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Trade, Standards, and Poverty: Evidence from Senegal

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Summary. — In the debate on trade and poverty it is argued that standards act as trade barriers and cause marginalization of the poor. This paper quantifies income and poverty effects of high-standards trade and integrates labor market effects, by using company and household survey data from the vegetable export chain in Senegal. We find that exports grew sharply despite increasing standards, contributing importantly to rural incomes and poverty reduction. Tightening standards induced a shift from smallholder contract farming to integrated estate production, altering the mechanism through which poor households benefit: through labor markets instead of product markets.

Key words — trade, poverty, standards, vertical coordination, modern supply chains

1. INTRODUCTION

The integration of developing countries in global trade is generally believed to stimulate economic growth in those countries (Dollar & Kraay, 2002; Frankel & Romer, 1999; Irwin & Tervio, 2002). [1] However, there is much less consensus about the impact of trade on poverty. While some advocate participation in international trade as a major potential engine for global poverty reduction (Aksoy & Beghin, 2005; Anderson & Martin, 2005; Bhagwati & Srinivasan, 2002; Dollar & Kraay, 2004), in a broad survey of the evidence, Winters *et al.* (2004, p. 106) conclude that "there can be no simple general conclusion about the relationship between trade liberalization and poverty."

The recent debate on standards and development casts further doubt on the beneficial effect of trade liberalization. The first critique is that the proliferation and tightening of quality and safety standards in high-income markets is causing new (non-tariff) barriers for developing country exports (Garcia Martinez & Poole, 2004; Unnevehr, 2000). However, others argue that standardization and certification reduces transaction costs and act as catalysts for upgrading developing countries' export sectors, leading to enhanced market access, and competitiveness (e.g., Jaffee & Henson, 2005).

The second critique is that increasing standards result in the marginalization of small businesses and poor farm-households in developing countries as they are excluded from high-standards supply chains while the rents in the chain are extracted by large (often multinational) companies and developing country elites (Farina & Reardon, 2000; Gibbon, 2003; Key & Runsten, 1999; Kherralah, 2000; Reardon, Codron, Busch, Bingen, & Harris, 1999). This critique is not confined to international trade but also concerns supermarket-driven supply chains and the associated spread of high standards within developing countries (e.g., Reardon, Timmer, Barrett, & Berdegué, 2003; Weatherspoon & Reardon, 2003). However, there is considerable debate and uncertainty on the extent of this "smallholder exclusion" and empirical studies have come to diverse conclusions (Swinnen, 2007). Evidence from Kenya, Ghana, and Cote d'Ivoire, for example, suggests that horticulture exports are increasingly grown on large industrial estate farms, thereby excluding smallholder suppliers in the export supply chain (Danielou & Ravry, 2005; Jaffee, 2003; Minot & Ngigi, 2004). Also supermarket-driven supply chains have been observed to exclude smallholders from their preferred supplier lists; for example, in South Africa (Sautier, Vermeulen, Fok, & Bienabé, 2006). Others find very different effects. For example, Minten, Randrianarison, and Swinnen (2006) find that in Madagascar most FFV exports are produced on very small farms, often on a contract basis with the agro-food industry, and with important positive effects on farmers' productivity. The inclusion of smallholders in modern supply chains is also found by studies in South Asia (Gulati, Minot, Delgado, & Bora, 2007), China (Wang, Dong, & Rozelle, 2006), and in Eastern Europe (Dries & Swinnen, 2004). Moreover, in several cases this smallholder inclusion in modern supply chains is associated with vertical coordination, leading to increased access to inputs, technology, and increased productivity and investments (Gow & Swinnen, 1998; Swinnen, Dries, Noev, & Germenji, 2006).

There is a more fundamental problem with this literature on standards, trade, and poverty. Empirical studies have almost exclusively focused on the question of small farmers' contribution in supplying high-standards value chains and have failed to measure overall welfare and poverty effects. Most studies ignore labor market effects. Some studies have pointed to the potential importance of employment effects in modern supply chains and high-value trade. For example, von Braun *et al.* (1989) for Guatemala and Neven, Odera, Reardon, and Wang (2008) for Kenya indicate that high-value horticulture production is associated with increased use of hired labor on the farms. Yet, very few studies have actually analyzed the link between high-value trade, employment, and poverty. The few studies that do suggest that it is essential to integrate labor market effects in welfare analyzes of high-value trade and modern supply chains. For example, McCulloh and Ota (2002) show that employment in the Kenyan horticulture export industry is especially important for the poor. Barron and Rello (2000) find that the tomato agro-industry in Mexico provides jobs for poor migrant workers, thereby contributing to income rises in poverty struck regions of the country.

The aim of this study is to contribute to both the literature on standards and development and the more general literature on trade and poverty by assessing the welfare and poverty implications of increasing standards on fruit and vegetable (FFV [2]) exports in Senegal. We first analyze how the structure

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of the FFV export supply chain in Senegal has changed in response to tightening food standards and then investigate how this has affected welfare of poor households. Our study uses household level data to assess the poverty effects of FFV trade. In doing so, we attempt to contribute to filling the empirical gap identified by Winters *et al.* (2004, p. 107) who conclude that "there is relatively little empirical evidence about the effects of trade … on poverty dynamics at the household level, and on how households respond to … potential opportunities." Our approach is also in line with Srinivasan and Bhagwati's (2001) argument that more convincing evidence may be derived from country case studies than from cross-country regressions.

High-standards FFV exports from Senegal is a particularly relevant case for a number of reasons. First, Sub-Sahara Africa is the region generally considered most lagging in global market integration and poverty reduction. Second, FFV is one of the most dynamic export sectors, especially for developing countries where they have grown importantly in recent years—from 14% of total food exports in 1980 to 22% in 2000 (Aksoy, 2005). Given the intensity of land and unskilled labor in this sector, the longer cultivation periods in tropical countries, and export incentives such as preferential trade agreements, developing countries have been able to capture a significantly increased share of world FFV trade (Diop & Jaffee, 2005). Third, FFV exports are increasingly confronted with tightening food standards—arising from public legislation as well as from private multinational companies who increasingly dominate world trade (Maertens & Swinnen, 2007; Reardon & Berdegué, 2002).

To measure the poverty and welfare impacts of high-standards horticulture exports in Senegal we use a unique dataset compiled from extensive data collection at different levels. First, we collected statistics on horticulture production and exports from existing data sources and conducted a series of qualitative interviews with local experts. Second, in April 2005, we conducted quantitative and structured interviews with nine of the 20 horticulture exporting companies in the main horticulture zone *Les Niayes* from where the large majority of FFV exports originates. Third, in the period August–September 2005, we organized a large survey among farm-households in this region.

Our study yields several important findings. First, we find that FFV exports from Senegal to the EU have increased sharply over the past decade, despite increasing food standards in the EU. Second, these FFV exports contribute to poor household incomes in the FFV producing regions. Third, tightening food standards induced structural changes in the supply chain, including a shift from smallholder contract-based farming to large-scale integrated estate production. Fourth, despite these changes, the welfare implications of high-standards FFV export production for rural households are found to remain strongly positive. Supply chain restructuring has altered the mechanism through which local households benefit: increasingly through labor markets instead of through product markets. Fifth, this induced change in the mechanism of income gains guarantees an equitable distribution of the gains within rural communities as the poorest benefit relatively more from working on large-scale agro-industrial farms than from contract farming.

The structure of the paper is as follows: In the next section we describe FFV exports from Senegal and the increasing EU standards. Section 3 deals with standards-induced structural changes in the export supply chain. We look at household participation in the chain and overall welfare implications of this participation—in terms of income and poverty—in Section 4. A comprehensive econometric analysis of the income and poverty effects is presented in Sections 5 and 6. In a final section, we present the main conclusions and implications.

2. HORTICULTURE EXPORTS FROM SENEGAL

(a) *Increasing exports*

The horticulture sector plays a central role in Senegal's export diversification strategy toward high-value commodities. FFV exports increased sharply over the past 15 years: from 2,700 ton in 1991 to 16,000 ton in 2005 (Figure 1). The period of the sharpest growth was after 1997 when the export of French beans alone increased from 3,000 ton to almost 7,000 ton. French beans (FB) represent almost half (42%) of the total FFV export volume aside from other major crops including cherry tomatoes (23%) and mangoes (16%). Apart from some small volumes exported to neighboring countries, FFV are exported to the EU; in particular to France (40%), the Netherlands (35%), and Belgium (16%). Senegal ranks fourth as African supplier of beans to the EU, after Morocco, Egypt, and Kenya (Eurostat, 2006).

The production of French beans for export is concentrated in the region *Les Niayes*—an area along the North Coast of Dakar—while the production of cherry tomatoes is concentrated in the delta of the Senegal River valley, close to the Mauritanian border. Yet, ongoing investments in other regions—often supported by government and donor-funded projects—are expanding the horticulture export sector to a larger area.

