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Horticultural exports and food security in Senegal

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ABSTRACT

Horticultural exports from developing countries are expanding. While concerns are rising about the consequences of this growth for local food security, there is no empirical evidence that directly measures this impact. We provide such evidence for Senegal, one of the African countries with a sharp growth in horticultural exports. Using secondary data and panel survey data, we analyse the link between horticultural exports and the availability, access, utilization and stability components of food security. Results suggest that horticultural exports contribute to the capacity to import food, and do not jeopardize availability of food at the macro-economic level. At the micro-economic level, we find that female wage employment in the horticultural export sector reduces the probability of self-reported food insecurity, improves the quality of food consumption, and shortens the hunger season.

1. Introduction

Horticultural exports from developing countries have increased tremendously during the last two decades. Average annual growth rates over the period 1995–2014 amount to 6.3% for developing America, 7.5% for Africa and 7.8% for developing Asia (Van den Broeck and Maertens, 2016). Horticulture has become the most important agri-food export sector for developing countries, having surpassed traditional tropical commodities, such as tea, cocoa and coffee. They are mostly destined for high-income countries, where consumer demand for year-round availability of fresh produce and for tropical fruits is increasing. These exports are often realized by medium- and large-scale farms who hire local labourers to work on their fields and in their processing units. A large number of workers are employed in horticultural export sectors; e.g. up to 500,000 in Kenya, 450,000 in Chile and 400,000 in Morocco (Fernandez-Stark et al., 2011).

Concerns have risen about the food security consequences of these exports in the countries of origin. Many countries that have become important suppliers of horticultural produce to the world market – such as South-Africa, Kenya and Peru – have high rates of poverty and food insecurity within their borders, and especially so in rural areas. Despite these concerns, Van den Broeck and Maertens (2016) conclude in a recent review article that there is no empirical evidence that directly measures the impact of horticultural exports on food security in developing countries. However, many studies have investigated the implications of horticultural exports, both at the macro- and micro-economic level, which allows to shed some light on the channels through which horticultural exports can affect food security.

At the macro-economic level, horticultural exports may affect a country's food security status both positively and negatively. On the one hand, horticultural produce is characterized by a high and relatively stable value which raises national foreign exchange earnings and a country's capacity to import food. On the other hand, dependency on food imports and fluctuating international food prices may increase a country's vulnerability (Khoury et al., 2014). Also, competition for resources (e.g. land, labour and water) between export production and food production for the domestic market may lead to general equilibrium effects that cause further food price increases (Patel-Campillo, 2010). Lately, concerns have been raised on the environmental sustainability of horticultural exports, specifically on the overexploitation of water and soil nutrients, and on pollution through overuse of chemical fertilizer and pesticides (Sierra et al., 2015; Schwarz and Mathijs, 2017). There is some evidence on stringent production standards inducing a reduction in pollution by horticultural exporters (Asfaw et al., 2009).

At the micro-economic level, wage employment in a horticultural export sector influences households' food security through different channels. First, households' direct access to food (i.e. through own food production) might decrease because land and labour are allocated to export production – as has been documented for example for the Colombian cut-flower industry (Patel-Campillo, 2010). However, if smallholders face liquidity constraints, wages earned in the export sector might alleviate these constraints and result in increased investments in own farm production, leading to higher farm output and

