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Horticulture Exports, Agro-industrialization and Farm-nonfarm Linkages with the Smallholder Farm Sector: Evidence from Senegal

Miet Maertens¹

Abstract

In this paper we address the question of farm-nonfarm linkages at the household level for a case-study in Senegal. We examine whether increasing off-farm employment opportunities for rural households – resulting from increased horticulture exports and associated agro-industrialization – has benefitted the smallholder farm sector through investment linkages. We use data from a household survey in the main horticulture export region in Senegal. We find that access to unskilled employment in the export agro-industry has contributed to alleviation farmers' liquidity constraints, resulting in increased smallholder agricultural production.

JEL codes: J23, O12, Q12, Q17

Keywords: farm-nonfarm linkages, agri-food exports, smallholder farming, rural development

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Horticulture Exports, Agro-industrialization and Farm-nonfarm Linkages with the Smallholder Farm Sector: Evidence from Senegal

1. Introduction

Linkages between farm and nonfarm economic sectors are important in creating multiplier effects for growth and rural development (Davis et al., 2002; Delgado et al., 1998; Haggblade et al., 1988; Hazell and Roell, 1983). Many studies point to positive spillover effects from the farm sector to the rural non-farm economy (e.g. Delgado et al., 1998; Woldehana, 2002; Anriquez and Stamoulis, 2007). The effects emerge through backward and forward production linkages from agriculture to rural input suppliers and agro-processors, and through expenditure linkages as farm incomes are spent on locally produced goods and services or invested in non-farm activities (Davis et al., 2002).

However, there is much more debate on the effects of nonfarm income on agricultural production and the existence of farm-nonfarm investment linkages at the household level. On the one hand, the use of family labor off-farm reduces the availability of labor on the family farm which can lead to productivity loss and stagnating or declining agricultural incomes (Ruben and van den Berg, 2001). On the other hand, off-farm income can compensate for a lack of capital and credit, and provide the necessary cash for farm expenses, resulting in agricultural growth. It is a well-known fact that highly imperfect – or even missing – credit markets (and factor markets in general) severely constrain agricultural productivity growth in developing countries. Whether or not off-farm employment and income can alleviate these constraints and result in farm investment linkages or whether it further restricts agricultural growth remains an empirical question. Studies focusing on this question

have come to diverse conclusions (e.g. Low, 1981; Woldehana, 2002; Ruben and van den Berg, 2001).

In this paper we address the question of farm-nonfarm linkages² at the household level for a case-study in Senegal. We examine whether increasing off-farm employment opportunities for rural households – resulting from increased horticulture exports and associated agro-industrialization – has benefitted the smallholder farm sector through investment linkages. This is particularly relevant for a number of reasons. First, most studies on farm-nonfarm linkages do not differentiate between different types of off-farm income and employment. Yet, diverse off-farm activities – such as low-skilled wage labor, high-skilled labor and self-employment – might have distinct implications on farm production. In this paper we focus on one specific type of off-farm income and analyze the impact of employment in the growing vegetable export industry through farm investment linkages.

Second, horticulture is a high-value and dynamic sector, and is therefore likely to have multiple and diverse linkages (Davis et al., 2002). Horticulture is becoming an important export sector in many developing countries, including poor Sub Saharan African countries such as Ethiopia, Madagascar and Senegal. The share of horticulture products in total developing country agri-food exports has increased sharply over the past decades, from 14% in 1980 to 22% in 2000 (Aksoy and Beghin, 2005).

Third, despite the fact that a high-value and dynamic export sector such as horticulture is likely to create multiple and diverse linkages, studies on the implications of increasing horticulture exports for local farm households have focused

² In the focus on farm-nonfarm linkages the definition of what is nonfarm can vary. For the purpose of this paper, we follow Haggblade, Hazell and Brown (1988) and Hazell and Roel (1983) and define the “nonfarm” sector to include any economic activity outside the family farm, including agro-industrial production, processing and marketing.

almost exclusively on forward production linkages. Many authors have analyzed how local farm households are linked to export markets through contract-farming with the export agro-industry and have come to diverse conclusions³ (e.g. Key and Runsten, 1999; Dolan and Humphrey, 2000; Minot and Ngigi, 2004; Gulati et al., 2006; Jaffee, 2003; Minten et al., 2006). Some studies have focused on linkages in the labor market, which are increasingly important with ongoing agro-industrialization in horticulture sectors. For example McCulloh and Ota (2002) and Maertens and Swinnen (2008) find that horticulture exports create substantial employment in rural areas with direct income gains for local households. However, whether the increasing rural employment in export agro-industries is restricting growth in the smallholder farm sector – because of labor outflows – or whether it leads to agricultural growth in the smallholder sector – because of investment linkages – is still unexplored.

Fourth, this study focuses on Senegal, a poor Sub Saharan African country. Especially for such countries, the existence of farm-nonfarm linkages for rural development is important. It has been observed that in the case of Africa production linkages are limited while expenditure linkages – including consumption and investment linkages – are crucial for African rural development (Davis et al., 2002; Delgado et al., 1988; Woldehana, 2002). Our approach, with a focus on investment linkages, is in line with this observation and might contribute importantly to better understand the implications of increasing vegetable exports for rural development and the smallholder farm economy.

The paper is organized as follows. In the next section we explain the background of our case-study on increasing vegetable exports and agro-industrialization in Senegal. In section three we specify the type of data that were

³ A main debate centres on the question whether smallholders are included – mainly through production contracts – and benefit or whether they are excluded from high-value export supply chains.

collected for this study and the research area. In section four we describe the importance of nonfarm employment and income at the household level, and in section five the constraints farmers face for agricultural production. In section six we present an econometric approach to analyze farm investment linkages and discuss the results. Section seven concludes.