(b) *Increasing standards*

The FFV sector in Senegal experienced accelerated export growth during a period when food standards increased substantially. FFV exports to the EU now have to satisfy a series of stringent public and private quality and safety standards. EU legislation imposes (1) common marketing standards for FFV;[3] (2) sanitary and phytosanitary (SPS) measures; (3) general hygiene rules based on HACCP control mechanisms; and (4) traceability standards. The latter two requirements came into force with the General Food Law of 2002. Traceability implies that EU food companies have to document from/to

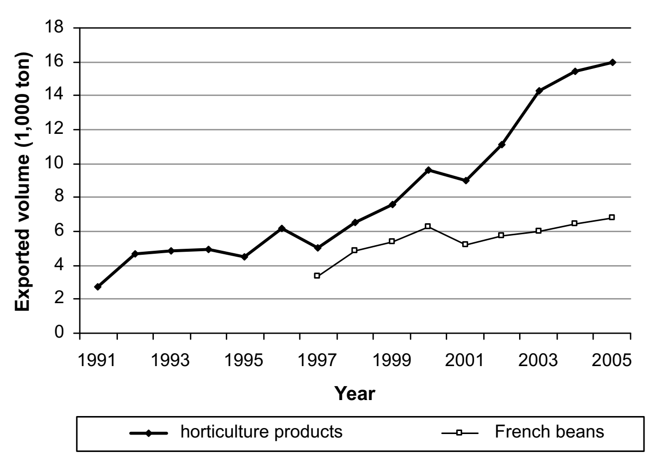

Figure 1. *Export volume (thousand ton) horticulture products from Senegal, 1991–2005. Source: data from ONAPES – Organisation National des Producteurs Exportateurs de Fruits et Légumes de Sénégal (2005).*

whom they are buying/selling produce such that products can be traced back to their origin in case of food safety problems. Also SPS measures became much more stringent; for example, decreasing tolerance for chemical residue levels,[4] treatment of wooden packaging material (since 2005), and maximum levels of contamination by heavy metals (since 2002).

Moreover, in addition to increasing public standards, many large trading and retailing companies have engaged in establishing private food standards that are even stricter. For example, the Euro-Retailer Produce Working Group (Eurep) has engaged in adapting food quality and safety standards into the EurepGAP certification protocol. On top of public traceability regulations that apply within the EU, they require complete traceability throughout the chain up to the level of overseas producers. Agri-food businesses in the EU increasingly require such private certification from their suppliers.

Despite these increasing standards, Senegal has been able to increase horticulture export earnings—as was also the case for, for example, Kenya Jaffee (2003). This proves that tightening standards do not necessarily undermine the competitive position of developing countries in international agricultural markets. The World Bank (2004) argues that the development of a certification scheme and validation of the label *Origine Sénégal* has played an essential role in raising the quality and standards of Senegalese FFV, and thereby realizing export growth.

3. STRUCTURAL CHANGES IN THE EXPORT SUPPLY CHAIN

Many studies have documented important structural changes in the supply chains of FFV for export (or for supermarkets) in developing countries. These changes include increased levels of consolidation with fewer and larger firms and producers, and increased levels of vertical coordination in the chains. Most notable is the ongoing shift from smallholder contract-based production to large-scale integrated estate production; documented, for example, by Jaffee (2003) for Kenyan vegetable exports, Minot and Ngigi (2004) for FFV exports from Cote d'Ivoire, and Danielou and Ravry (2005) for pineapple exports in Ghana. Increasing quality and safety requirements are usually mentioned as a major driving factor behind the observed supply chains restructuring. French bean export from Senegal is a similar case of standards-induced consolidation and vertical coordination.

Changes in EU standards put pressure on FFV exporters in Senegal to stay up to date with the changing requirements and to make additional investments for compliance. The growing demands also increase the need for tighter coordination and have led to important structural changes in the FFV export supply chain in Senegal, with major implications for Senegalese farmers. Key structural changes are (1) increased consolidation at the level of the agro-exporting industry as well as at the level of the primary producers; and (2) increased vertical coordination with downstream buyers in the EU as well as with upstream suppliers. This translates into a decreasing volume of French beans that is procured from small farmers and an increase in vertically integrated estate production.

We document and analyze these structural changes in more detail with quantitative information from interviews with nine FFV exporting companies in the research region. Our company sample constitutes a mixture of firms recently entering the market and older firms, a mixture of smaller and larger exporter, and includes two firms with a majority share of foreign ownership;[5] jointly representing almost 40% of the exported volume French beans (Table 1).

Table 1. *Characteristics of selected horticulture exporting companies*

Company name	Export volume (ton), 2004		Year entering FB export	Foreign ownership
	FB[a]	Other FFV[b]		
Soleil Vert	800	1,100	2000	80%
Sepam	883	1,410	1992	0
Master	68	0	1989	0
Baniang	80	150	1999	51%
Agriconcept	100	80	2002	0
ANS interexport	64	0	2001	0
Pasen	30	0	2000	0
Agral export	180	0	1992	0
PDG	173	239	1993	0

[a] FB: French beans.
[b] FFV: Fresh fruits and vegetables.

(a) *Increased consolidation*

Because of financial constraints, only larger firms are able to comply with increasingly stringent food standards. Since 1994, most exporters are member of the organization SEPAS[6] which coordinates transport, provides market information, and assists its members in the contact with overseas buyers. However, following the increasing EU standards, the seven largest FFV exporters founded the organization ONAPES[7] in 1999. One of their specific aims was to comply with traceability standards and become EurepGAP certified. Four ONAPES companies are in our sample (Table 2) among which one is EurepGAP and HACCP certified (since 2004). Three other firms are in the process of certification and made substantial investments for this in the past couple of years. The remaining exporters, mainly smaller ones, are not certified and not undertaking particular investments in the scope of certification.

As a result, since 2000, the export sector is consolidating with mainly smaller exporters dropping out. While the number of French bean exporting companies dropped from 27 to 20 firms in the past three years, the market share of the three largest companies increased from less than half in 2002 to two-thirds in 2005.

Table 2. *Changing procurement of selected horticulture exporting companies*

Company name	Organization membership	% of Supply from smallholder contract-farming	
		First year of operation	Last season
Soleil Vert	ONAPES[a]	100	20
Sepam	ONAPES	100	60
Master	ONAPES	50	40
Baniang	ONAPES	85	85
Agriconcept	SEPAS[b]	30	30
ANS interexport	SEPAS	100	100
Pasen	SEPAS	100	60
Agral export	SEPAS	100	100
PDG	SEPAS	100	100

[a] ONAPES—*Organization National des Producteurs Exportateurs de Fruits et Légumes de Sénégal.*
[b] SEPAS—*Syndicat des Exportateurs des produits Agricoles.*

(b) *Increased vertical coordination*

Vertical coordination increased, both downstream and upstream. First, FFV exporters—especially larger firms—increasingly engage in tighter coordination with downstream importers and wholesalers in the EU market. Smaller exporters deal with importers through non-binding indicative agreements on the supplied quantity. Larger exporters have recently changed to more binding contracts with overseas buyers; including price, quantity and timing of delivery, and sometimes also pre-financing. Exporters mention the volatility of EU market prices and the incidence of produce refusal by importers to be the main reasons to engage in tighter coordination.

Second, to guarantee product quality, food safety, and traceability throughout the supply chain and to assure accurate timing of production and harvesting exporters—especially larger firms—increasingly rely on tighter vertical coordination with upstream suppliers of primary produce. This occurs in two ways. The first is through more elaborate production contracts and tighter coordination within those contracts. Contracts signed with small family farms are typically specified for one season—lasting from November to April—and indicate the area to be planted—usually 0.5 or 1 ha—all technical requirements, and the price. As part of the contract, the firms provide technical assistance and inputs to the farmers; especially seeds and chemicals, sometimes also cash credit. Some firms go as far in contract-coordination as the complete management of fertilizer and pesticide application and daily or weekly inspection of the farmers' fields. Also field preparation, planting and/or harvesting can be coordinated and financed completely by the contractor firm. Especially larger exporters provide pre-financing and apply tighter contract-coordination while smaller exporters leave management decisions to the farmers.

A second, and even more radical, change toward vertical coordination is the shift from smallholder contract-based farming to large-scale estate production. Larger exporters are increasingly engaging in fully integrated estate production. In fact, the ONAPES exporting companies have agreed among themselves that each member should seek to process every season a volume of at least 200 ton of which at least 50% should originate from the companies own estate production—a measure that is having a profound impact on the structure of the export supply chain. Three firms in our sample have already substantially reduced procurement through smallholder contract farming: from 100% in their first year of operation to, respectively, 60% and 20% in the last season (Table 2). These companies cited quality rather than quantity to be the reason for this change. Also other firms in the sample mentioned fully integrated production to be an important strategy for compliance with food standards in the future and hence for the survival and growth of the firm.

An important issue to note is that the expansion of estate production is not happening at the expense of smallholder landholdings. Companies seeking to expand estate production either buy or rent land from large commercial farms, integrate with these farms, or invest in uncultivated land belonging to the government. In addition, the competition for resources between French bean export production and more traditional agricultural production is limited as export production is concentrated in one season (from November till April), which does not coincide with the main "rainy" agricultural season—during which a variety of traditional food and cash crops are cultivated.

4. HOUSEHOLD PARTICIPATION AND WELFARE IN FFV EXPORT PRODUCTION

It is generally argued in the literature that increased vertical integration in modern supply chains leads to the marginalization of small farmers, resulting in detrimental welfare and poverty effects. The analysis in this and subsequent sections show that this has not been the case in Senegal.

(a) *Survey and data*

To measure the effects of FFV exports for local households, we organized in August–September 2005 a large household survey in the main horticulture zone *Les Niayes*—from where over 90% of exported French beans originate (Gergely, 2001). The majority of households in this area are smallholder horticulture farmers producing—next to French beans for export—a large variety of vegetables and basic food crops for the local market and for direct consumption (Fall & Fall, 2000).

The research area includes three rural communities in the regions Dakar and Thiès—Sangalkam, Diender, and Noto (Figure 2)—where the interviewed exporting companies source produce and recruit laborers from. As the rural community is the smallest administrative unit in Senegal and no systematic information was available on the exact location (village or "*localité*") of export producers, we randomly selected 25 of the 115 villages in these three rural communities. From company-level information we estimated the total number of smallholder French bean producers to be close to 1,000 in 2005 (at the time of the survey). To assure a sufficient coverage in the data we used a stratification method aimed at including sufficient French bean producers. The remainder of the sample was drawn from non-French bean producers. A total of 300 households of the almost 2,500 households in the 15 villages were included in the sample. Of these 300 households, 59 produced French beans on contract with an agro-exporting company during the 2005 export season. To correct for oversampling of French bean producers and draw correct inferences we apply a procedure described by Deaton (1997) and use sampling weights calculated as the inverse of the probability of French bean producers and non-French bean producers to be included in the sample.