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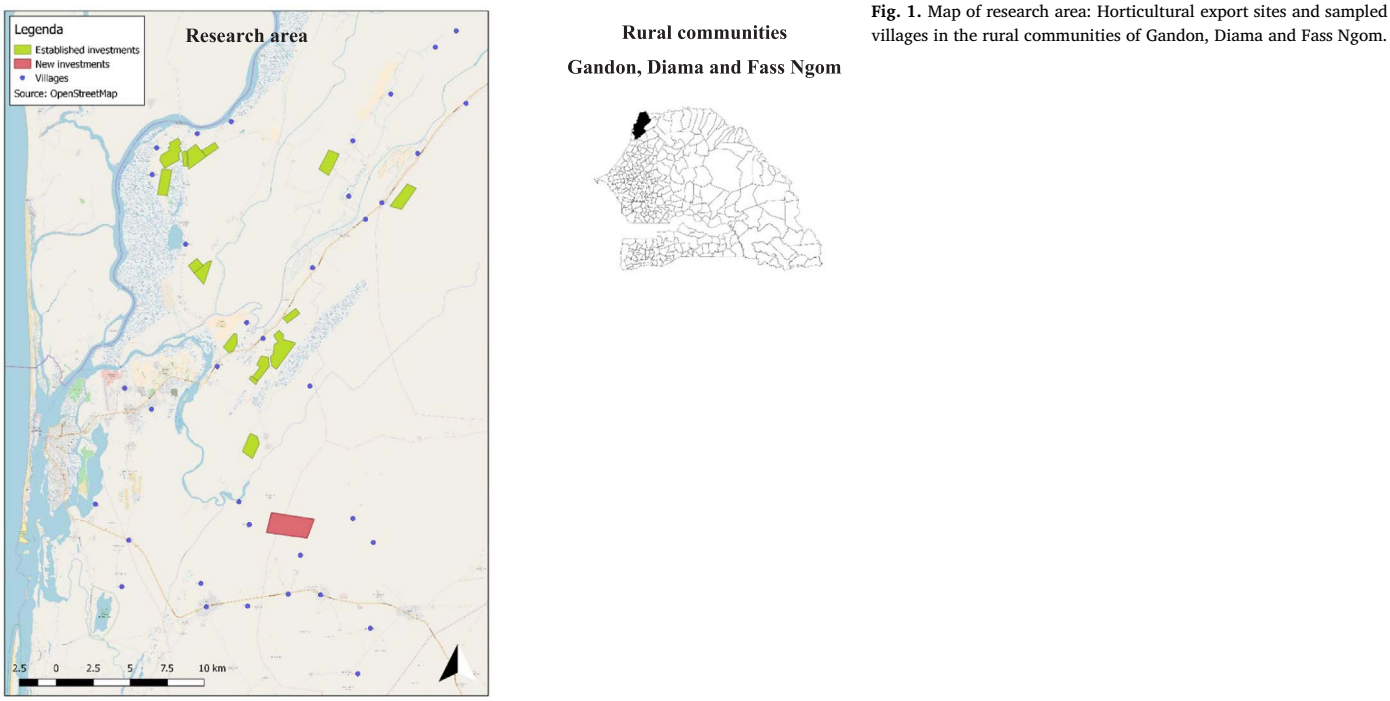

Fig. 1. Map of research area: Horticultural export sites and sampled villages in the rural communities of Gandon, Diama and Fass Ngom.

revenues. This has been the case for example in the Senegalese horticultural export sector (Maertens, 2009). Second, households' indirect access to food (i.e. through the market) might improve if employment leads to higher income levels. It has been demonstrated for Senegal that wage employment results in upward income mobility, particularly for the poorest households (Maertens et al., 2011; Van den Broeck et al., 2017). Yet, if food prices increase more rapidly than wages, households' purchasing power decreases, which might lead to food access problems – as has been shown for the horticultural export sectors in Mexico, Argentina and Colombia (Barron and Rello, 2000; Ortiz and Aparicio, 2007; Patel-Campillo, 2010). Third, the majority of workers in horticultural export sectors are women (sometimes up to 90%) (Barrientos et al., 2003). The creation of off-farm wage employment opportunities for women, especially in areas where such opportunities are limited, may lead to important gender and empowerment effects (Newman, 2002; Said-Alssopp and Tallontire, 2015; Van den Broeck and Maertens, 2015; Getahun and Villanger, 2017). It has been documented that if women earn their own income, it can increase their bargaining power in the household, which might further result in higher food and nutrition expenditures (Duflo and Udry, 2004; Doss, 2006; Fischer and Qaim, 2012).

The available evidence shows a mixture of effects but does not allow to draw firm conclusions on the link between horticultural export growth and food security because direct evidence is lacking. In this paper, we provide such evidence by investigating the effect of horticultural export growth on food security in Senegal. We focus on Senegal as one among quite a few African countries with net imports of staple food crops, with rapidly increasing horticultural exports – from 25.8 million USD in 2000 to 123.6 million USD in 2015 (UNCTADSTAT, 2017), and with a remaining food security problem – with a daily food supply of 2454 kcal per capita per day and 11.3% of the population undernourished in 2013 (FAOSTAT, 2017). We provide both macro- and micro-economic evidence on the link between horticultural exports and food security, and analyse the four different components of food security (availability, access, utilization and stability). We use secondary data for macro-level effects and primary data from a two-round panel household survey for micro-level effects. The detailed survey data allow us to analyse possible gender effects and to accurately estimate impacts of households' wage employment in the horticultural export sector on food security using fixed effects regressions.

2. Background and data

2.1. The Senegalese horticultural export sector

The horticultural export sector in Senegal has expanded rapidly during the past 15 years (Baglioni, 2015). The sharp boom in horticultural exports fits within the country's strategy of agricultural export diversification towards higher-value commodities, as the government has actively attracted (foreign) private investors in the sector. Nowadays fresh fruits and vegetables are the most important agricultural export commodity. Compared to other larger African countries, Senegal exports smaller volumes but at a faster average annual growth rate during the past ten years (15.8% compared to 10.2% for South-Africa and 5.4% for Kenya), illustrating the growing importance of the sector (UNCTADSTAT, 2017).