2. Background

Since the early 1990s, the export of horticulture products from Senegal has increased sharply; from less than 3,000 ton in 1991 to almost 16,000 ton in 2005. The sharpest growth was after 1997 when the export of French beans alone – the main export crop – increased from 3,000 ton to 7,000 ton (figure 1). Horticulture now represents the fourth main primary export sector – after phosphates, fish and peanuts – and plays an important role in Senegal's export diversification strategy. Apart from some minor volumes to neighboring countries, these exports are destined for the European Union (EU), most importantly France (40% of the exported volume), the Netherlands (35%) and Belgium (16%). Exports are mostly fresh produce and include French beans (42% of the exported volume), cherry tomato (23%), mango (16%) and some minor crops such as melon, pepper and hibiscus. Senegal actually ranks fourth as African supplier of French beans to the EU, after Morocco, Egypt and Kenya.

The growth in vegetable exports in Senegal has been associated with the development of a modern agro-industry, built by local and some foreign investors responding to profitable opportunities created by increasing demands for year-round availability of fresh vegetables and tropical fruits in EU countries. In 2005, the Senegalese horticulture agro-industry constituted 20 medium to large domestic companies exporting mainly French beans and some mango, melon and tomato from

the region *Les Niayes*; and one large multinational company exporting mainly cherry tomatoes and some French beans from the area around the Senegal River Delta.

There are specific product and process standards associated with horticulture exports to the EU – whether public requirements or corporate standards. These include for example common marketing standards, sanitary and phytosanitary measures, and traceability requirements. These standards have increased the need for large-scale operations with consistent volumes and with intensive handling / conditioning of produce after harvest – including activities such as sorting, grading, washing, cold storage, packing and labeling – and have lead to modernization of the sector and further agro-industrialization.

The horticulture export agro-industry interacts with the rural smallholder economy by sourcing part of the produce from local smallholders and by recruiting laborers from local farm households. From interviews with a dozen of exporting companies⁴ – together representing 45% of exported French beans and 82% of cherry tomatoes – we estimate that for the 2004/2005 export season, about half of the exported French beans (and none of the cherry tomatoes) was sourced from local smallholder farms. This translates into about 1,000 local farmers in the region *Les Niayes* producing French beans on contract with the agro-industry. Moreover, we estimate that the horticulture export industry employs more than 15,000 workers on the fields of agro-industrial producers and in the conditioning centers; about 12,000 in the region *Les Niayes* and 3,000 in the Senegal River Delta area.

It is clear from those figures that an important impact of the development and growth of the fruit and vegetable export agro-industry has been the creation of rural

⁴ We conducted semi-structured quantitative interviews with 11 horticulture exporting companies in April-May 2005 in “Les Niayes” and in February 2006 in the Senegal River Delta area. The interviews addressed the proprietor of the company or the manager director in case of large companies and gathered qualitative information on the developments in the export horticulture sector and quantitative firm-level data.

employment. In this paper, we further investigate whether this off-farm rural employment has created investment spillover effects on the smallholder farm sector for a case-study in the region *Les Niayes*.

3. Data collection

We organized in August – September 2005 a large household survey in the main horticulture zone *Les Niayes* – an area stretching over a width of some tens of kilometers along the coast north of *Dakar* up to *Saint Louis* and from where over 90% of exported French beans originate (Gergely, 2001). The majority of households in this area are smallholder horticulture farmers producing a large variety of vegetables – most importantly tomatoes, cabbage, onion and carrots – and some basic food crops for the local market and for direct consumption (Fall and Fall, 2000).

The research area includes three rural communities in the regions *Dakar* and *Thiès* – *Sangalkam*, *Diender* and *Noto* (figure 2) – where the horticulture agro-industry is located and where they source produce and recruit laborers from⁵. We randomly selected 25 of the 115 villages in these three communities and established a stratified random sample of 300 household in these villages. Household stratification was based on producing French beans on contract with the agro-industry and 60 of these contract-farmers were included in the sample. However, the focus of the paper is on the effects of the growing horticulture industry through labor markets and investment linkages rather than production linkages. Therefore, we use a subsample of 240 observations representing smallholders not producing French beans on contract. The sample includes 83 households with members employed in the

⁵ The employment created in the horticulture agro-industry has attracted temporary migrant workers from other regions in Senegal. Our study does not include these migrant workers and focuses only on households permanently residing in the area.

horticulture agro-industry. These were randomly drawn from the subpopulation of non-contract farmers.

The survey data – including recall data – provide details on household demographic characteristics, land and non-land asset holdings, agricultural production, off-farm employment and income, non-labor income, credit and savings; and allow calculating household net income from farm and off-farm sources.

4. Off-farm employment in the horticulture agro-industry

4.1. Participation in off-farm employment

Since the mid 1990s when vegetable exports from Senegal started to boom, the horticulture export industry has created massive employment in the research area. Among the sampled households, the share of households having one or more members employed in the horticulture agro-industry increased from 3% in 1995 to 34% in 2005. We classify households according to this employment and distinguish between agro-industrial employees – 83 households – and a comparison group of 157 households (table 1).

A comparison of the characteristics of these two groups of households (table 1) reveals that the agro-industrial employees come from households with significantly more female laborers. The horticulture agro-industry has especially attracted female workers – according to some company managers because of their “delicate fingers” in picking and handling the produce. In the sample, 94% of the household members working in the horticulture agro-industry are female. There are no significant differences in the level of education across the two groups of households, indicating that employment in the agro-industry does not require specific skills or experience. This is in line with other studies pointing out that agro-industrialization in the

horticulture sector is associated with intensive use of unskilled and female labor (e.g. Minot and Ngigi, 2004; Barrientos et al., 2001 and 2000; Smith et al., 2004).