The sample represents small household farms in the area. The average farm size is 5 ha and 88% of the sampled households cultivate less than 10 ha—which is in the region considered as the threshold to be classified as a smallholder (Fall & Fall, 2000). The sampled households hold diversified income portfolios with agriculture constituting on average more than 80% of total household income.

The survey data—including recall data—provide details on household demographic characteristics, land and non-land asset holdings, agricultural production, off-farm employment, non-labor income, credit, and savings; and allow calculating household net income from farm and off-farm sources. In addition, detailed and recall questions were asked on the participation of households in French bean (FB) export production through contracts with or employment in the FFV export industry. From this information we classified the surveyed households according to their participation in FB exports: *contract farmers* are households where one of the members—usually the household head—holds a contract for FB production with an agro-industrial exporter; *agro-industrial employees* are households where one or more members work as employees in the FB export agro-business; and *non-participants* are households not participating in FB export production.

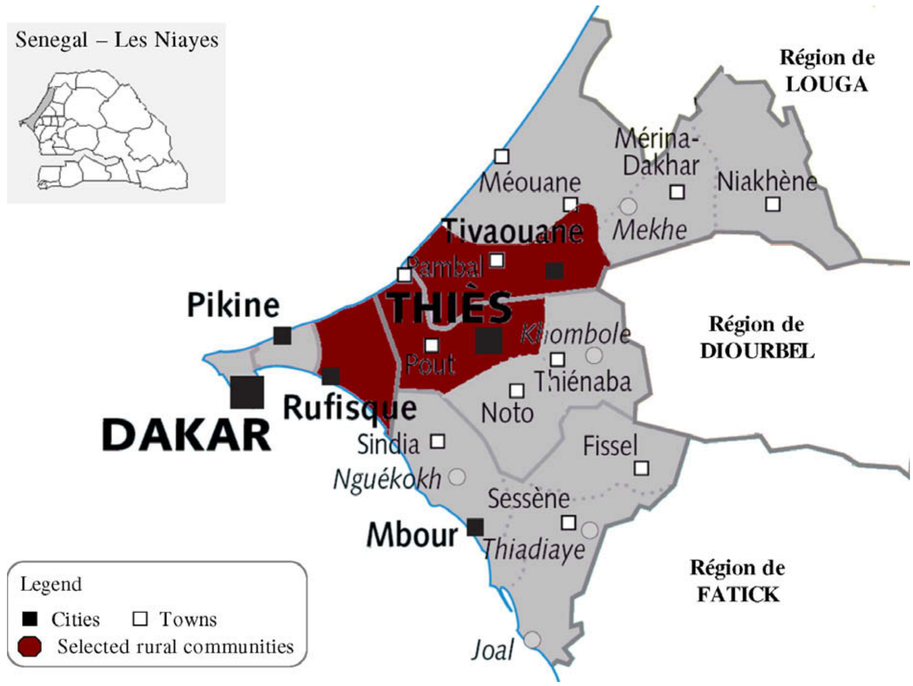

Figure 2. *Research area: selected rural communities for a household survey. Source: Map from Atlas du Sénégal—IRD—Cartographie A. LE FUR—AFDEC.*

(b) *Household participation*

Along with increasing exports also the participation of rural Senegalese households in French bean (FB) production increased dramatically over the past 15 years. Based on company level data for the 2005 season, we estimate that almost 1,000 farmers produce French beans on contract and that the FB export industry employs almost 12,000 workers. In the 15 sampled villages, the share of households involved in FB production and processing increased from less than 10% in 1991 to 40% in 2005 (Figure 3). However, as a result of increasing exports and standards-induced structural changes in the supply chain the nature of increased household participation differed strongly in the 1990s from more recent years. During the 1990s local farm-households increasingly took part in export production through contract farming while from 2000 onwards the incidence of contract farming decreased sharply. In 2000 an estimated 23% of households in the sampled villages were contracted to produce beans for export but that Figure decreased to slightly less than 10% in 2005 (Figure 3). Yet, in the period 2000–05 employment on the fields and in the conditioning centers of FB exporting companies increased sharply. In 2005, 34% of households in the sampled villages had one or several members working as employee in the FB agro-industry while this was less than 10% in 2000 (Figure 3). As a result of supply chain restructuring since 2000, 72% of contracted farmers in the sampled villages lost their FB contract. Almost half of them (43%) started to work as agro-industrial employees. The exporting firms that dissolved the contracts either exited the market or started their own estate production. Still, on aggregate, participation of rural households in high-standards FB exports continues to increase with their role shifting from contract farmers to agro-industrial employees.

Export growth and the shift from smallholder contract farming to integrated estate farming has important implications for the distribution of rural incomes, which we analyze

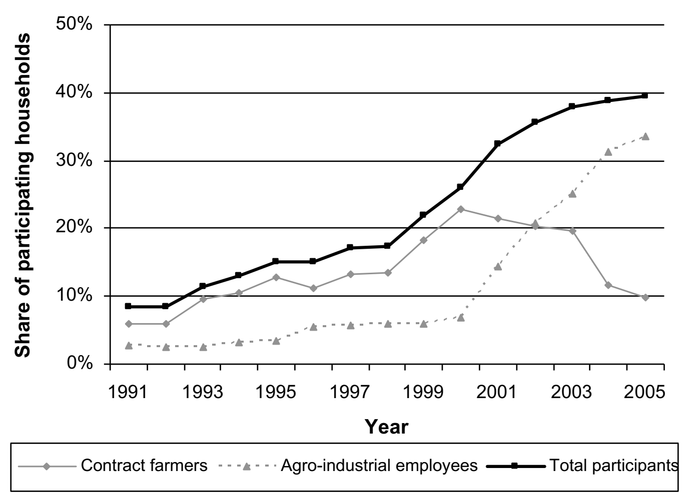

Figure 3. *Household participation in French bean export production, 1991–2005. Contract farmers are households where one of the members—usually the household head—holds a contract for the production of French beans with an agro-industrial exporter. Agro-industrial employees are households where one or more members work as employees in the French bean export agro-business. The figure is based on recall data collected in 2005. To account for demographic effects, households for which the household head did not reach the age of 25 in a particular year and households who migrated to the area after a particular year are not taken into account for the figures of that year.*

in detail in the next sections. However, before turning to this analysis, it is important to note that the shifting role of households in FB export production should not be perceived as an absolute change in household status from independent farmers to subordinate workers. Farm-households generally allocate only part of their land and/or labor and only in a confined export season to export activities—thereby continuing to primarily be independent smallholders.

(c) *Characteristics of FFV producers*

The distributional implications of high-standards FFV exports critically depend on the participation of poorer households in the supply chain. In Table 3 we compare the characteristics of households who do not participate at all in FB production and processing (non-participants), households with one or more members employed in the FB agro-industry (agro-industrial employees), and households producing French beans on contract (contract farmers)—and find that there is substantial differences in their human, physical, and social capital. First, both contract farmers and agro-industrial employees come from households with significantly more laborers and a slightly higher education. Participants in agro-industrial employment are slightly older households while contract farmers have fewer dependents. No female-headed households are involved in contract farming. Second, contract farmers have significantly larger farms—6.8 ha compared to 4.9 ha for non-participating households—and more livestock—4.1 units compared to 2.9 units. These comparatively larger contracted farms are in *per capita* terms, however, still small with 1 ha of land *per capita* – compared to 0.83 ha for non-participating households. Agro-industrial workers have less land—0.78 ha *per capita*—less livestock—1.8 units—and less non-land assets—176 thousand FCFA compared to 320 thousand FCFA for other households. Third, among the agro-industrial employees there are less ethnic minority households. More contracted farmers are a member of a farmers' organization. Fourth, in the region Dakar—which is closer to exporting companies and shipping facilities—there are more farmers involved in FB export production than in Thiès.

(d) *Income and poverty*

The participation of rural households in FFV export production is associated with sharp welfare differences. We measure welfare using household total and *per capita* income, which is calculated from the survey data for the 12-month period prior to the survey and using the modified OECD adult equivalence scale for *per capita* measures. We lack the data to use expenditures or consumption as a welfare measure, which is the preferred approach because expenditures are less susceptible to seasonal and yearly fluctuations (Deaton, 2001). The income approach to welfare measurement is widely used in the empirical literature (e.g., Verpoorten & Berlage, 2007) and provides the best alternative if expenditure data are lacking (Deaton, 2001). Further, we calculate the proportion of households living with *per capita* incomes that fall below the national rural poverty line. In order to compare the 2005 income data from our survey with the poverty lines constructed from the ESAM I and II surveys in 1994 and 2002 (République du Sénégal, 2004), we follow the standard approach explained by Deaton (2001, 2008) by using consumer price indices (African Development Bank, 2006) to update the poverty lines. The updated poverty lines are 143,080 FCFA/*capita* for poverty and 31,812 FCFA/*capita* for extreme poverty.

A simple comparison of means reveals large differences in household income: 1.8 million FCFA for non-participating households compared to 4.5 million and 6.4 million for agro-industrial employees and FB contract farmers, respec-

Table 3. *Comparison of household characteristics for contract farmers, agro-industrial employees and non-participants in French bean export production*

	Total sample	Non-participants	Agro-industrial employees	Contract farmers
Number of households in the sample	300	158	109	59
Human capital				
Age of the household head	54	53	56*	53
Number of laborers	6.9	6.4	7.7***	7.7***
Dependency ratio[a]	0.568	0.571	0.566	0.527*
Female headed households	3.0%	3.3%	2.8%	0%*
Household head with primary education	17.6%	16.5%	18.8%	19.4%
Physical capital				
Farm size (ha)	5.03	4.92	5.05	6.82***
Per capita landholdings[b] (ha)	0.83	0.84	0.78	1.03**
Units of livestock[c]	2.64	2.87	1.84	4.14**
Value of non-land assets[d] (1,000 FCFA)	270.7	320.9	176.9	308.8
Social capital				
Ethnicity (non-Wolof)[e]	27%	31%	17%***	32%
Membership of a farmer's union	58%	54%	62%**	77%***
Location				
Dakar region	50%	42%	60%***	67%***

Non-participants are households who do not participate at all in French bean (FB) production and processing; *agro-industrial employees* are households with one or more members employed in the FB agro-industry; and *contract farmers* are households producing FB on contract with the agro-industry. Twenty-six households are in both categories, *agro-industrial employees* and *contract farmers*.