One of Senegal's principal horticultural export zones comprises the departments of Saint-Louis and Dagana in the north of Senegal. More specifically, the main export activities take place in three rural communities (Gandon, Diama and Fass Ngom). A first horticultural export company invested in this area in 2003. Since then the number of exporters has increased to six, and the cultivated area and produce variety are still expanding. The total cultivated area in 2016 was 2700 ha, occupying 4.1% of the total agricultural land in the departments (ANSD, 2015). All the export companies rely completely on a vertically integrated production system with primary production, post-harvest handling and exporting organised by the company. The investments have created approximately 6000 jobs by 2016, of which 80% is occupied by women. This represents a major source of employment in the three rural communities: 11% of the labour force works in the export sector while rural unemployment rates in the departments mount up to 45% (ANSD, 2015).

2.2. Data collection

We use secondary data to analyse effects at the macro-economic level and primary data from a two-round panel household survey to analyse micro-economic effects. We derive secondary data on national

Table 1
Household Food Insecurity Access Scale: Questions, responses and factor analysis.

Question	Year	Percentage response on occurrences over last 30 days					Factor Loadings
		Never	Rarely	Some-times	Often	Test	
1. In the past four weeks, did you worry that your household would not have enough food?	2013	72.45	18.66	8.68	0.22	***	0.58
	2016	59.22	26.46	13.45	0.87		
2. In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	2013	63.56	23.64	11.71	1.08	***	**0.85**
	2016	46.42	34.49	17.79	1.30		
3. In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	2013	66.38	21.69	10.85	1.08	**	**0.83**
	2016	59.44	23.21	17.35	0.00		
4. In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	2013	72.89	18.22	7.81	1.08		**0.74**
	2016	69.85	17.57	11.93	0.65		
5. In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	2013	85.03	11.50	3.25	0.22		0.49
	2016	87.64	6.29	6.07	0.00		
6. In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?	2013	96.53	0.87	2.60	0.00	***	0.24
	2016	91.76	5.42	1.52	1.30		
7. In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	2013	98.48	1.30	0.22	0.00	***	0.06
	2016	93.93	3.69	0.22	2.17		
8. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	2013	99.57	0.22	0.22	0.00	***	0.04
	2016	96.10	1.95	1.52	0.43		
9. In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	2013	99.78	0.00	0.00	0.22	**	0.04
	2016	98.48	1.30	0.22	0.00		

Wilcoxon rank-sum tests are used to test differences between 2013 and 2016. Significant differences are indicated with $p < 0.1$ *, $p < 0.05$ **, $p < 0.01$ ***. 'Never' indicates 0 times, 'rarely' 1–2 times, 'sometimes' 3–10 times, and 'often' more than 10 times. Factor loadings higher than 0.6 are presented in bold.

food security and food production from FAOSTAT for 2000–2013 and data on national export values and trade balance from UNCTADSTAT for 2000–2015.

We collected household survey data in the rural communities of Gandon, Diama and Fass Ngom. Fig. 1 depicts a map of the research area with the sampled villages and horticultural export companies. We distinguish an area north of Saint-Louis town, where most of the export companies are located and exports are realized since 2003, and an area south of Saint-Louis town where a company started exporting in 2014. Households in the research area are farm-households deriving the majority of their income and livelihood from cropping (mainly irrigated rice production and rain-fed vegetable production) and livestock-rearing (selling of meat and milk from cattle, goats and sheep). Households increasingly diversify their incomes through wage employment in the horticultural export sector and the non-farm sector.

We conducted a two-round panel household survey using a two-stage stratified sampling design. During the first round in April – June 2013 (i.e. *before* export activities started in the south area), we selected 34 villages across the three rural communities in the first stage. In the second stage, we selected 500 households within these villages and stratified according to whether a household member was employed in the horticultural export sector during the 12 months prior to the survey with an oversampling of employed households. During the second round in June – July 2016 (i.e. *after* export activities started in the south area), we tried to track all the households of the previous round. We could not track 36 households of the original 500, resulting in an attrition rate of 7.2%. We do not know why these households moved out of the region, but attrition bias is deemed to be sufficiently low because the relocated households are statistically not different from other sampled households. Three households were dropped from the final sample because of outlying observations. The final sample consists of a balanced panel of 461 households, including 161 households who were employed in the horticultural export sector in the first round, of which 137 remained employed in the second round, and 83 who newly entered employment in 2016 as a result of expanding investments in the horticultural export sector in the region.

We use in both rounds the same structured quantitative questionnaire with fine-tuning of the questions and modules for the follow-up survey. The survey provides household-level data on crop and livestock production, food security status, land assets and living conditions, and individual-level data on demographic characteristics, employment (in horticultural companies) and other off-farm income sources. The module on food security was always addressed to the woman responsible for cooking, who is usually the spouse of the household head. Household survey data are complemented with village survey data on geographic and institutional characteristics of the sampled villages.