Further, the share of Wolof households is significantly higher among the agro-industrial employees compared to other households. Wolof households might be more attracted to this type of employment because of differences in preferences. However, also differences in location might play a role. The share of Wolof households is much higher in the Dakar region and – as can be seen from the figures in table 1 – employment in the horticulture industry is also significantly higher in this region. Most of the horticulture exporting companies are located in this region and hence households in this region face lower transport costs to reach the companies.

Yet, although total agricultural landholdings do not differ between the two groups of households, agro-industrial employees have significantly lower per capita landholdings – 0.65 ha compared to 0.77 ha for the comparison group. Moreover, agro-industrial employees have slightly lower livestock holdings and significantly less non-land assets. This indicates that households involved in employment in the horticulture industry are rather resource-poor households with less land and non-land assets. The horticulture agro-industry seems to create employment opportunities that are accessible for poorer and less educated households. Studies focusing on labor market effects of horticulture exports have come to similar conclusions (e.g. McCulloh and Ota, 2002 and Maertens and Swinnen, 2008).

Off-farm employment opportunities and non-farm economic activities have often been observed to be biased to relatively richer and more educated households (Dercon and Krishnan, 1996; Abdulai and CroleRees, 2001; Barret et al., 2000). This is not the case for employment opportunities in the horticulture export agro-industry in Senegal. The fact that this employment is relatively well accessible for poorer and

less educated households might condition the existence of farm-nonfarm investment linkages from this type of employment.

4.2. Off-farm income

Employment in the horticulture agro-industry is associated with sharp differences in household income; agro-industrial employees have average incomes that are 80% higher than for other households (table 2). Also in per capita terms this difference in income remains large: 350,000 FCFA⁶ for agro-industrial households compared to 245,000 FCFA for other households. The wages earned in the horticulture agro-industry average 393,000 FCFA among agro-industrial employees and constitute on average 39% of total income for these households. For the sample as a whole, income from the agro-industry represent on average 14% of total incomes⁷, which is higher than any other off-farm income category (other wages, self-employment and transfers). These figures show again the magnitude of the impact the expanding horticulture export industry has had on employment in this area.

In addition to having wage incomes that contribute importantly to total household income, agro-industrial employees also have significant higher farm incomes; 2,14 million FCFA compared to 1,26 million FCFA for households not employed in the export agro-industry (table 2). This is remarkable as these households were observed to have less land, livestock and non-land resources for farming. The existence of farm-nonfarm investment linkages might contribute to explaining this.

⁶ FCFA - *franc de la communauté financière d'Afrique* – is the local currency with a fixed exchange rate to the Euro; 100 FCFA = 0.152449 Euro.

⁷ There is an important discrepancy between the figures on the importance of wage income from the agro-industry calculated as average share of that wage income in total household income (14%) or calculated as share of average wage income in average total income (7.5% = 148,000 FCFA / 1,958,000 FCFA). This is because agro-industrial wage income is relatively more important among lower income households.

5. Agricultural production and farmers' constraints

5.1. Farm size

Ninety-two percent of the households in the sample engage in agricultural production and can be categorized as farming households. The other 19 households are either landless (9 households) or specialize in non-farm activities. The average agricultural landholdings among the farming households in the sample is 4.97 ha. However, the average farm size – or the average area that is cultivated – is only 2.6 ha. On average farm households cultivate only 55% of their agricultural land. Only about one third of the farmers cultivate all or nearly all (more than 80%) of the land they have while 42% cultivate less than half their area. Yet, most farmers (90%) want to cultivate more land and expand agricultural production.

The main reasons behind this low land use intensity are lack of irrigation water and infrastructure, and lack of financial means. Farmers in the survey were asked to indicate important limitations for agricultural production and productivity growth. Their responses are summarized in table 3. The figures indicate that availability of water and irrigation infrastructure, access to credit and access to chemical inputs are important constraints for respectively 81%, 67% and 59% of the farmers. Moreover, the large majority of farmers (90%) cultivating less than 80% of their land indicated to be unable to cultivate more land because of a lack of financial means to buy the necessary inputs and make the necessary investments (mostly for wells and irrigation infrastructure). This shows that capital and credit constraints – rather than land or labor constraints – are very important in determining smallholder agricultural production.

5.2. Liquidity constraints

The importance of credit constraints also appears when looking at data on credit. Sixty-one percent of the sampled households are credit constrained (not having access to credit at all) or credit rationed (not having access to the desired amount of credit). Among these credit constrained households, 83% does not have access to official sources of credit – including credit institutions and microfinance projects – and 44% does not have access to any source of credit, including unofficial credit from moneylenders, traders or family. Total household credit – expressed as the amount of credit a household has taken up in the 12-month period prior to the survey – averages 108,000 FCFA. This is quite low and only about 40% comes from official credit institutions and microfinance programs (table 4). Access to credit is much more limited among households with lower landholdings while these households rely relatively more on unofficial credit sources.

The observed credit constraints might severely limit agricultural production and productivity growth. Thus, in a setting of poorly functioning credit markets, access to off-farm income might relax farmers' liquidity constraint and play a role in financing agricultural production, thereby creating farm-nonfarm linkages at the household level.

5.3. Farm expenditures

In table 5 we compare the area cultivated and farm expenditures for inputs such as seeds, fertilizers, and phytosanitary products; and for hired workers across agro-industrial employees and other households. Despite the fact that agro-industrial employees do not have larger landholdings, they cultivate a significantly larger area. In addition, they have significantly higher expenditures for crop inputs, including chemical inputs such as fertilizers and phytosanitary products as well as other inputs

such as fuel. However, there are no differences in expenses for hired farm workers across the two types of households.

