023)	(0.009)	(0.008)	(0.017)
Fungicide, lts per ha (log)	0.007*	0.009*	-0.008	0.005*	0.012***	-0.008
	(0.004)	(0.005)	(0.007)	(0.003)	(0.003)	(0.005)
Insecticide, lts per ha (log)	0.012**	0.012*	0.015**	0.013***	0.013***	0.018***
	(0.005)	(0.006)	(0.007)	(0.003)	(0.004)	(0.005)
Seeds/seedlings, per ha (log)	0.021***	0.018*	0.030**	0.011*	0.020***	0.002
	(0.008)	(0.009)	(0.013)	(0.006)	(0.007)	(0.009)
Seed type (=1 if hybrid)	0.251***	0.191**	0.514***	0.053	0.032	0.127*
	(0.056)	(0.076)	(0.075)	(0.045)	(0.054)	(0.070)
Variable cost of irrigation per ha (log)	0.037***	0.046***	-0.004	0.022***	0.030***	-0.006
	(0.006)	(0.007)	(0.017)	(0.004)	(0.005)	(0.012)
Soil quality (=1 if fertile)	0.117***	0.095*	0.111*	0.100***	0.137***	0.044
	(0.036)	(0.049)	(0.058)	(0.026)	(0.033)	(0.041)
Farmer type (=1 if horti-preneur)	0.162***			0.113***		
	(0.060)			(0.038)		
Vegetable type dummy	Yes	Yes	Yes	Yes	Yes	Yes
District/Woreda dummy	Yes	Yes	Yes	Yes	Yes	Yes
Constant	12.138***	11.626***	12.500***	5.724***	5.600***	6.512***
	(0.186)	(0.211)	(0.250)	(0.137)	(0.157)	(0.267)
Gamma	0.868	0.782	0.831	0.909	0.920	0.910
Log-Likelihood	-1,501	-1,073	-424	-1,117	-782	-274
LR test of one-sided error	240	144	68	442	337	140
Number of observations	1,417	958	459	1,417	958	459

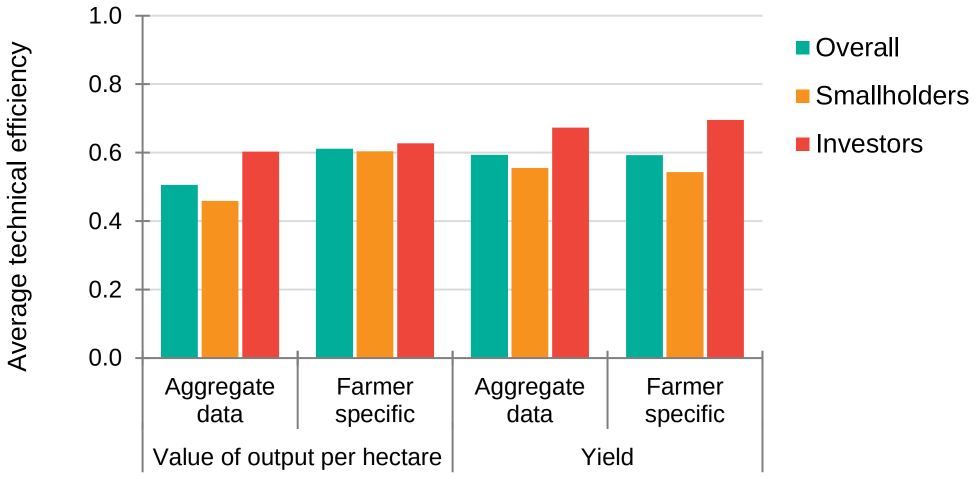
Source: Vegetable Producers' Household Survey.
Notes: Numbers in parentheses are standard errors. Significance of coefficients indicated with *** (1%), ** (5%), and * (1%).

The log-likelihood ratio test is used to check whether the stochastic frontier analysis is an appropriate method. This test has the null hypothesis of a Cobb-Douglas production function (H_0: $U_{hp} = 0$, for all *h* and *p*). The one-percent critical value of this test is 46.98. The smallest test statistic we obtained across our models is 68, indicating that stochastic frontier analysis is an appropriate method to deploy on the data. Moreover, this result is corroborated by the estimates of gamma, which gauges the share of total variation explained by the inefficiency component (or $\gamma = \sigma_U^2/(\sigma_U^2 + \sigma_V^2)$). The estimates indicate that 78 to 92 percent of the variation in the composed error term is due to inefficiency.