3. Methods

3.1. Approach

We measure food security as defined by the 1996 World Food Summit and analyse four different components: availability, access, utilization and stability. We first assess macro-economic effects, focussing on availability and stability, and then assess micro-economic effects, focussing on access, utilization and inter- and intra-annual stability. We try to identify the causal effect of wage employment in the horticultural export sector on households' food security using fixed effects regressions.

3.2. Measurement of food security

Food availability entails a sufficient supply of food in a certain area. At the macro-economic level the supply of food is determined by food production for the domestic market within a country's boundaries, food stock levels and net food imports. We measure availability using secondary data from FAOSTAT on daily food supply and prevalence of undernourishment. We also assess national food production, imports and exports (expressed in volume) and the agricultural trade balance and horticultural exports (expressed in value).

Food access implies the ability to obtain a sufficient quantity of sufficiently nutritious food, and is determined by resources, markets and policies. We measure access using the Household Food Insecurity Access Scale (HFIAS), which is developed by the Food and Nutrition Technical Assistance (FANTA) program of USAID (Coates et al., 2007). Using nine fixed questions, this indicator measures the access to food that a household experienced during a four weeks period prior to the survey. For each question, respondents are asked to indicate how often they experienced food insecurity problems: never, rarely (1–2 times), sometimes (3–10 times) and often (more than ten times). The different questions and its responses are presented in Table 1. We follow the

guidelines proposed by Coates et al. (2007) and recode the HFIAS into four different classes (food secure, lightly food insecure, moderately food insecure and severely food insecure). Maxwell et al. (2014) show that the HFIAS is a sensitive index because it includes less severe manifestations of food insecurity, including anxiety and uncertainty about household food access. Therefore, we define a binary variable *Insecurity in food access*, equalling one if a household is moderately or severely food insecure and zero if a household is food secure or lightly food insecure.

Food utilization entails aspects of nutritional quality, and safety and sanitation of consumption. We measure utilization by exploiting the nature of the questions asked in the HFIAS, and apply a factor analysis to find a latent variable related to food quality (Table 1). We find a factor with an eigenvalue of 3.18, explaining 73.93% of the total variance, and that is highly correlated with questions 2, 3 and 4, which are all related to quality aspects of food consumption. We call this variable *Insecurity in food quality,* with higher scores indicating a lower quality of food consumption.

Stability of food security refers to continued availability and access to food, and is related to food resilience and environmental sustainability. At the macro-economic level, we assess inter-annual fluctuations in horticultural export earnings. At the micro-economic level, we assess intra-annual stability using the Months of Adequate Household Food Provisioning (MAHFP), which is also an indicator developed by FANTA (Bilinsky and Swindale, 2010). Households answer the question 'Were there months, in the past 12 months, in which you did not have enough food to meet your family's needs?'. If yes, they indicate in which months they experienced food insecurity. We define this variable as *Length of the hunger season*, so that 12 represents a whole year of food insecurity. Especially in our research area, where agriculture is mostly rain-fed and a rainy season only occurs from July to September, it is specifically important to measure intra-annual stability.

We need to note that our measurement of food security at the micro-economic level has some limitations. We use self-reported, subjective measures and did not collect data on actual food consumption or expenditures. However, the HFIAS and MAHFP indices have been demonstrated to provide a representative image of a households' food security status and to be suitable for impact assessment in different contexts (Knueppel et al., 2009; Kabunga et al., 2014). These measures have been widely used and promoted by international agencies such as FAO as easily collectible food security indicators (Gebreyesus et al., 2015). Nevertheless, we limit potential self-reported bias by using the same type of respondent (spouse of household head) across households and years. Moreover, all three indicators (insecurity in food access and quality, and length of hunger season), are strongly correlated with household income ($\rho = -0.19^{***}$, $\rho = -0.22^{***}$ and $\rho = -0.15^{***}$), indicating the reliability of the measures.

3.3. Econometric analysis

We analyse the impact of wage employment in the horticultural export sector on households' food security status according to the following model:

$$Y_{it} = \beta EM_{it} + \gamma EF_{it} + \delta X_{it} + \alpha_i + \theta_t + \varepsilon_{it}, \quad (1)$$

where β, γ and δ are coefficients to be estimated, α_i is a set of time-constant unobservable household variables, θ_t is a year dummy (taking the value of one for 2016) and ε_{it} is a set of time-variant unobservable household variables. The dependent variable Y_{it} is the food security status of household i at time t and is measured as (1) *Insecurity in food access*, (2) *Insecurity in food quality*, and (3) *Length of the hunger season* (see Section 3.2 for more details). The main variables of interest EM_{it} and EF_{it} represent male and female employment in the horticultural export sector. We use two specifications to test both the extensive and intensive margin of employment. In model A we use two dummy variables equalling one if male respectively female members of household i were employed in the horticultural export sector during the 12 months period before the survey. We include the logarithm of total household income as well to control for all other income sources besides wages earned in the export sector. From this model, we reveal the effect of entry into employment or the extensive margin of employment. In model B we use the logarithm of income earned by male and female employees in the horticultural export sector. From this model we reveal the effect of increased income from employment or the intensive margin of employment. All income data are real data and inflated to 2015 consumer index prices. In both models we include a vector of other explanatory time-variant household variables X_{it} that are likely to influence food security. We control for human capital by including age, education, and gender of the household head, household size (both number of non-dependent men and women, and number of dependents) and the share of literate non-dependent men and women; and for physical capital by including productive assets of the household (landholdings and livestock units) and whether they have access to electricity and clean sanitation in their compound. The variable θ_t captures all temporal variation in the region between 2013 and 2016, such as weather shocks and price variations.