Characteristics of agro-industrial employees and contract farmers are compared to those of non-participating households using *t*-test. Significant differences are indicated with $^{*}p < .1$; $^{**}p < .05$; $^{***}p < .01$.

[a] Dependency ratio is calculated as the number of dependents (children below the age of 15, students and those unable to work) over the total household size.

[b] *Per capita* landholdings are calculated using the modified OECD adult equivalence scales.

[c] One livestock unit equals 1 cow, 0.8 donkey, and 0.2 sheep/goat.

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

[e] Non-Wolof households refer to ethnic minorities in Senegal.

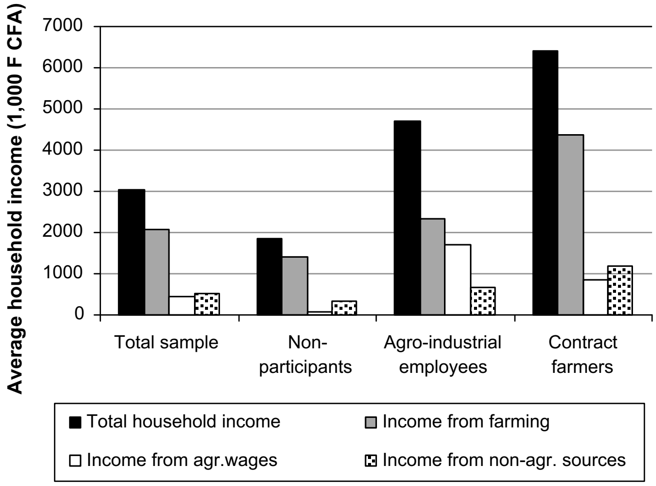

Figure 4. *Average household income from different sources for contract farmers, agro-industrial employees and non-participants in French bean export production. Household income is yearly income calculated for the 12 month period prior to the survey, July 2004–05. Farm income is calculated taking into account total production (valued at market prices) in three different seasons ("hivernage" 2004; "contre-saison chaude" 2004–05, and "contre-saison froide" 2005), the cost of variable inputs, cost of hired labor, and the depreciation of machinery and equipment Agricultural wage income includes wages earned in the export agro-industry (80%) and other agricultural wages (20%). Income from non-agricultural sources includes wages from non-agricultural employment; income from small businesses—mostly small trading activities; and non-labor income—mostly remittances.*

tively (Figure 4). These differences in income remain large in *per capita* terms: the average *per capita* income for agro-industrial employees is 552,000 FCFA and for contract farmers 924,000 FCFA, which is, respectively, double and more than triple the *per capita* income of non-participating households (266,000 FCFA). On average, agriculture is the main source of income in the area and two-thirds of household income is derived from own farming (Figure 4). Yet, agro-industrial employees derive more than one-third of their income from agricultural wages—mainly (more then 80%) earned in the vegetable export agro-industry—while still having farm incomes that are higher than non-participating households.

The incidence of poverty in the research area is estimated to be 42%—which is considerably lower than the national rural poverty rate of 58%. Poverty is much higher among households who do not participate in export production (47%) than among households employed in the export agro-industry (40%) and especially among FB contract farmers (13%) (Figure 5). The incidence of extreme poverty is 12% in the surveyed region but is much lower among households involved in FB export production—5% among agro-industrial employees and 2% among contract farmers—than among non-participating households (17%).

In conclusion, both relatively larger farms or better-off households, and poorer households participate in high-standards vegetable production but the former rather as contract farmers and the latter as agro-industrial employees while both have incomes that are substantially higher than for non-participating households. These correlations suggest that the current structure of the export supply chain with the coexistence of smallholder contract-based production and large-scale estate farming guarantees a more equitable participation in the export supply chain and translates into a more equitable distribution of the gains from high-standards exports.

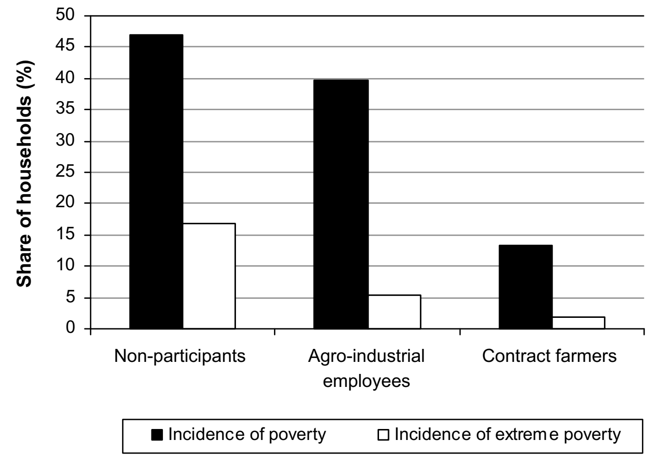

Figure 5. *The incidence of poverty and extreme poverty across contract farmers, estate employees and non-participants in horticulture export production.*

5. ECONOMETRIC ANALYSIS OF INCOME EFFECTS

The data and descriptive analysis presented in the previous section show substantial differences in income across households. However, based on a simple comparison of means it is impossible to identify causality and to satisfactorily attribute these differences to the impact of vegetable export production. In this section we present a comprehensive econometric analysis to address this causality and analyze the overall income effects of participation in French bean export production. Before going to the actual analysis, we need to emphasize that both participating and non-participating households may be influenced by FB supply chains and exports—for example, through price effects in product market, and technology spillovers. For example Swinnen, Vercammen, and Rozelle (2008) have identified several mechanisms of such indirect effects. We measure specifically the overall income effects of participating households without distinguishing between separate mechanisms.

We first discuss the potential sources of selection bias and present three different methods we use to correct for this bias. We then discuss the results and perform some robustness and sensitivity checks.

(a) *Selection bias*

There are various potential sources of selection bias that obscure the causal relation because participation in FFV export production is likely to be non-random. First, households can decide—based on their access to resources and their preferences—to participate and self-select into contract farming or into agro-industrial employment. Second, exporting companies might select or exclude potential employees and potential contractors based on their skills, access to resources, *etc.* Third, there might be some geographic selection because firms face increasing transaction costs in sourcing from distant (or isolated) farmers or because workers' travel costs increase with distance from employment location.

The possibility to correct for selection bias crucially depends on the availability of observable covariates that are correlated with selection into contract farming or estate employment, and/or with the outcome variable of interest—household income. Observable characteristics related to households' access to resources (land, capital, and labor); their access to information (membership of a farmers' union); their skills and ability (age, education); their preferences (age, ethnicity, demographic structure); and geographic location (village, region) are hence potential covariates for selection adjustment. Variables that are correlated with selection into contract farming or agro-industrial employment and/or household income are identified in Table 4. To avoid endogeneity problems some potentially relevant but likely endogenous covariates (such as livestock holdings and farm assets) are not considered while lagged variables—based on recall data—are considered for the covariates land and union membership (Table 4).

(b) *Correction for selection bias*

To correct for potential selection bias we apply regression and matching techniques from the average treatment effects literature[8] in estimating the impact of two treatments—participation in employment in the FB agro-industry (W_1) and in FB contract farming (W_2)—on household income (Y). We are ultimately interested in estimating the average treatment effects ATE_1 and ATE_2 with Y_1 and Y_2 representing the income with treatment, and Y_0 the income without treatment

$$\text{ATE}_1 = E(Y_1 - Y_0) \quad \text{for } W_1 = 1 \text{ : agro-industrial employment} \tag{1}$$

$$\text{ATE}_2 = E(Y_2 - Y_0) \quad \text{for } W_2 1 \text{ : contract farming} \tag{2}$$

We hypothesize that high-standards FFV exports has positive welfare implications and hence expect both ATEs to be significantly positive.