Among households employed in the agro-industry 14% does not cultivate at all (of which about half is landless) while among other households this is only 4%. So, it seems that certain household leave farming and specialize in off-farm activities. However, most farm-households with access to income from unskilled employment in the agro-industry continue their own agricultural production, with larger farm sizes and higher crop expenditures than household without access to this off-farm income. This points to the existence of investment linkages between off-farm income and the family farm.

6. Analysis of farm non-farm linkages

We observe sharp differences in the area cultivated and in crop expenses between households having access to income from off-farm employment in the horticulture industry and households who don't. To reveal whether these differences can be attributed to the existence of investment linkages between off-farm income and the family farm and identify causality, further econometric analysis is needed.

6.1. Econometric approach

To examine the effect of income earned in the horticulture agro-industry (INC_agrind) on agricultural production, we estimate the following three models:

$$AREA = \alpha_0 + \alpha_1 INC_agrind + \alpha_2 X + \mu_1 \quad (1)$$

$$EXP_input = \beta_0 + \beta_1 INC_agrind + \beta_2 X + \mu_2 \quad (2)$$

$$EXP_labor = \gamma_0 + \gamma_1 INC_agrind + \gamma_2 X + \mu_3 \quad (3)$$

We hypothesize that – because of investment linkages between non-farm and farm activities at the household level – wage income from the agro-industry has a positive effect on the area household cultivate (*AREA*), the input expenses for cropping⁸ (*EXP_input*) and the expenses for hired labor on the family farm⁹ (*EXP_labor*). So, the main interest is in the coefficients α_1 , β_1 and γ_1 .

Wage income from the agro-industrial employment is not randomly distributed over households; we already observed significant differences in household characteristics and endowments across agro-industrial employees and other households (table 1). To correct for potential selection bias that could obscure the causal relation between the main regressor (*INC_agrind*) and the outcome variables of interest (*AREA*, *EXP_input* and *EXP_labor*), we include a large set of observable covariates (*X*) in the models. The vector of control variables *X* relates to households' access to resources (agricultural landholdings - *LAND*, dummy variable for access to a modern irrigation system - *IRRIG*, and the value of agricultural equipment and machinery – *EQ_agr*); their labor endowments (the number of male and female laborers – *LABOR_mal* and *LABOR_fem*, a dummy for female-headed households – *FEM_head*, and a dummy for a household head with at least primary education - *EDUC*); their preferences (age of the household head – *AGE_head*, a dummy for Wolof ethnicity – *ETHNIC*); and geographic location (a dummy variable for location in the region Dakar – *REGION*). To avoid endogeneity problems, we use lagged variables for the covariates *LAND* and *EQ_agr*. These variables represent agricultural landholdings and agricultural equipment in 1995 – before the horticulture export sector started to

⁸ Input expenses include variable costs such as expenses for seed, chemicals, fertilizers, contributions for irrigation water, fuel,

⁹ Expenses for hired labour include the salaries paid to labourers as well as the meals and other in-kind compensations for hired workers.

boom and households engaged in off-farm wage employment in the agro-industry – and are calculated based on recall data.

In a first specification, we estimate the three models separately using ordinary least squares (OLS)¹⁰. In a second specification, we additionally include village fixed effects to correct for potential differences in geo-physical characteristics, infrastructure and institutional environment across the sampled villages. However, OLS is likely to create correlated error terms μ_1 , μ_2 , and μ_3 because the three equations use the same set of regressors and have outcome variables that are closely related. To account for this, we use - in a third model specification – the seemingly unrelated regression (SUR) technique, first developed by Zellner (1962).

By including the vector X , we can only correct for observable heterogeneity while the possibility of unobserved heterogeneity biasing the estimations still remains. This could e.g. be related to economic motivation (or ability) which is unobserved and which could lead to an upward bias in the estimation of the effect of off-farm wage income on agricultural production as households with highly motivated (or highly capable) members might seek off-farm employment as well as expansion of agricultural production. On the other hand, the bias might be downward e.g. because households facing more constraints to agricultural production might choose to allocate more labor to off-farm activities such as employment in the agro-industry.

In a fourth specification of the models, we attempt to correct for potential unobserved effects using instrumental variable (IV) regressions. We instrument the main variable of interest *INC_agr* using the total number of female laborers in the household (*LABOR_fem*) and a dummy variable for households with female members involved in a village organization or women's union (*ORG_fem*) as instruments. These

¹⁰ Many households do not use hired labor on their farm, resulting in a probability mass at 0 for the outcome variable *EXP_labor*. We additionally estimated equation (4) using tobit regression; yielding identical results as the OLS regression. For matter of convenience we only report the OLS regressions.

variables are both highly correlated¹¹ with the instrumented variable as the horticulture agro-industry employs mainly women and many companies recruit laborers through village organizations. The variable *LABOR_fem* is a valid instrument – despite its use in the covariate vector *X* in the first three model specifications – as the results of the OLS and SUR estimations show that it has no significant effect and no explanatory power in the regressions on *AREA*, *EXP_input* and *EXP_labor* (table 7). Because *INC_agr* is censored at zero – reflecting the fact that a high share of households in the sample does not earn wages from the horticulture agro-industry – we use a tobit regression in the first stage of the IV estimation¹².

In a fifth and final specification, we estimate all equations – including the IV estimation of the endogenous explanatory variable *INC_agr* – simultaneously using a three stage least square model.

6.2. Results and discussion

The results of the different regressions are given in table 7. The five different model specifications – OLS with and without village fixed effects, SUR, IV and 3SLS regression – all yield qualitatively identical and quantitatively similar results. This is a strong indication of the robustness of the estimated effects.