Most of the production frontier parameters in Table 4.1 show the expected positive signs, but not all are significant. Labor use is significantly and positively associated with yields for all specifications. It has higher values for the value of output regressions compared to physical yields, indicating that returns to labor are higher when measured in value than in physical outputs. Quality of land has one of the higher elasticities – fertile lands produce 10 and 12 percent higher yields and value of output, respectively. Application rates of all modern inputs (fertilizers, fungicides, insecticides, use of improved/hybrid seeds, and irrigation) are all positively associated with yields. Application rates of fertilizers, fungicide, and irrigation, however, are not statistically significant in the horti-preneur subsample, perhaps because of the considerably higher or over-use of these inputs by horti-preneurs, but also possibly because of the large heterogeneity in these products – particularly for fungicides and insecticides, liters used might be an imperfect unit of measure.

The constant/intercept term, together with the estimate of farmer type dummy, take special significance in these analyses. Comparison of estimates of constant terms of the smallholder and horti-preneur subsample models, respectively, indicate that horti-preneur's production frontiers have higher intercepts or envelope smallholders' production frontiers from above. These results imply that, compared with smallholder farmers, horti-preneurs operate at a superior production frontier or have higher levels of total factor productivity.

Figure 4.1: Average technical efficiency of vegetable farmers, by type



Source: Vegetable Producers' Household Survey.

In Figure 4.1 we summarize estimates of vegetable farmers' technical efficiency (TE) from the six production frontiers estimated in Table 4.1.[4] Three observations can be made. First, the TE averaged 0.59 in the aggregate subsample using yields as dependent variable. This implies that an average vegetable farmer in our sample is only 59 percent technically efficient relative to optimal farmers (who would have a TE of 1.0). Second, relative to an average smallholder, an average horti-preneur is more technically efficient. At a TE of 0.67 (aggregate data/yield) an average horti-preneur is nearly 21 percent more technically efficient than an average smallholder, who has an average TE of 0.56. Out of observations with TE estimates of 0.1 or less (0.9 or higher) horti-preneurs accounted for 8.7 (40.4) percent, indicating the superior performance of horti-preneurs in TE. Third, average TE estimates obtained from value of output per hectare are lower relative to estimates obtained from yields because of the higher variation in value of outputs, which, as indicated earlier, includes the effect of prices and quality differences of output. The results indicate that TE differences in this case of horti-preneurs compared to smallholders becomes even larger with horti-preneurs being 31 percent more technically efficient when measured in value terms.[5,6]

We provide estimates of the inefficiency equation parameters in columns 2 to 7 of Table 4.2, which are estimated simultaneously using the corresponding production frontiers from Table 4.1. The results provide the type and degree of association of each factor with levels of inefficiency

[4] Note that TE estimates obtained from production frontiers estimated using each of the subsamples compare farmers in that subsample. Consequently, the summary should be interpreted within that context. To compare the relative performance in TE of an average smallholder and horti-preneur farmer we look at *Aggregate data* results, while we look at *Farmer specific* results to compare smallholders/horti-preneurs amongst themselves.

[5] A simple way to view this is to compare the constant terms/intercepts of the production frontiers obtained using value of output per hectare with those obtained using yields. The former are at 2.2 to 3.0 times higher relative to the latter. This roughly implies that the average distance between the points farmers operate and the production frontiers (U_{hp}) is relatively higher and TE is lower in equations using value of output per hectare as the dependent variable.

[6] Performance in TE of both smallholders and horti-preneurs is higher in *farmer specific* equations relative to corresponding estimates in aggregate data equations. This is because TE estimates obtained from *farmer specific* equations compare smallholders/horti-preneurs only amongst themselves.

(U_{hp}). The factors expected to be positively associated with technical efficiency ($\exp(-U_{hp})$) are expected to have a negative sign and vice versa.

Table 4.2: Factors explaining vegetable production technical efficiency, by type of farmer