We are dealing with two treatments W_1 and W_2 that are not mutually exclusive as 26 households are involved in both contract farming and estate employment. The literature generally deals with describing methods (regression, matching and propensity score methods) for estimating the ATE for one single treatment. These methods logically extend for multiple (mutually exclusive) treatments as long as the basic assumptions apply to the vector of treatments (Lechner, 2000; Wooldridge, 2004)—an issue addressed in the next section. To account for the fact that the two treatments are mutually non-exclusive, we redefine the treatments such that they are mutually exclusive as follows:

$$\text{ATE}'_1 = E(Y_1 - Y_0) \quad \text{for } (W_1 = 1, W_2 = 0) : \text{ agro-industrial employment} \tag{3}$$

$$\text{ATE}'_2 = E(Y_2 - Y_0) \quad \text{for } (W_1 = 0, W_2 = 1) : \text{ contract farming} \tag{4}$$

$$\text{ATE}'_3 = E(Y_3 - Y_0) \quad \text{for } (W_1 = 1, W_2 = 1) : \text{ agro}-\text{industrial employment and contract farming} \tag{5}$$

In a first model—referred to as *regression on covariates*—we control for selection bias by including a large set of observable covariates (X) as control functions in the regression on household income.

$$\text{For}(W_1 = 1, W_2 = 0) : Y_i = \theta + \alpha_1 + \beta X_i + \varepsilon_i \tag{6}$$

$$\text{For}(W_1 = 0, W_2 = 1) : Y_i = \theta + \alpha_2 + \beta X_i + \varepsilon_i \tag{7}$$

$$\text{For}(W_1 = 1, W_2 = 1) : Y_i = \theta + \alpha_1 + \alpha_2 + \alpha_3 + \beta X_i + \varepsilon_i \tag{8}$$

To correctly identify the average treatment effects ATE_1 and ATE_2 we assume that $\alpha_3 = 0$; indicating that there are no additional income effects from being involved in both FB contract farming and agro-industrial employment. Hence, the ATEs can be estimated with OLS as the regression coefficients on W_1 and W_2 (Imbens, 2004; Wooldridge, 2002) in the following model—where the vector X includes all the covariates identified in Table 4 to be correlated with selection into treatment and/or household income, including also village dummies:

$$Y_i = \theta + \alpha_1 W_{1i} + \alpha_2 W_{2i} + \beta X_i + \varepsilon_i \quad \forall i \tag{MODELI}$$

In addition to correcting for a large number of relevant covariates directly,[9] adjustments can be made based on the propensity score—defined as the conditional probability of receiving treatment (Dehejia & Wahba, 2002; Imbens, 2004)—a method pioneered by Rosenbaum and Rubin (1983). As we have two

Table 4. *Observable covariates for selection bias adjustment*

Description of covariates			Sample mean	Correlation coefficient with outcome and treatment variables		
				Household income	Employment in FB agro-industry	FB contract farming
Continious variables						
Land	Household landholdings in 1995[a]		4.24	0.121^{**}	0.056	0.162^{***}
Labor	Household labor endowments		6.9	0.219^{***}	0.202^{***}	0.143^{**}
Age	Age of the household head		54	−0.084	0.109^{*}	−0.014
D-Ratio	Dependency ratio[b]		0.57	0.005	−0.023	-0.100^{*}
Dummy variables						
Education	Hh head with primary education		0.18	0.106^{*}	−0.057	0.033
Ethnicity	Non-Wolof households		0.27	−0.092	-0.171^{***}	0.027
Union	Membership of farmers' union in 1995[1]		0.31	0.022	-0.125^{**}	0.097^{*}
Region	Dakar region		0.50	−0.009	0.143^{**}	0.053
Village_{1-25}	Village dummies[c]	Lowest corr.		−0.076	-0.162^{***}	-0.109^{*}
		Highest corr.		0.400^{***}	0.161^{***}	0.361^{***}

$^{*}p < .1$; $^{**}p < .05$; $^{***}p < .01$.
[a] Data for 1995 are based on recall survey information.
[b] Dependency ratio is calculated as the number of dependents (children below the age of 15, students, and those unable to work) over the total household size.
[c] Instead of reporting all correlation coefficients for all 25 villages in the sample, we only report the correlation coefficients for those village dummies with lowest correlation and those with the highest correlation with the outcome and treatment variables. The correlations coefficients for the other village dummies are then between those two extremes.

Table 5. *Estimated treatment effects using regression, matching, and propensity score methods*

	Estimated treatment effects	
	W_1: Employment in FB agro-industry	W_2: FB contract farming
Model 1: Regression on covariates	1.95^{**} (0.912)	3.36^{**} (1.358)
Model II: Regression on propensity scores[1]	1.83^{**} (0.829)	3.35^{**} (1.272)
Model III: Matching on propensity scores[1]	1.90^{**} (1.042)	4.26^{***} (1.559)

$^{*}p < .1$; $^{**}p < .05$; $^{***}p < .01$ (numbers) are standard errors, 1 standard errors are bootstrapped.
Total household income is measured in million FCFA.

different treatments that are not mutually exclusive, we use a bivariate probit model to estimate the propensity scores. Covariates that are significantly (at the 5% level) correlated with the treatment indicator and/or the outcome variable are included as explanatory variables (Table 5). This specification assures that overlap assumptions and balancing properties are satisfied, which is addressed in detail in the following subsections.

In a second model—referred to as *regression on the propensity score*—we use the estimated marginal probabilities (p) as additional propensity score (PS) correction functions in the regression of W_1, W_2, and X on household income. Here again, the ATEs can be estimated using OLS (Imbens, 2004; Wooldridge, 2002)

$$Y_i = \theta + \alpha_1 W_{1i} + \alpha_2 W_{2i} + \phi_1 PS_{1i} + \phi_2 PS_{2i} + \beta X + \varepsilon_i \qquad \text{(MODELII)}$$

with $PS_1 = \hat{p}(W_1 = 1|X)$; $PS_2 = \hat{p}(W_2 = 1|X)$.

Thirdly, we estimate the ATEs with a *propensity-score matching* method. Matching involves pairing treatment and comparison units that are similar in terms of their observable characteristics (Abadie & Imbens, 2002; Dehejia & Wahba, 2002). As the dimensionality of the set of potentially relevant observable covariates X is large, matching directly on the covariates is not straightforward. Therefore, we match treated and control units according to the estimated propensity score and calculate the ATEs as a weighted average of the outcome difference between treated and matched controls as in Dehejia and Wahba [10] (2002). We use single-nearest-neighbor matching, which according to Imbens (2004) leads to the most credible inferences with the least bias. Matching is done with replacement as to assure that each treatment unit is matched to the nearest comparison unit, which reduces bias (Dehejia & Wahba, 2002). Moreover, only observations in the common support region—where the propensity score of the treated units is not higher than the maximum or less than the minimum propensity score of the control units—are used for calculating the ATEs (Becker & Ichino, 2005). The propensity matching method estimates the ATEs as follows:

$$ATE_1 = \frac{1}{N_1}\sum_{i\in N_1}(Y_{1i} - Y_j);$$

$$ATE_2 = \frac{1}{N_2}\sum_{i\in N_2}(Y_{2i} - Y_j), \qquad \text{(MODELIII)}$$

with N, the number of treated units Y_j, the income of the control unit $C(i)$ that is matched to the treated unit i: $C_1\ (i) = \min_{j\in C}\|PS_{1i} - PS_{1j}\|$; $C_2(i) = \min_{j\in C}\|PS_{2i} - PS_{2j}\|$ and with $PS_1 = \hat{p}(W_1 = 1, W_2 = 0|X)$; $PS_2 = \hat{p}(W_1 = 0, W_2 = 1|X)$.

To deal with the two mutually non-exclusive treatments in this matching method we define the treatment group N_1 (83) as households only participating in employment in the FB agro-industry; the treatment group N_2 (32) as households participating in FB contract farming; and the control group C (159) as those households not participating in export production. Matching between treated and controls is done on the propensity scores estimated as bivariate probabilities from the bivariate probit model specified above.

(c) *Results and discussion*

The estimation results are presented in Tables 5 and 6 and Table A1 in appendix. The main results, that is, the estimated treatment effects, are summarized in Table 5. This summary reveals that the applied regression, matching, and propensity score methods yield qualitatively identical and quantitatively similar estimations of the treatment effects—which indicates that the estimated effects are robust to changes in the econometric approach. The estimated coefficients of the covariates in the full structural regression models I and II are presented in appendix Table A1. The results of the bivariate probit model estimating the propensity scores used in models II and III are presented in Table 6. We discuss these results in turn.

First, the estimated effects for both treatments—agro-industrial employment and FB contract farming—are significantly

Table 6. *Propensity score estimated using a bivariate probit model*

Treatment	W_1: Employment in FB agro-industry		W_2: FB contract farming	
Covariate	Coefficient	Robust Std. Err.	Coefficient	Robust Std. Err.
Land	0.014	0.020	0.036^{**}	0.017
Labor	0.353^{***}	0.123	0.050^{**}	0.025
Labor^2	-0.017^{**}	0.008		
Ethnicity	-0.453^{**}	0.183		
Union	-0.570^{***}	0.189		
Region	0.491^{***}	0.174	0.584^{***}	0.175
Constant	-1.908^{***}	0.480	-2.151^{***}	0.257
rho	0.112	0.106		
Wald test rho = 0: $\chi^2(1) = 1.096$;	Prob > $\chi^2 = 0.296$			

$^{*}p < .1$; $^{**}p < .05$; $^{***}p < .01$.

(at the 5% level) positive (Table 5). This confirms our hypothesis that participation in FFV export production, whether through contract farming or through agro-industrial employment, has positive effects on rural incomes. After correction for potential selection bias (and taking the most conservative among the three estimators) we estimate that employment in the FB agro-industry increases household income with 1.9 million FCFA and FB contract farming with about 3.3 million FCFA. So, participants in FB export production have incomes that are 60% to 110% higher than the average income in the research area—indicating very strong positive effects. The estimations indicate that the impact on household income from FB contract farming is significantly higher than the impact from FB agro-industrial employment.

Second, the structural models I and II (table A1) indicate that, apart from French bean contract farming and agro-industrial employment, labor endowments and education levels have significant positive effects on household income. This is in line with the expectations. Some of the village dummies, most notably village 5, have very high coefficients in the structural models. A detailed analysis of the data suggests that these estimated effects reflect geographic, infrastructure, institutional, and ecological differences across the sampled villages. For example village 5 is, of all sampled villages, located nearest to an urban center (Rufisque) and to Dakar. Moreover, 80% of the household plots in village 5 are connected to an advanced irrigation and drainage system while for the other villages in the sample this is generally less than 10%, often even 0%. These findings confirm the importance of including village fixed effects to correct for potential differences in infrastructure, institutions, and geography. However, to further assess how influential these differences across villages are for the overall estimated effects we did some additional robustness tests (see further section d).

Third, the results of the bivariate probit model (Table 6) confirm that FB contract farming is biased toward households with initially larger farms while agro-industrial employment is not. Every additional hectare of initial (1995) landholdings increases the likelihood of a household having a contract for FB export production with 3.5%. There is no significant effect of initial landholdings on the probability of being an agro-industrial worker which indicates that also the smallest farmers participate in such employment. The results further indicate that larger households with more labor endowments and households in the Dakar region—closer to exporting companies—are more likely to be involved in FB export production, through contract and/or employment. Also ethnicity and membership of a farmers' organization influence selection into agro-industrial employment.