The main interest is in the effect of wage income from employment in the agro-industry on family-farm production and hence on the coefficients of the variable *INC_agrind*. We find that there is a significant positive effect of wages earned in the agro-industry on the area households cultivate (*AREA*) and on expenditure on crop inputs (*EXP_inputs*). For these two outcome variables – and in all but one of the five

¹¹ Correlation coefficients are 0.37 and 0.15 for *LABOR_fem* and *ORG_fem* respectively, which are both significant at the 1% significance level.

¹² To adjust standards errors in the two-step estimation procedure, the estimates of the latent variable from the first stage tobit model are used as a sole instrument in a normal IV estimation – as described by Wooldridge (2002).

model specifications – the estimated coefficient of *AGR_agrind* is positive and significant at the 5% level. The estimated effects are larger in the IV and 3SLS regressions compared to the OLS and SUR regressions, indicating that unobserved heterogeneity results in a downward bias of the estimated effects.

We find that an increase in off-farm wage income of 100,000 FCFA – which is about 40 to 50 days of work at an hourly wage of 250 FCFA – increases the cultivated area with 0.11 to 0.24 ha and the crop input expenses with 17,000 to 56,000 FCFA. Taking into account that households with agro-industrial employees earn on average about 400,000 FCFA per year from this employment, the estimated results means that these households cultivate between 17% and 37% more land and spend between 23% and 75% more on agricultural inputs than households without such employment. These are large and important effects, implying that off-farm income is partially invested in the family farm and pointing to the existence of farm-nonfarm investment linkages at the household level.

We find no evidence of an effect of off-farm income earned in the agro-industry on expenses for hired labor (*EXP_labor*). Labor allocated to employment in the horticulture agro-industry – especially female labor – is not compensated by hiring in additional labor to work on the family farm. This indicates again that labor is not the most scarce factor limiting smallholder agricultural production in the research area. Moreover, employment in the horticulture agro-industry is temporary – mostly on a day-to-day basis – and is confined to a specific agricultural season – from November till April when vegetables are exported to the EU – which does not coincide with the main “rainy” agricultural season. Therefore, the need to replace the outflow of family labor towards off-farm employment with non-family hired labor might be quite limited.

Apart from the effect of off-farm income, other variables are also important in determining agricultural production. First – as could be expected – households' total landholdings strongly determine farm size; we find that an additional ha of land increases the cultivated area with 0.35. Despite a highly significant effect, the estimated coefficient is rather low – indicating again that land is not cultivated intensively and that access to land is not a major constraint in the region. In addition, larger landholdings significantly increase the expenses for hired labor and for crop inputs – although for the latter the effect is only significant at the 10% level. Second, access to modern irrigation infrastructure significantly increases expenses for inputs and hired labor and has a marginally significant effect on the area cultivated. This indicates that irrigated land is used much more intensively. Third, the ownership of agricultural equipment increases the expenditures for hired labor – an effect significant at the 10% level in four out of the five specifications – but has no major impact on the cultivated area or crop expenditures.

Fourth, also labor endowments are important in determining the cultivated area and crop expenditures. Only male labor has significant positive effects on *AREA* (at the 10% level) and *EXP_input* (at the 5% level). Female labor has a strong negative (but statistically insignificant) effect on *EXP_labor*. This result is related to the fact that, although many female household members work on the family plots, male household members control the land and generally make farm decisions. Many farm tasks are gender specific, but the results seem to suggest that a lack of female labor is more easily compensated by hired labor.

Fifth, all other covariates in the model do not have strong effects on the three outcome variables. The results indicate that Wolof households and households without primary education are slightly more likely to hire in labor and that older

households cultivate less land – effects that are significant only at the 10% and only in some model specifications.

These results are in line with the expectations and indicate that access to land, water, and capital resources and family labor endowments are important for smallholder agricultural production.

The results of the first stage tobit estimation on off-farm income from the agro-industry – which are used in the IV and 3SLS estimations – are presented in table 8. The results show that – as expected – the two instrumental variables *LABOR_FEM* and *ORG_FEM* have large and significant effects in the regression on *INC_agrind*. Also geographic location is important in explaining differences in off-farm wage income; households in the Dakar region – closer to agro-industrial companies – have significantly higher off-farm wage incomes. None of the other covariates has a significant effect, which shows again that off-farm employment in the horticulture agro-industry is not biased to better endowed and better educated households.

In conclusion, we find that off-farm employment in the vegetable agro-industry has not restricted agricultural growth by displacing family labor off the farm. On the contrary, through relaxing farmers' liquidity constraints, the growing off-farm employment opportunities – resulting from expanded horticulture exports to the EU – contribute to increasing agricultural production. Similar results were found by Woldehana (2002) for rural Ethiopia and by Ruben and van den Berg (2001) for Honduras. Our findings contradict the results by Low (1981) who finds that off-farm employment contributes to declining agricultural productivity in Swaziland and Lesotho.

Our results imply that the implications of increasing horticulture exports and associated agro-industrialization – observed in many African and other developing countries – go much beyond direct production linkages which are usually analyzed in the empirical literature. This is contrary to the view of Kimenyi (2002) who argues – mainly looking at production and consumption linkages – that the growth in the vegetable agro-industry in Kenya has not contributed much to creating farm-nonfarm linkages.

7. Conclusion

In this paper we have provided case-study evidence of household-level farm investment linkages related to low-skilled off-farm employment. We find that earnings from employment in the growing horticulture export industry in Senegal are partially invested in the family farm, resulting in larger farm sizes, higher farm expenditures, and increased farm incomes. Constraints farmers face in credit and input markets can partially be alleviated by off-farm employment and income, resulting in increased agricultural production. These findings imply that the development of rural labor markets can be associated with farm-nonfarm linkages and growth multiplier effects, and should therefore be an important element in rural development strategies. Moreover, the results suggest that an analysis of the welfare implications of increasing horticulture exports and associated agro-industrialization in developing countries should look beyond direct production linkages.