	Dep. variable: Value of output/ha			Dep. variable: Yield		
Variable	Overall	Small holder	Horti-preneur	Overall	Smallholder	Horti-preneur
Farmer characteristics						
Gender of head of household	0.266	0.303	0.978	0.280	0.278	1.811
	(0.209)	(0.331)	(1.253)	(0.208)	(0.202)	(2.031)
Age of head of household	0.012***	0.017**	0.034***	0.017***	0.010***	0.047***
	(0.004)	(0.007)	(0.013)	(0.004)	(0.004)	(0.018)
Head education	-0.031	-0.005	0.068	0.008	-0.017	0.071
	(0.040)	(0.067)	(0.086)	(0.041)	(0.044)	(0.095)
Household size	0.008	0.024	0.083*	0.011	-0.013	0.046
	(0.019)	(0.031)	(0.044)	(0.019)	(0.020)	(0.050)
Household wealth index	-0.141***	-0.214***	-0.168**	-0.152***	-0.143***	-0.115
	(0.028)	(0.066)	(0.083)	(0.030)	(0.029)	(0.085)
Tropical livestock units	-0.006	-0.003	-0.026*	-0.004	0.003	-0.019
	(0.007)	(0.012)	(0.016)	(0.007)	(0.008)	(0.016)
Farmer type (=1 if horti-preneur)	-0.058	-	-	0.034	-	-
	(0.181)	-	-	(0.164)	-	-
Land management, risk, and shocks						
Experience cultivating vegetables (years)	-0.010*	-0.008	-0.045**	-0.003	-0.001	-0.033*
	(0.005)	(0.008)	(0.018)	(0.005)	(0.005)	(0.018)
Area in ha (log)	-0.222***	0.092	-0.472***	-0.132**	-0.048	-0.467**
	(0.065)	(0.130)	(0.146)	(0.065)	(0.076)	(0.197)
Percent of rented-in land	-0.001	-0.003	0.003	0.000	-0.002	0.006
	(0.001)	(0.003)	(0.003)	(0.001)	(0.002)	(0.004)
Percent of vegetable sold	-0.007**	-0.014***	-0.003	-0.011***	-0.011***	-0.005
	(0.003)	(0.005)	(0.007)	(0.003)	(0.003)	(0.008)
Plot affected by drought or excess rainfall	0.330***	0.451**	0.480*	0.232**	0.351***	0.174
	(0.103)	(0.177)	(0.283)	(0.099)	(0.105)	(0.292)
Plot suffered from diseases	0.166*	0.347**	0.276	0.238***	0.281***	0.125
	(0.085)	(0.161)	(0.192)	(0.087)	(0.091)	(0.207)
Access to services						
Household taken out a loan	0.116	0.105	-0.074	-0.014	-0.011	-0.145
	(0.101)	(0.165)	(0.228)	(0.102)	(0.108)	(0.251)
Applied extension information	0.192*	0.132	0.174	0.163	0.058	0.090
	(0.108)	(0.175)	(0.254)	(0.108)	(0.114)	(0.268)
Applied non-extension info	-0.086	-0.066	0.156	-0.116	-0.143	0.163
	(0.106)	(0.162)	(0.242)	(0.106)	(0.110)	(0.258)
Distance to nearest cooperative selling inputs	0.000	0.002	-0.008	0.001	0.001	-0.007
	(0.001)	(0.002)	(0.006)	(0.001)	(0.001)	(0.006)
Constant	1.334***	0.070	-1.454	0.594	1.426***	-2.834
	(0.451)	(0.793)	(1.691)	(0.454)	(0.434)	(2.766)

Source: Vegetable Producers' Household Survey.
Notes: Numbers in parentheses are standard errors. Significance of coefficients indicated with *** (1%), ** (5%), and * (1%).

Unlike findings in other studies (e.g., Bachewe et al. 2015) demographic factors, except for age of the farmer, appear not to be associated with technical efficiency. The sex of the farmer is not significant, perhaps because of little variation in this dataset, with less than 5 percent of the vegetable farmers being female, significantly lower than the over 20 percent of household heads being female in rural Ethiopia. Similarly, household size is insignificant, likely because family labor plays little role for labor provision among these vegetable farmers. Farmers' age is positively and strongly associated with inefficiency, implying that TE declines with farmers' age. We expected education to be positively associated with efficiency given the higher variation of the variable in this dataset. However, the association of farmers' age and TE may also incorporate the effect of education on TE.[7]

Consistent with our expectations, the household wealth index is positively associated with TE. That is, in addition to the higher liquidity that wealthier households have, which works through higher levels of inputs used, there appears to be other unobservable factors, such as better information sources and knowledge, through which wealthier households can achieve higher TE.[8] While tropical livestock units, which normalizes the number of livestock households owned in camel terms, is expected to have an association similar to that of household wealth with TE, this holds in only one of the six equations.

Several variables characterizing farmers' land management, risk, and shock are associated with technical efficiency. Experience (number of years) with cultivating vegetables is positively associated with TE. As might have been expected, farmers adversely affected by drought, excess rainfall, or diseases have lower TE. Land size is positively associated with TE, implying that TE generally increases with cultivated area. TE appears to be unassociated with percent of rented-in land, given the estimate of the parameter for the variable is significant in only one of the equations (at 10 percent) and the magnitude is nearly zero.