(d) *Robustness tests*

(i) *Assessing the underlying assumptions*

The applied regression and matching methods can yield unbiased estimates of the income effect of FB contract farming and agro-industrial employment subject to two main assumptions (Wooldridge, 2002). The first assumption—referred to as conditional independence [11] (CI)—denotes that, conditional upon observable covariates, the receipt of treatment is independent of the potential outcomes with and without treatment (Dehejia & Wahba, 2002; Imbens, 2004). Hence, participation in FB contract farming and/or agro-industrial employment cannot depend on unobservable characteristics that are arbitrarily correlated with household income. [12] This assumption is not directly testable [13] but Ichino *et al.* (2006) proposed a method for addressing robustness of matching estimators to failure of the CI assumption. The method simulates a binary confounder in the data that is used as an additional matching factor. [14] We use the method with a neutral confounder and with confounders calibrated to mimic observable binary covariates as in Ichino *et al.* (2006). The results (Table 7) show that the estimators with binary confounder differ by less than 5% from the baseline matching estimator for treatment 1 and by less than 10% for treatment 2. This is an indication of the robustness of the ATE estimates and the validity of the CI assumption.

The second key assumption in estimating ATE requires sufficient overlap and balancing in the covariate distribution between treated and untreated observations (Dehejia & Wahba, 2002; Imbens, 2004). If participating and non-participating households differ substantially in observable characteristics, the ATE is difficult to estimate—whether using regression, matching, or propensity score methods. Figure 6 compares the distribution of the propensity scores between treated and untreated (control) observations for both treatments. The estimated propensity scores are strictly between 0 and 1—which is the first requirement (Imbens, 2004)—and show distributions with sufficient overlap between treated and control units and

Table 7. *Simulation-based sensitivity analysis for propensity score matching estimators*[a]

	Estimated treatment effect	Outcome effect[b]	Selection effect[c]
Treatment W^1: FFV estate employment			
Baseline propensity score matching estimator (Model III)	1.896		
Matching estimators with simulated binary confounder			
Neutral confounder	1.951	1.845	1.026
Confounder calibrated to mimic Ethnicity	2.003	1.139	0.487
Confounder calibrated to mimic Union	1.986	1.323	0.466
Confounder calibrated to mimic Region	1.907	2.169	2.010
Treatment W_2: FFV contract farming			
Baseline propensity score matching estimator (Model III)	4.265		
Matching estimators with simulated binary confounder			
Neutral confounder	4.645	1.498	1.126
Confounder calibrated to mimic Region	4.759	1.648	1.536

[a] The method is described by Ichino *et al.* (2006) and builds on Rosenbaum and Rubin (1983) and Rosenbaum (1987). It is supposed that the conditional independence assumption is not satisfied but that it would be satisfied if an additional binary variable could be observed. The method simulates this binary confounder in the data that is used as an additional matching factor. A comparison of the estimates obtained with and without matching on the simulated confounder informs to what extent the estimator is robust to this specific source of failure of the conditional independence assumption (Ichino *et al.*, 2006).
[b] The outcome effect measures the estimated effect of the simulated binary confounder on the outcome variable—household income.
[c] The selection effect measures the estimated effect of the simulated binary confounder on the selection into treatment.

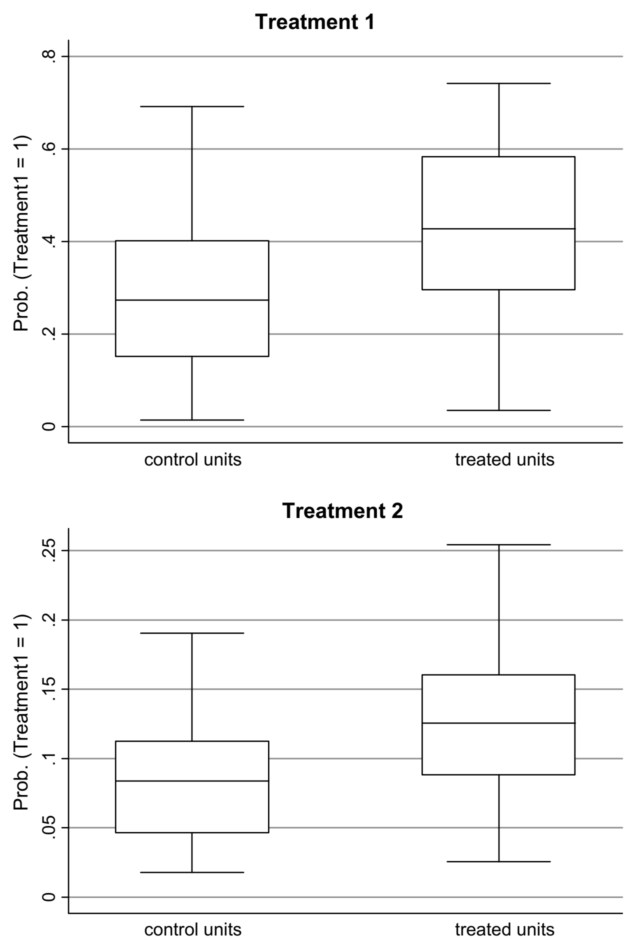

Figure 6. *Distribution of propensity scores over control and treated units. Treatment 1: Employment in the FB agro-industry Treatment 2: FB contract farming.*

with a sufficiently large region of common support—where the propensity score of the treated units is not higher than the maximum or less than the minimum propensity score of the control units. Moreover, we address balancing properties by testing for equality of means between treated and (matched) control units for all relevant covariates. The results of this test (Table 8) show that there is a strong bias for most covariates but that matching eliminates this bias such that there is a good balance in covariate distribution between treated and matched control units (for both treatments) (see Figure 7).

(ii) *Sensitivity to the choice of covariates*

The literature on ATE and propensity score methods emphasizes the importance of including a "proper" set of covariates (e.g., Becker & Ichino, 2005; Dehejia & Wahba, 2002; Imbens, 2004). The results of ATE estimations may be sensitive to different specifications of conditioning variables, but little is known about strategic covariate choice (Imbens, 2004). The generally applied strategy is to include covariates that are highly correlated with treatment indicators and/or the outcome variable—as we did in the baseline models specified above. To test the sensitivity of our baseline results we additionally estimate the ATEs using alternative sets of covariates and model specifications. The estimated ATEs using these alternative specifications (Table 9) are qualitatively and quantitatively very similar to the estimates in the baseline models—which is an indication that the results are robust to the choice of covariates.

(iii) *Sensitivity to influential observations*

Influential observations might bias estimation results. To rule out the possibility that our treatment effect estimations are influenced by the rather atypical observations in village 5 (see the discussion in Section (c)), we re-estimate models I and II excluding all ten observations in village 5. Comparing these results (Table A2) with the earlier derived results (Table A1) shows that the estimated effects are qualitatively and quantitatively similar. The estimated effect of contract farming is somewhat lower due to the fact that 4 out of the ten deleted observations are contract farmers combined with the fact that farmers in village 5 have better access to infrastructure leading to generally higher incomes. This suggests that part of the beneficial impact of contract farming might be concentrated in villages with better access to modern infrastructure. However, the effects without village 5 are still significant and large, corroborating our main results.

(e) *Summary*

In summary, the results from the econometric analysis are found to be robust to different estimation techniques and alternative model specifications. The findings imply that (a) participation in high-standards agricultural trade significantly contributes to rural incomes; (b) this income effect is larger for contract farmers than for agro-industrial workers; (c) participation in contract farming is biased toward the relatively larger farms among the smallholders while participation as employee is not. In the next section we examine how these findings translate into poverty effects.

6. SIMULATION OF POVERTY AND INEQUALITY EFFECTS

To assess the poverty effects, we simulate household income for two alternative scenarios and compare the outcomes with the actual income situation. Ideally, the poverty impact of FB exports should be measured by looking at households' economic mobility and changes in poverty over time. However, since we only have cross-sectional data, we use a simulation exercise to assess the poverty effects based on the estimated coefficients. For the first scenario ("No Exports") both participation variables W_1 and W_2 are set to zero for all households in the sample, which simulates a situation in which there would be no exports of French beans at all. The second scenario ("Contract") corresponds to the case where FB exports would have been mainly realized through contract farming—as was the case till 2000 before increasing standards induced a shift from smallholder contract farming to large-scale estate farming. For this scenario participation in contract farming W_2 is set as if none of the farmers who had a contract in 2000 lost their contract in the period 2000–05, and participation in agro-industrial employment W_1 is set as it was in 2000. For these two scenarios we simulate household income based on the results of the baseline propensity score matching estimator (model III), calculate *per capita* incomes, and derive poverty indicators.