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Tables

Table 1: Comparison of household characteristics across agro-industrial employees and other households

	Total sample (N=240)	Agro-industrial employees (N=83)	Comparison group (N=157)	Comparison of households t-statistic
HUMAN CAPITAL				
Number of male laborers	3.25	3.35	3.19	-0.578
Number of female laborers	3.36	4.13	2.96	-4.912***
Age of the household head	53.65	54.87	53.00	-1.153
Dependency ratio	0.57	0.57	0.56	-0.389
Female headed household	0.04	0.04	0.04	0.080
Education (years) of the head	1.36	1.20	1.45	0.555
PHYSICAL CAPITAL				
Total landholdings (ha)	4.721	4.870	4.642	-0.352
Per capita landholdings ¹ (ha)	0.729	0.652	0.769	1.283*
Livestock units ²	2.078	1.660	2.299	1.009
Value of non-land agr. assets ³ (1,000 FCFA)	156.7	115.9	178.3	1.024
Value of non-agr. assets ³ (1,000 FCFA)	47.6	9.3	67.8	1.440*
SOCIAL CAPITAL				
Ethnicity: wolof household	70%	81%	65%	-2.568***
Membership of a farmers' union	78%	86%	75%	-0.918
Membership of a women's union	8%	12%	6%	-1.515*

Agro-industrial employees are defined as households having one or more members employed in the vegetable export agro-industry. The Comparison group constitutes households without members employed in the vegetable export agro-industry.

¹ Per capita landholdings are calculated using the modified OECD adult equivalence scale.

² One livestock unit equals 1 cow, 0.8 donkeys and 0.2 sheep/goat.

³ Non-land and non-agricultural assets include all equipment and machinery for farming and non-farm businesses and their value is revealed from the survey as the price the household would receive if selling an item.

Legend: * p<.10; ** p<.05; *** p<.01

Source: Calculated from household survey data

Table 2: Comparison of income from different sources across cross agro-industrial employees and other households

	Total sample (N=240)	Agro- industrial employees (N=83)	Comparison group (N=157)	ttest comparing households t-statistic
Total income	2,025	2,884	1,577	-2.135**
Per capita income	281	350	245	-1.642**
Average household income from different sources:				
Income from farming	1,494	2,137	1,158	-1.687**
Wage income	185	415	65	-8.335***
- horticulture agro-industry	135	393	0	
- other wages	50	22	65	1.464*
Income from self-employment	248	240	252	0.135
Income from transferts	98	92	101	0.135
Average share of income from different sources:				
Income from farming	66%	46%	77%	
Wage income	17%	41%	5%	
- horticulture agro-industry	14%	39%	0%	
- other wages	4%	1%	5%	
Income from self-employment	12%	10%	12%	
Income from transferts	5%	4%	6%	

Agro-industrial employees are defined as households having one or more members employed in the vegetable export agro-industry. The Comparison group constitutes households without members employed in the vegetable export agro-industry.

Household income is yearly nominal income calculated for the 12 month period prior to the survey, July 2004 to June 2005. Per capita income is calculated using the modified OECD adult equivalence scale. Farm income is calculated taking into account total production (valued at market prices) in three different seasons ("*hivernage*" 2004; "*contre-saison chaude*" 2004/2005, and "*contre-saison froide*" 2005), the cost of variable inputs, cost of hired labor, and the depreciation of machinery and equipment. Income from self-employment includes income from small businesses – mostly small trading activities. Transfers include public transfers, remittances, and other non-labor income.

Legend: * $p < .10$; ** $p < .05$; *** $p < .01$

Source: Calculated from household survey data

Table 3: Farmers' perception of constraints to agricultural production and productivity growth

	One of the important constraints	The main constraint
Access to chemical inputs	58.8%	6.9%
Access to credit	67.5%	16.7%
Availability of water and irrigation infrastructure	81.3%	60.3%
Soil fertility	37.5%	2.5%
Low prices	66.7%	5.9%
Other		6.9%

Source: Calculated from household survey data

Table 4: Access to credit across households with different size of landholdings

	Total sample	Households with landholdings of			
		0-1 ha	1 - 5 ha	2 - 5 ha	> 5 ha
	(N=240)	(N=48)	(N=54)	(N=62)	(N=76)
Total amount of credit (1,000 FCFA)	108.6	57.1	82.7	162.7	115.4
Credit from official sources ¹ (1,000 FCFA)	45.3	17.5	21.8	82.4	49.3
Credit from unofficial sources ² (1,000 FCFA)	63.3	39.6	61.0	80.3	66.1

¹ Official credit sources include credit institutions such as CNCR – *Caisse National de Credit Agricole*, and microfinance programs.