We use a fixed effects regression to reduce the bias caused by a non-random assignment of households into wage employment. This model focuses on the variation within households over time and removes all time-constant observable and unobservable household characteristics. Twenty percent of the sampled households switched wage employment status over time, which renders sufficient within-household variation to use a fixed effects approach. As additional robustness check we use a second model in which we include a set of village-year dummies. This model controls for all unobserved time-variant village characteristics that are correlated with food security and participation in horticultural wage employment, such as expansion of companies or construction of roads.

4. Results

4.1. Macro-economic effects

Fig. 2 presents the evolution of food availability in Senegal over the period 2000–2013. Food availability measured as food supply has significantly improved over time; from 2164 kcal per capita per day in 2000 to 2454 kcal in 2013; and prevalence of undernourishment has decreased from 29.4% of undernourished people in 2000 to 11.3% in 2013. However, daily food supply is still below the food security threshold of 2500 kcal per capita per day. While the macro-level data do not distinguish between urban and rural areas, we can plausibly assume that food insecurity is more severe in rural areas, given higher poverty levels in rural Senegal.

Food production within Senegal has (slightly) increased over time; from 4.4 million tonnes in 2000 to 5.0 million in 2013 (Fig. 2). On the other hand, food imports have more than doubled over time; from 1.3 million tonnes in 2000 to 2.8 million in 2013. This implies that Senegal imported 36.1% of its total food supply in 2013. Senegal is a net importer of staple food crops: e.g. the domestic production in 2013 of rice (Senegal's main staple crop) was 0.4 million tonnes in 2013 while imports amounted to 1.1 million tonnes. At the same time, agri-food exports (including food and live animals, animal and vegetable oils, fats and waxes and oil seeds and oleaginous fruits) increased as well at a similar rate (an increase of 96.4% between 2000 and 2013), but the absolute quantities are much lower than those of imports (e.g. total exports in 2013 amounted to only 19.5% of total imports).

The trend of Senegal's high dependency on food imports also showcases in the national agri-food trade balance (Fig. 2). Especially in 2008, during the food price crisis, the trade balance became highly negative. The trade deficit started to decrease again from 2012 onwards and accounted for 236 million USD in 2015. The decrease in trade deficit is associated with an increase in horticultural exports. The value