The results are striking (Figure 6). First, the incidence of poverty in the sampled villages is estimated to be 14% points lower due to high-standards vegetable exports. Without the possibility for rural households to participate in high-standards export production (*No Export* scenario), the incidence

Table 8. *Balancing properties of covariates in treated and control groups*

Covariate	Sample	Mean treated units	Mean control units	% Bias between treated and controls	% Reduction in bias	*t*-Test Mean(treated) = Mean (control)	
						t	Prob. > |*t*|
Treatment W_1: Employment in FB agro-industry							
Land	Unmatched	3.765	3.676	2		0.15	0.883
	Matched	3.858	3.932	−1.7	17.2	−0.10	0.924
Labor	Unmatched	7.482	6.153	43.5		3.18	0.002
	Matched	7.432	6.940	16.1	63.0	1.07	0.288
Labor^2	Unmatched	64.687	47.631	35.6		2.62	0.009
	Matched	64.049	56.651	15.4	56.6	1.00	0.320
Ethnicity	Unmatched	0.181	0.331	−34.9		−2.49	0.013
	Matched	0.185	0.181	1	97.0	0.07	0.942
Union	Unmatched	0.181	0.338	−36.2		−2.59	0.010
	Matched	0.185	0.133	12.2	66.4	0.92	0.359
Region	Unmatched	0.663	0.497	33.9		2.48	0.014
	Matched	0.654	0.699	−9.1	73.2	−0.61	0.545
Treatment W_2: FB contract farming							
Land	Unmatched	4.919	3.676	24.8		1.34	0.182
	Matched	4.561	4.953	−7.8	68.5	−0.26	0.795
Labor	Unmatched	7.313	6.153	36.4		1.90	0.059
	Matched	7.065	6.469	18.7	48.6	0.74	0.460
Region	Unmatched	0.594	0.497	19.4		1.00	0.320
	Matched	0.581	0.500	16.1	16.8	0.63	0.529

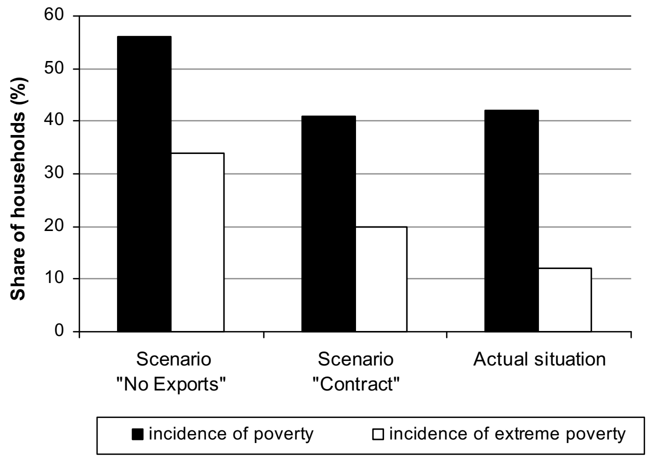

Figure 7. *The incidence of poverty and extreme poverty for two alternative scenarios.*

of poverty in the region would be 56%—similar to the average rural poverty rate for Senegal—while the actual poverty rate is only 42%. Moreover, the incidence of extreme poverty would be three times higher: an estimated 34% in the *No Export* scenario compared to 12% in the actual situation. These are very large and important effects.

Second, we find that *per capita* incomes do not differ much between the *Contract* scenario (0.42 million FCFA) and the actual situation (0.40 million FCFA) while they are much lower in the *No Export* scenario (0.27 million FCFA). Also poverty rates are not significantly different in the actual situation compared to the scenario *Contract* (Figure 6). However, the incidence of extreme poverty is much lower in the actual situation—12% compared to 20% in the *Contract* scenario (Figure 6). Hence the results imply that the high-standards FFV trade has a beneficial impact even if it is realized through large-scale estate farming. In fact, by creating employment opportunities that are relatively more accessible for the smallest farmers, FFV agro-industrial farming contributes even more to the alleviation of (extreme) poverty.

These findings demonstrate that high-standards agricultural production and trade can directly reduce poverty and improve welfare even if it is realized through large-scale agro-industrial production. This challenges the general view in the literature of increasing food standards and agro-industrialization leading to a concentration of the gains from trade with large food companies and to the marginalization of the smallest farmers and the poorest households.

7. CONCLUSION

The impact of trade on poverty remains the subject of considerable controversy, reinforced by recent studies on the growing importance of public and private standards in trade. This paper has analyzed these effects using micro-data from Senegal. FFV exports from Senegal to the EU grew sharply over the past decade despite increasing standards in EU markets. The response of FFV exporting companies to these increased standards has resulted in consolidation and increased vertical coordination at different levels of the supply chain. Part of the institutional response has been a shift away from smallholder contract-based farming and toward large-scale agro-industrial production. Based on conventional arguments in the literature, one could expect these developments to be particularly bad for the smallest farmers and the poorest households.

However, our analysis in this paper shows that this is not the case. We find that more and poorer households participate in

Table 9. *Sensitivity analysis*

	Estimated treatment effects	
	W_1: Employment in FB agro-industry	W_2: FB contract farming
Regression on covariates		
Baseline specification (Model 1)	1.95** (0.912)	3.36 ** (1.358)
	1.99** (0.992)	3.86*** (1.206)
Regression on the propensity score[1]		
Baseline specification (Model II)	1.83** (0.829)	3.35 ** (1.272)
	1.85** (0.879)	3.29*** (1.322)
Specification C	1.82** (0.820)	3.43** (1.302)
	1.97** (0.817)	3.43*** (1.268)
Matching on the propensity score[1]		
Baseline specification (Model III)	1.90** (1.042)	4.26 *** (1.559)
	1.85** (1.017)	5.02*** (1.379)
Specification C	2.05*** (0.987)	5.38*** (1.590)
	1.37** (1.084)	4.15*** (1.705)

*$p < .1$; **$p < .05$; ***$p < .01$.
(numbers) are standards errors,[1] standard errors are bootstrapped.
Specification A: right-hand side variables include next to the two treatment variables and the vector of covariates X as in the baseline model I, the interaction terms between the demeaned covariates and the treatment variables:
Specification B: propensity scores are estimated with a bivariate probit model including covariates that are correlated at the 1% significance level with the specific treatment variable and/or the outcome variable (household income). X = Land, Labor, Labor^2, and Ethnicity.
Specification C: propensity scores are estimated with a bivariate probit model including village dummies and covariates that are correlated at the 1% significance level with the specific treatment variable and/or the outcome variable (household income). X = Land, Labor, Labor^2, Ethnicity, and Village$_{1–23}$.
Specification D: propensity scores are estimated with a bivariate probit model including covariates that are correlated at the 10% significance level with the specific treatment variable and/or the outcome variable (household income). X = Land, Labor, Age, D-ratio, Education, Ethnicity, Union, and Region.

and share in the gains from high-standards FFV export production. Supply chain restructuring has altered the mechanism through which local households benefit—increasingly through labor markets rather than through product markets—and thereby improved the distribution of gains within rural communities.

We find highly significant and large effects on income and poverty, which demonstrate that rural households involved in high-standards export supply chains, either through contract farming or as workers on agro-industrial estates, do share importantly in the gains from export. Although these conclusions are obviously drawn from the specific sector which we studied and one should be careful to generalize, we believe that these findings are important as they challenge arguments in the literature that the gains from international trade and the rents in high-standards supply chains are captured by foreign investors and large agro-food companies while small farmers and poor households are marginalized. First, contract farming has often been criticized as a tool for agro-industrial firms and multinationals to exploit unequal power relationships *vis-à-vis* farmers and extract rents from the supply chain. However, we find very strong income effects of contract farming, which is consistent with other empirical findings (e.g., Dries & Swinnen, 2004; Gulati *et al.*, 2007; Minten *et al.*, 2006) and with recent theoretical work hypothesizing that farmers in countries with factor market imperfections and weak contract enforcement benefit from trade in high-standards products through a price premium (Swinnen & Vandeplas, 2007).

Second, the growth of large estate farms is usually interpreted as indicating exclusion of smallholders from modern supply chains, instead of a source of employment for the poor. Our results demonstrate that high-standards agricultural trade benefits rural incomes and reduces poverty even if the export industry is consolidating and even if export production is realized on industrial estate farms. In fact, we find that this model has the strongest positive effects on poverty reduction. The findings challenge the implicit assumption underlying many empirical studies that high-standards food production and trade needs to integrate farm-households as primary producers in the supply chain if it is to benefit rural incomes. We show that also households involved as wage workers reap significant benefits from high-standards trade.

The insight from this study that poorer households benefit from agricultural export development through the labor market rather than through product markets has largely been neglected in the empirical literature on trade, standards, and modern supply chains (see introduction). We could draw the analogy with insights from the Green Revolution of the 1960s—that triggered major productivity growth and rural income rises in South-East Asian countries. The Green Revolution was at first believed to benefit richer farmers while marginalizing poorer farmers because of the specific constraints they face in accessing and using Green Revolution inputs. However, David and Otsuka (1994) showed that poorer households did benefit from this technology-driven agricultural development because of labor market effects. Our results—along with previous results by McCulloh and Ota (2002) and Barron and Rello (2000)—suggest that the same might hold for standards-driven (or supply chain-driven) agricultural development. At the same time, Carter, Barham, and Mesbah (1996) have argued for exports from Latin America, that poverty effects might strongly depend on the nature of the commodities, with poverty-reducing benefits more likely in labor-intensive than in land-intensive production systems. Horticulture is generally a labor-intensive sector, and our findings on French bean exports in Senegal validate the argument that labor-intensive export sectors strongly benefit poverty alleviation.

Another important finding from this study is that high-standards agricultural export development in poor African countries is possible, despite the many constraints. This case study on Senegalese FFV exports could add to the existing evidence of high-standards export development in Sub-Sahara Africa (e.g., in Kenya, South Africa, *etc.*) and thereby shift the balance from viewing standards as barriers to trade to the standards-as-catalysts view—put forward by Jaffee and Henson (2005). In addition, our results demonstrate that support of high-standard export sectors can be a pro-poor development strategy. Although the benefits from horticulture export growth in Senegal are concentrated in some regions and not yet shared equally all over the country, there is scope that ongoing investments in horticulture export development in other regions of the country will result in expanded poverty-reduction impacts. In analogy with the technology-driven developments in South-East Asia in the 1960s, there might be scope for standards-driven agricultural development—in which Sub-Sahara Africa and its poor are not left behind.

NOTES

1. See Rodriguez and Rodrik, 2000 for a critique on this conclusion and Winters, McCulloh, and McKay (2004) for a survey of the arguments.