² Credit from unofficial sources include credit from traders, moneylenders, family and neighbours, etc

Source: Calculated from household survey data

Table 5: Comparison of farm size and farm expenses across agro-industrial employees and other households

	Total sample	Agro-industrial employees	Comparison group	ttest comparing households
	(N=240)	(N=83)	(N=157)	t-statistic
Share of landless households	4%	8%	1%	
Share of non-farming households	8%	14%	4%	
Total area cultivated (ha)	2.58	3.06	2.35	-1.529*
Expenses for farm inputs (1,000 FCFA)	299.5	370.2	266.0	-1.329*
Expenses for hired farm workers (1,000 FCFA)	93.7	73.9	103.1	0.895

Legend: * p<.05; ** p<.05; *** p<.01

Source: Calculated from household survey data

Table 6. Variable included in the econometric analysis

Variable name	Description	Sample mean
Outcome variables		
AREA	Cultivated area (ha)	2.375
EXP_inputs	Expenditures on inputs (1,000 FCFA)	278.2
EXP_labor	Expenditures on hired labor (1,000 FCFA)	86.34
Endogeneous explanatory variable		
INC_agrind	Off-farm income earned in the horticulture industry	185.1
Instrumental variables		
LABOR_fem	The number of female laborers	3.363
ORG_fem	Dummy for female membership of an organisation	0.083
Exogenous covariates		
LAND	Total landholdings in 1995 (ha)	3.707
IRRIG	Dummy for access to a modern irrigation infrastructure	0.146
EQ_agr	Value of non-land agricultural assets in 1995 (1,000 FCFA)	70.85
LABOR_mal	The number of male laborers	3.246
AGE_head	Age of the household head	53.65
FEM_head	Dummy for female headed households	0.038
ETHNIC	Dummy for Wolof-ethnic households	0.704
EDUC	Dummy for household head with primary education	0.838
REGION	Dummy for household located in the Dakar region	0.554

Table 7: Regression results for different model specifications

	MODEL SPECIFICATION				
	OLS regression	OLS with village fixed effects ¹	Seemingly unrelated regression	Instrumental variable regression ²	Simultaneous regression ²
Dependent variable: AREA					
INC_agrind	0.0011**	0.0015**	0.0011**	0.0024**	0.0024**
LAND ³	0.3596***	0.3330***	0.3596***	0.3546***	0.3589***
IRRIG	0.9191*	0.4393	0.9191**	0.8415*	0.8545*
EQ_agr ³	0.001	0.001	0.001	0.001	0.001
LABOUR_mal	0.1854*	0.1849*	0.1854**	0.1767*	0.1701*
LABOUR_fem	0.0268	-0.0456	0.0268		
AGE_head	-0.1425	-0.1425	-0.1425	-0.1543*	-0.1625*
AGE_head ²	0.0013	0.0013	0.0013	0.0014	0.0015*
FEM_head	-0.6652	-1.0998	-0.6652	-0.5396	-0.5222
ETHNIC	0.346	0.2739	0.346	0.2863	0.2864
EDUC	-0.2719	-0.4211	-0.2719	-0.3833	-0.3798
REGION	-0.5206		-0.5206	-0.7215*	-0.6962*
Constant	4.1060*	6.5348**	4.1060*	4.4844*	4.7014*
	(R ² =0.40)	(R ² =0.47)	(R ² =0.40)	(R ² =0.38)	(R ² =0.38)
Dependent variable: EXP_inputs					
INC_agrind	0.2322**	0.2863**	0.1697*	0.5561**	0.4967**
LAND ³	15.5175*	14.6056*	13.0253*	13.8103*	12.973*
IRRIG	627.29***	527.61***	484.09***	589.61***	467.48***
EQ_agr ³	-0.0973	-0.0794	-0.0659	-0.0932	-0.0515
LABOUR_mal	45.676**	45.228**	47.586**	44.536**	47.332**
LABOUR_fem	14.395	2.5294	20.811		
AGE_head	-22.609	-24.421	-22.826	-24.899	-25.615
AGE_head ²	0.1265	0.1315	0.1299	0.1563	0.1632
FEM_head	-181.48	-103.02	-135.52	-121.37	-87.605
ETHNIC	-8.1284	-53.773	-11.135	-12.484	-26.19
EDUC	-91.101	-95.864	-111.605	-111.27	-131.25
REGION	-16.009		-18.826	-61.644	-63.726
Constant	864.98*	721.31	857.02*	948.58*	968.24**
	(R ² =0.25)	(R ² =0.38)	(R ² =0.22)	(R ² =0.23)	(R ² =0.18)
Dependent variable: EXP_labor					
INC_agrind	0.0229	-0.0055	0.0049	-0.0273	-0.0148
LAND ³	11.979***	10.748**	11.663***	12.037***	11.643***
IRRIG	146.307***	115.927**	147.151***	149.345***	148.08***
EQ_agr ³	0.1125*	0.0334	0.1122**	0.1094*	0.1105**
LABOUR_mal	8.3234	10.8678	6.7805	6.7867	6.0214
LABOUR_fem	-8.3725	-11.1868	-4.0933		
AGE_head	-0.9104	0.3301	-0.1634	-1.4003	-0.5015
AGE_head ²	-0.0087	-0.0147	-0.0126	-0.0061	-0.0104
FEM_head	-70.8715	-110.7828	-42.7598	-79.2769	-47.789
ETHNIC	59.488*	64.879	48.731*	59.016*	49.521*
EDUC	-55.187	-68.652*	-59.492*	-55.675	-60.089
REGION	65.465**		63.353**	71.873**	65.825**
Constant	58.248	-70.119	33.43	59.427	35.989
	(R ² =0.17)	(R ² =0.34)	(R ² =0.17)	(R ² =0.16)	(R ² =0.17)

¹ Village fixed effects are included but not reported.

² The variable *INC_agrind* is instrumented.

³ The variables *LAND* and *EQ_agr* are lagged variables for the year 1995.