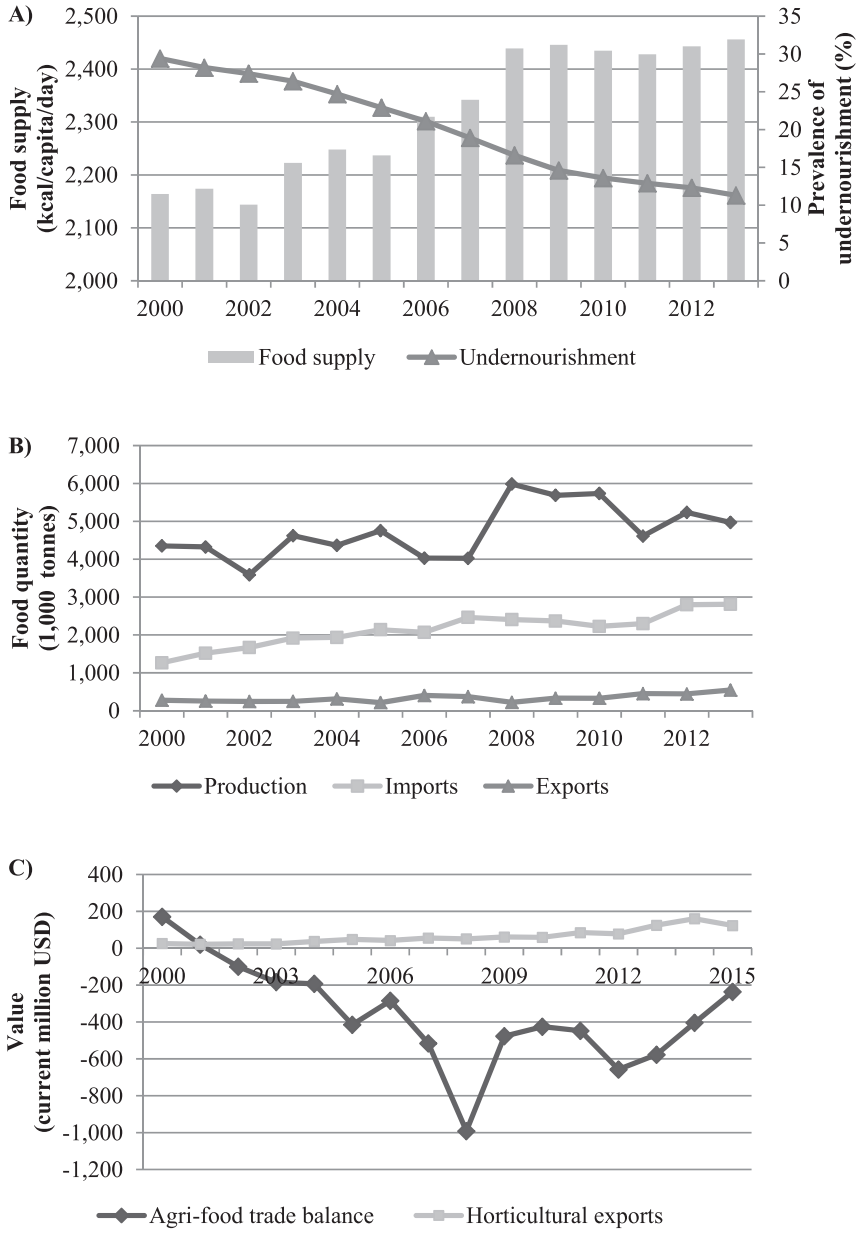

Fig. 2. Evolution of food availability in Senegal: (A) Food supply and prevalence of undernourishment, 2000–2013 (Source: Faostat); (B) Food production, imports and exports, 2000–2013 (Source: Faostat); and (C) Agri-food trade balance and horticultural exports, 2000–2015 (Source: Unctadstat). Agri-food produce comprises SITC 0 (Food and live animals), SITC 4 (Animal and vegetable oils, fats and waxes) and SITC 22 (Oil seeds and oleaginous fruits).

of horticultural exports has more than quadrupled over the past 15 years – from 25.8 million USD in 2000 to 123.6 million USD in 2015. Especially since 2012, when exports reached almost 100 million USD, the agri-food trade deficit became smaller. Senegal's main export crops are French beans, tomatoes and mangoes, but produce variety is still expanding. The direct, long-term commercial relations between the horticultural export companies and European retailers also contribute to more stability in exports.

4.2. Micro-economic effects

Table 2 presents the different indicators of food security across households with and without male / female employees in the horticultural export sector for 2013 and 2016. In sum, households with employees in the horticultural export sector report a shorter hunger season for 2016 and households with female employees perceive a higher quality of food consumption for 2013. Fig. 3 depicts the intra-annual dimension of food security and reveals two trends. First, access to food is not equal over the whole year and more households experience hunger during June, July and August than during the rest of the year. These months coincide with the last months before the first rainfall and the period in which export companies hire fewer workers. Second, households with employees are less likely to experience a month with insufficient food access than households without employees. This is consistent across the twelve months and in both survey rounds.

These observed differences do not automatically imply a causal effect of employment in the horticultural export sector, because households do not randomly self-select into employment. Households with employees have an older and more educated head, more (literate) household members, less landholdings and livestock units, and better access to electricity and sanitation (Table 3). With fixed effects regression models we control for differences in observed and unobserved characteristics, and attempt to estimate the causal impact of wage employment (Table 4). Income earned by men in the export sector does not have a significant effect on any of the food security indicators in any model specification. Income earned by women, on the other hand, leads to a reduction in perceived insecurity in food access, an improvement in

Table 2
Food security status and income of households with and without male / female employees in the horticultural export sector for 2013 and 2016.

	2013 households				2016 households			
	without employees in export	with male employees in export	with female employees in export		without employees in export	with male employees in export	with female employees in export	
Insecurity in food access (share)	0.24	0.27	0.21		0.29	0.24	0.31	
Insecurity in food quality (index)	−0.05	−0.12	−0.25	**	0.15	−0.12	*** 0.06	
Hunger season (months)	1.25	1.20	0.92		1.14	0.67	** 0.60	**
Income per adult eq. (1000 FCFA/year)	468.73	534.82	489.53		431.09	577.30	*** 517.08	**
Income per source (1000 FCFA/year)								
Agricultural self-employment	610.04	617.65	266.68	***	851.24	1129.98	934.22	
Non-farm income	1281.97	996.09	1108.05		1176.15	931.85	962.27	
Male wage employment in export	0.00	962.26	*** 499.00	***	0.00	1023.53	*** 514.29	***
Female wage employment in export	0.00	320.79	*** 622.16	***	0.00	386.99	*** 627.80	***
Number of observations	300	99	101		241	135	161	

Insecurity in food access and quality are based on HFIAS and hunger season is based on MAHFP. Agricultural self-employment includes crop production and livestock; non-farm income includes wage and self-employment in the non-farm sector and non-labour income. Significant differences between households with and without employees are indicated with $p < 0.1$*, $p < 0.05$**, $p < 0.01$***.

perceived quality of food consumption and a shorter hunger season, both at the extensive and intensive margin. When we control for unobserved time-variant village-level factors, most of the results remain robust although the effect on length of the hunger season becomes insignificant.