2. The term FFV, standing for "fresh and processed fruits and vegetables," is used throughout the paper. The term was defined by Diop & Jaffee (2005, p. 237) to comprise all SITC (Standard International Trade Classification) Revision 1, Chapter 5 items except nuts, roots, and tubers.

3. Commission Regulation (EC) No. 912/2001, an amendment of EC No. 2000/96, specifies a classification for French beans based on quality and size, and stipulates provisions concerning the presentation and marketing of the beans.

4. Since 2000 there have been 29 new EU notifications of maximum residue levels (MRL) to the WTO (World Trade Organization, 2006).

5. This foreign ownership does not concern multinational companies but rather individual foreign entrepreneurs investing in Senegal.

6. *Syndicat des Exportateurs des Produits Agricoles.*

7. Organization National des Producteurs Exportateurs de Fruits et Légumes de Sénégal.

8. The techniques described in this literature were initially applied to the impact evaluation of job training programs but have since known a wide application in the development economics literature.

9. Regression on covariates might obscure information on the distribution of covariates in the treated and the untreated groups. Propensity score methods reduce this problem to a single dimension.

10. The propensity score matching method discussed and applied by Dehejia and Wahba (2002) differs from earlier methods in that unmatched control units are discarded and not directly used in estimating the ATE. This avoids extrapolating or smoothing across the treatment and comparison groups.

11. Different versions of this assumption are referred to as *unconfoundedness*, *selection on observables*, *ignorability of treatment*, or *conditional independence* (Imbens, 2004; Lechner, 1999; Rosenbaum & Rubin, 1983).

12. This is a strong assumption and, in general, the plausibility of this assumption in an economic setting has been questioned. Optimizing behavior would preclude choices being independent of potential outcomes. Imbens (2004) however provides some basic arguments for using the assumption and the econometric techniques relying on the assumption in economic settings.

13. The conditional independence assumption is intrinsically non-testable because the data are completely uninformative about the distribution of the untreated outcome for treated units and *vice versa* (Ichino, Mealli, & Nannicini, 2006; Imbens, 2004).

14. The central presumption in this method is that the assignment to treatment is not independent given a set of covariates X but that the CI does hold given X and an unobserved binary covariate (see Ichino *et al.* (2006) for more details). In our setting the unobserved binary covariate could, for example, measure some unobservable component of ability that simultaneously influences participation in FB export production and household income.

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APPENDIX A

Table A1. *Results of structural regression Model I (regression on covariates) and Model II (regression on propensity scores)*

Covariates	Model 1			Model II		
	(Regression on covariates)			*(Regresion on propensity scores)*		
	Coefficient	Linearized Std. Err.	*t*	Coefficient	Bootstrap Std. Err.	*t*
W_1 (agro-industrial empl.)	1.950	0.913	2.14	1.831	0.889	2.06
W_2 (FB contract farming)	3.359	1.358	2.47	3.349	1.373	2.44
PS_W_1				5.310	3.800	1.40
PS_W_2				−18.413	15.347	−1.20
Land	0.038	0.074	0.51	0.135	0.130	1.04
Labor	0.482	0.154	3.13	0.502	0.207	2.42
AGE	−0.257	0.212	−1.21	−0.291	0.216	−1.35
AGE^2	0.001	0.002	0.80	0.002	0.002	0.97
D-Ratio	−0.400	1.883	−0.21	0.074	1.888	0.04
Education	2.243	1.564	1.43	2.475	1.540	1.61

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APPENDIX A1—*Continued*

Covariates	Model 1 (*Regression on covariates*)			Model II (*Regresion on propensity scores*)		
	Coefficient	Linearized Std. Err.	*t*	Coefficient	Bootstrap Std. Err.	*t*
Ethnicity	0.405	0.625	0.65	1.186	0.919	1.29
Union	−0.970	0.870	−1.11	−0.123	1.055	−0.12
$Village_1$	−0.013	2.502	−0.01	−0.054	2.552	−0.02
$Village_2$	−0.359	2.477	−0.14	−0.404	2.533	−0.16
$Village_3$	−1.342	2.744	−0.49	−1.387	2.807	−0.49
$Village_4$	−0.844	2.631	−0.32	−0.931	2.695	−0.35
$Village_5$	11.629	5.751	2.02	11.695	5.744	2.04
$Village_6$	0.184	2.583	0.07	0.344	2.639	0.13
$Village_7$	−0.575	2.602	−0.22	−0.522	2.657	−0.20
$Village_8$	7.995	5.185	1.54	6.825	5.043	1.35
$Village_9$	−1.902	2.890	−0.66	−2.602	3.125	−0.83
$Village_{10}$	0.415	2.456	0.17	−0.201	2.742	−0.07
$Village_{11}$	−1.636	2.717	−0.60	−2.537	3.107	−0.82
$Village_{12}$	−2.110	2.464	−0.86	−3.042	2.869	−1.06
$Village_{13}$	−0.068	2.501	−0.03	−0.830	2.831	−0.29
$Village_{14}$	0.084	2.381	0.04	0.269	2.440	0.11
$Village_{15}$	0.021	2.427	0.01	0.050	2.478	0.02
$Village_{16}$	0.375	2.511	0.15	0.257	2.565	0.10
$Village_{17}$	1.241	3.105	0.40	0.349	3.315	0.11
$Village_{18}$	3.213	2.713	1.18	2.393	3.111	0.77
$Village_{19}$	−1.001	2.979	−0.34	−1.212	2.956	−0.41
$Village_{20}$	−1.372	2.651	−0.52	−2.280	2.894	−0.79
$Village_{21}$	0.480	2.525	0.19	−0.079	2.800	−0.03
$Village_{22}$	2.693	2.892	0.93	1.822	3.187	0.57
$Village_{23}$	−0.656	2.435	−0.27	−0.515	2.472	−0.21
$Village_{25}$	−1.743	2.432	−0.72	−2.157	2.886	−0.75
Constant	7.684	7.079	1.09	7.662	7.070	1.08
		$R^2 = 0.3196$			$R^2 = 0.3232$	

Total household income, the dependent variable, is measured in million FCFA.
Village 24 is omitted and is the base category to which coefficients of the other village dummy variables need to be compared.

APPENDIX B

Table A2. *Results of structural regression model I (regresson on covariates) and model II (regression on propensity scores); excluding potentially influential observations*

Covariates	Model I (*Regression on covariates*)			Model II (*Regresion on propensity scores*)		
	Coefficient	Linearized Std. Err.	*t*	Coefficient	Bootstrap Std. Err.	*t*
W_1, (agro-industrial empl.)	1.879	0.888	2.11	1.804	0.868	2.08
W_2 (FB contract farming)	2.554	0.874	2.92	2.562	0.864	2.97
PS_W_1,				2.919	3.123	0.93
PS_W_2				−13.404	15.341	−0.87
Land	0.060	0.071	0.84	0.140	0.136	1.02
Labor	0.419	0.143	2.93	0.452	0.200	2.26
Age	−0.080	0.139	−0.58	−0.103	0.141	−0.73
Age^2	0.000	0.001	−0.05	0.000	0.001	0.13
D-ratio −0.586	1.716	−0.34	−0.317	1.715	−0.19	
Education	1.722	1.199	1.44	1.850	1.195	1.55
Ethnicity	0.332	0.601	0.55	0.765	0.842	0.91
Union	−0.826	0.861	−0.96	−0.357	1.055	−0.34
$Village_1$	−0.540	2.232	−0.24	−0.568	2.260	−0.25
$Village_2$	−0.809	2.213	−0.37	−0.840	2.247	−0.37
$Village_3$	−1.627	2.367	−0.69	−1.657	2.404	−0.69
$Village_4$	−1.244	2.317	−0.54	−1.298	2.355	−0.55
$Village_6$	−0.342	2.272	−0.15	−0.244	2.312	−0.11
$Village_7$	−0.808	2.311	−0.35	−0.778	2.350	−0.33

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APPENDIX A2—*Continued*

Covariates	Model I (*Regression on covariates*)			Model II (*Regresion on propensity scores*)		
	Coefficient	Linearized Std. Err.	*t*	Coefficient	Bootstrap Std. Err.	*t*
$Village_8$	7.155	5.085	1.41	6.259	5.057	1.24
$Village_9$	−1.901	2.449	−0.78	−2.473	2.784	−0.89
$Village_{10}$	−0.218	2.186	−0.10	−0.752	2.534	−0.30
$Village_{11}$	−2.073	2.387	−0.87	−2.790	2.840	−0.98
$Village_{12}$	−2.608	2.219	−1.18	−3.346	2.675	−1.25
$Village_{13}$	−0.728	2.247	−0.32	−1.357	2.622	−0.52
$Village_{14}$	−0.533	2.193	−0.24	−0.437	2.237	−0.20
$Village_{15}$	−0.685	2.216	−0.31	−0.668	2.244	−0.30
$Village_{16}$	0.078	2.334	0.03	0.002	2.363	0.00
$Village_{17}$	0.874	2.711	0.32	0.161	3.027	0.05
$Village_{18}$	2.552	2.447	1.04	1.887	2.925	0.65
$Village_{19}$	−1.315	2.866	−0.46	−1.457	2.830	−0.51
$Village_{20}$	−1.846	2.320	−0.80	−2.543	2.629	−0.97
$Village_{21}$	−0.267	2.268	−0.12	−0.778	2.591	−0.30
$Village_{22}$	2.272	2.690	0.84	1.572	3.044	0.52
$Village_{23}$	−0.778	2.258	−0.34	−0.709	2.289	−0.31
$Village_{25}$	−1.597	2.302	−0.69	−1.996	2.766	−0.72
Constant	3.407	4.861	0.70	3.622	5.268	0.69
		$R^2 = 0.281$			$R^2 = 0.283$	

Total household income, the dependent variable, is measured in million FCFA.
Village 24 is omitted and is the base category to which coefficients of the other village dummy variables need to be compared.