Legend: * p<.1; ** p<.05; *** p<.01

Source: Estimated from household survey data

Table 8: Results of the first-stage tobit regression

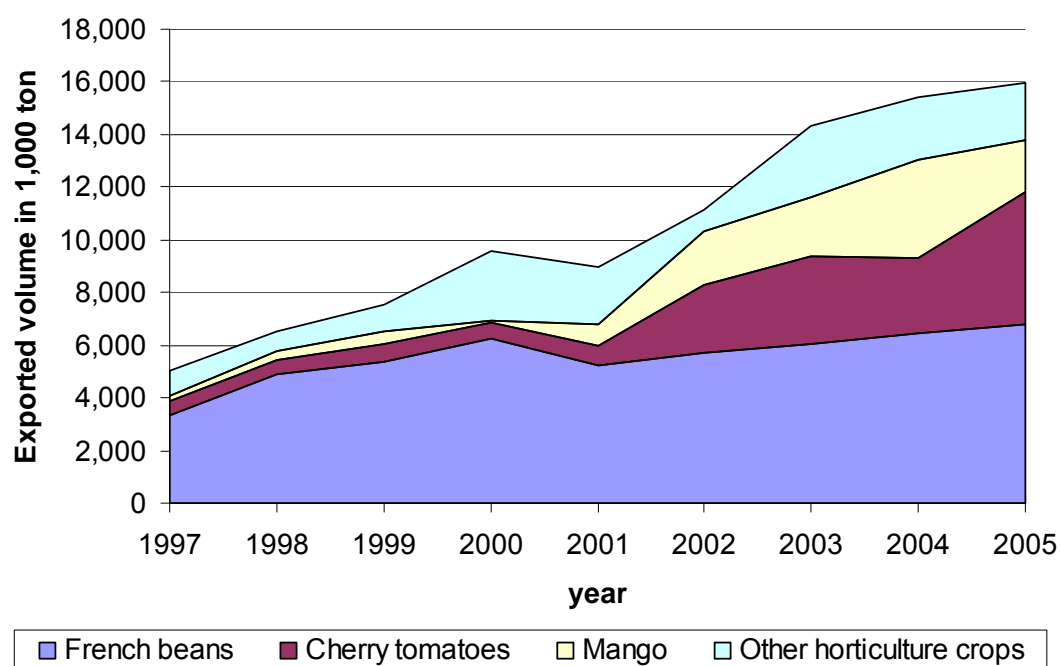
	Coef.	Std. Err.	t	P> t
LAND ¹	2.722	10.24	0.27	0.791
IRRIG	94.63	114.05	0.83	0.408
EQ_agr ¹	-0.087	0.187	-0.46	0.644
LABOUR_mal	0.104	22.33	0.00	0.996
LABOUR_fem	129.45	23.46	5.52	0.000
ORG_fem	313.75	135.86	2.31	0.022
AGE_head	17.56	23.75	0.74	0.460
AGE_head ²	-0.222	0.220	-1.01	0.314
FEM_head	-359.71	235.99	-1.52	0.129
ETHNIC	80.20	93.72	0.86	0.393
EDUC	125.39	119.14	1.05	0.294
REGION	318.74	90.62	3.52	0.001
Constant	-1182.94	659.43	-1.79	0.074
	Log likelihood			-900.157
	LR chi2(12)			61.03
	Prob > chi2			0.000

¹ The variables *LAND* and *EQ_agr* are lagged variables for the year 1995.

Source: Estimated from household survey data

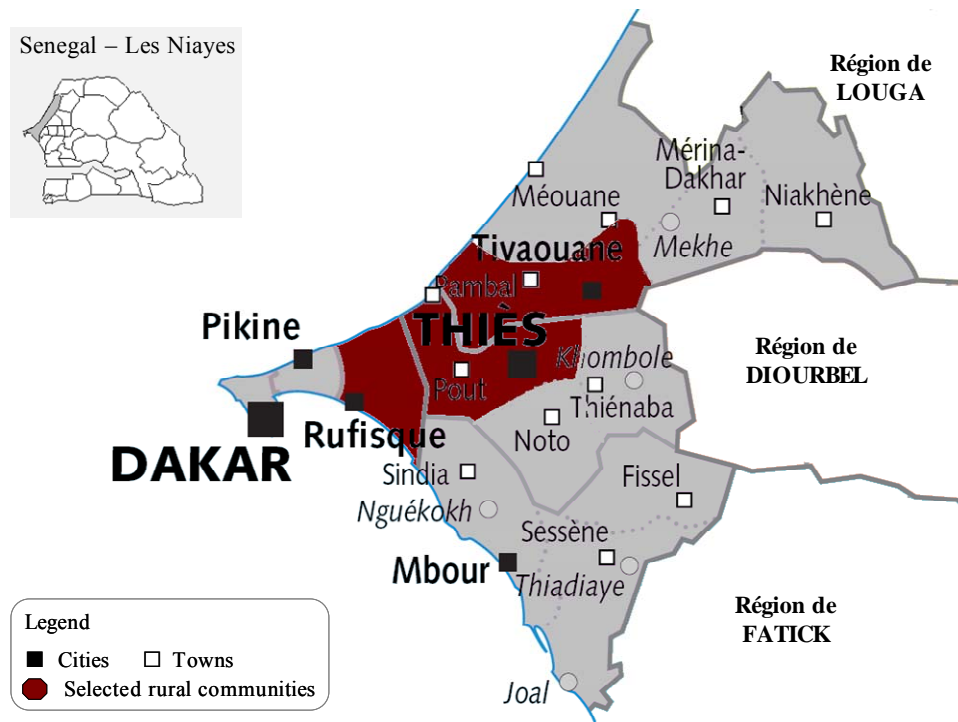
Figures

Figure 1: Exported volume of horticulture products from Senegal, 1997 - 2005



Source: data from ONAPES – *Organisation Nationale des Exportateurs de Fruits et Légumes de Sénégal*, SEPAS – *Syndicat des Exportateurs des Produits Agricoles*, and DH – *Direction de l'Horticulture*, 2006

Figure 2: Map of the Research Area in “Les Niayes”, Senegal



Source: Map from Atlas du Sénégal – IRD – Cartographie A. LE FUR -AFDEC