Other variables influence food security as well (Table 5). The

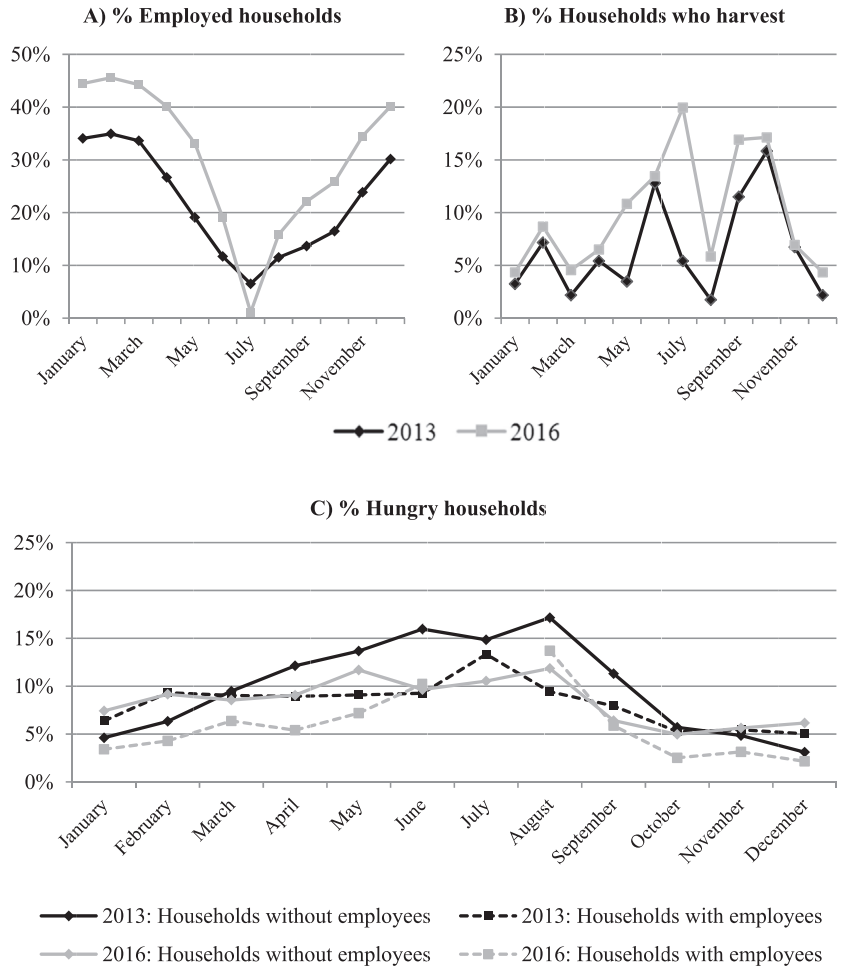

Fig. 3. Intra-annual trends in 2013 and 2016 for: A) Share of households with employees in the horticultural export sector; B) Share of households who harvest own farm production; and C) Share of households who experience hunger across employment status.

Table 3
Characteristics of households with and without male / female employees in the horticultural export sector for 2013 and 2016.

	2013 households				2016 households			
	without employees in export	with male employees in export		with female employees in export	without employees in export	with male employees in export		with female employees in export	
Female head (dummy)	0.14	0.05	***	0.12	0.15	0.15		0.17	
Age of head (years)	55.40	59.28	***	59.09	***	55.90	60.73	***	60.24	***
Schooling of head (years)	1.53	2.89	***	2.57	***	2.00	2.56	*	2.34	
Dependents (aged < 18 and > 65)	5.12	5.93	**	6.28	***	5.28	5.93	**	5.96	**
Male non-dependents (aged 18–65)	2.01	3.08	***	2.33	**	2.20	3.34	***	2.64	***
Female non-dependents (aged 18–65)	2.32	3.03	***	3.42	***	2.41	3.24	***	3.57	***
Share of literate male non-dependents	0.37	0.57	***	0.49	**	0.41	0.62	***	0.52	***
Share of literate female non-dependents	0.22	0.39	***	0.41	***	0.29	0.37	**	0.40	***
Livestock units[a]	10.01	4.53	*	4.54	*	3.37	3.28		2.78	
Landholdings (ha)	3.45	1.97	*	1.23	***	1.98	1.71		1.87	
Access to electricity (dummy)	0.49	0.62	**	0.60	**	0.63	0.67		0.63	
Access to sanitation (dummy)	0.07	0.12		0.14	**	0.12	0.16		0.17	
Number of observations	300	99		101		241	135		161	