The TE of vegetable producers is generally not associated with access to services. Farmers' access to credit and access to and application of non-extension information are not associated with TE, while application of extension information has the wrong sign in the value of output equations. Proximity to nearest cooperatives that also sell inputs is positively associated (at 10 percent) in only one of the value of output per hectare equations, with the magnitude being close to zero.

Finally and importantly, we find that TE is not associated with whether or not the farmer is a horti-preneur. That is, relative to an average smallholder, an average horti-preneur has higher TE, but this is explained by and associated with other factors and not as a result of being an horti-preneur. This might suggest that, if it were possible to provide similar access to know-how, output markets, and/or capital to smallholder vegetable farmers, they would be able to obtain similar levels of efficiency as horti-preneurs.

5. CONCLUSIONS

In Ethiopia, we note an increasing importance of medium-scale tenant farmers in horticulture who are increasingly supplying vegetables to rapidly growing urban markets. This seemingly is surprising, given declining farm sizes in the country and a widely acknowledged inverse farm size – productivity relationship. Based on detailed data from more than 800 horticultural farmers, we see that medium-scale tenant farmers (horti-preneurs) have significantly higher profitability per unit of land. We estimate that their profits per hectare are more than twice the level of profit of smallholders producing vegetables. We find that these higher profits are explained by two main factors.

First, horti-preneurs are more productive and efficient. While they use more inputs and face higher production costs than smallholders, they, however, are able to use these inputs more efficiently, as shown by significantly higher technical efficiencies. This is linked to horti-preneurs

[7] Age and education of farmers have a statistically significant (at 1 percent) correlation coefficient of -0.4 whereby the average age of illiterate farmers is 15 years higher than the average age of farmers with secondary education.

[8] Furthermore, wealth index is positively correlated with farmers' education (with correlation coefficient of 0.38).

being younger, more educated, wealthier, and with larger areas of land under vegetable production, as shown by significant associations of those characteristics with efficiency. We find overall that an average farmer obtains less than 60 percent of the yields of farmers operating optimally at the production frontier. However, relative to an average smallholder, an average horti-preneur is more technically efficient. At a level of technical efficiency of 0.67, an average horti-preneur is nearly 21 percent more technically efficient than an average smallholder, who has an average technical efficiency of 0.56. Higher input use and significantly higher technical efficiency lead to higher outputs per unit of land.

Second, horti-preneurs are able to produce higher quality produce and, as they are able to produce larger quantities, they are able to obtain significantly higher prices in markets. Moreover, they are able to sell their produce in better rewarding markets. This, therefore, makes the difference in efficiency when measured in value terms even higher, at 31 percent.

These significantly higher profits and efficiencies by these horti-preneurs seemingly explain the rapid growth of this type of farmer in commercial horticultural production in Ethiopia. However, this development raises some important questions.

First, while upscaling might be efficient, lack of inclusiveness – as many of the horti-preneurs are outsiders, rather than local smallholders – in this process might create tensions in societies, as evidenced by ethnic unrest in those regions where these horti-preneurs have been successful. This might then threaten the sustainable success of such transformations. In the case studied here, we found, however, that the first wave of outside horti-preneurs has left the area, but local farmers have learned by doing and seemingly now are taking this horti-preneurial strategy forward.

Second, we only see such emerging medium-scale farming happening in horticulture and, surprisingly, not in the cereal sector. This might indicate the heterogeneity within the agricultural sector where some sectors – often characterized by high investment requirements and high volatility – will be more likely to be subject to such upscaling.

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ABOUT THE AUTHORS

Fantu Nisrane Bachewe is a Research Fellow in the Development Strategy and Governance Division (DSGD) of the International Food Policy Research (IFPRI), based in Addis Ababa, Ethiopia. **Bart Minten** is a Senior Research Fellow in DSGD of IFPRI, based in Yangon, Myanmar.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
1201 Eye St, NW | Washington, DC 20005 USA
T. +1-202-862-5600 | F. +1-202-862-5606
Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info

POLICY STUDIES INSTITUTE
P.O. Box 2479, Addis Ababa, Ethiopia
T. +251.11-550-6066; +251-11-553-8633 | F. +251-11-550-5588
http://psi.gov.et/

IFPRI–ESSP ADDIS ABABA
P.O. Box 5689, Addis Ababa, Ethiopia
T. +251-11-617-2000 | F. +251-11-667-6923
Email: ifpri-essp@cgiar.org | http://essp.ifpri.info

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