[a] One tropical livestock unit equals 1 cow/horse, 0.8 donkey, and 0.2 sheep/goat. Significant differences between households with and without employees are indicated with $p < 0.1$*, $p < 0.05$**, $p < 0.01$***.

proxies for human capital do not seem to influence households' perceived food security, except for the age of the household head, which reduces perceived food insecurity and improves food quality. Land holdings do not affect food security while livestock contributes to a reporting of higher food quality, likely because it improves the direct access to dairy products and meat. Access to electricity and clean sanitation matter as well, as they both reduce perceived insecurity in food access. Access to electricity also reduces the length of the hunger season while access to sanitation improves reported food quality. As we control for total income (which improves food security as expected), all these effects need to be interpreted additionally to an income pathway (e.g. improved awareness, better cooking facilities).

5. Discussion

We find that female employment in the horticultural export sector has a positive effect on households' perceived food security. The effects are quite large: female employment decreases the probability of insecure access with 11.3% and the length of the hunger season with 24 days; a relative reduction of 77.7%. Also at the intensive margin employment matters: a 10% increase in income earned by women decreases the probability of insecure access with 10%. These results are not in line with studies that expect that the expansion of horticultural exports will lead to increased vulnerability of poor households (Ortiz and Aparicio, 2007; Patel-Campillo, 2010; Pegler, 2015). Our results complement previous findings on income-increasing and poverty-reducing effects of wage employment in large-scale export sectors (Maertens et al., 2011; Herrmann, 2017; Van den Broeck et al., 2017). They are also in line with the more general literature on non-farm employment that finds a positive impact on households' food security and nutrition (e.g. Ruben and van den Berg, 2001; Babatunde and Qaim, 2010; Owusu et al., 2011; Tsiboe et al., 2016). Although perceived food access and quality decrease over time in our research area, we find that households with female employees are able to mitigate this negative evolution. This is in line with a study in Madagascar by Bosch and Zeller (2013), who show that wages earned on a jatropha plantation helped to mitigate income losses from agricultural production due to climatic reasons.

Table 4
Impact of wage employment in the horticultural export sector on food security.

	Insecurity in food access				Insecurity in food quality				Length of hunger season			
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Specification A												
Dummy for male employment	0.028		0.042		−0.065		−0.002		0.301		0.389	
	(0.072)		(0.074)		(0.146)		(0.150)		(0.416)		(0.423)	
Dummy for female employment	−0.117	*	−0.113	*	−0.324	***	−0.265	**	−0.828	**	−0.314	
	(0.059)		(0.064)		(0.120)		(0.130)		(0.344)		(0.368)	
Total household income (log)	−0.015	*	−0.009		−0.043	***	−0.035	**	−0.168	***	−0.147	***
	(0.008)		(0.008)		(0.016)		(0.017)		(0.047)		(0.047)	
Specification B												
Income from male employment (log)	0.000		0.002		−0.010		−0.004		0.005		0.010	
	(0.006)		(0.006)		(0.011)		(0.012)		(0.032)		(0.033)	
Income from female employment (log)	−0.010	**	−0.010	*	−0.028	***	−0.023	**	−0.075	***	−0.031	
	(0.005)		(0.005)		(0.010)		(0.010)		(0.028)		(0.030)	
Village-year dummies	No		Yes		No		Yes		No		Yes	
Number of observations	922		922		922		922		922		922	

These are summarized results from full regressions presented in Table 5. Significant effects are indicated with $p < 0.1$*, $p < 0.05$**, $p < 0.01$***. Standard errors are reported between parentheses.

Table 5
Results of fixed effects regressions on the determinants of food security.

	Insecurity in food access		Insecurity in food quality		Length of hunger season	
Dummy for male employment in export	0.028		−0.065		0.301	
	(0.072)		(0.146)		(0.416)	
Dummy for female employment in export	−0.117	*	−0.324	***	−0.828	**
	(0.059)		(0.120)		(0.344)	
Total household income (Log)	−0.015	*	−0.043	***	−0.168	***
	(0.008)		(0.016)		(0.047)	
Female head	−0.029		0.046		0.316	
	(0.133)		(0.269)		(0.770)	
Age of head	−0.009	***	−0.014	**	−0.015	
	(0.003)		(0.007)		(0.019)	
Schooling of head	0.009		0.010		−0.056	
	(0.014)		(0.029)		(0.082)	
Dependents	0.010		0.031		0.017	
	(0.011)		(0.022)		(0.063)	
Male non-dependents	0.007		0.045		0.018	
	(0.024)		(0.048)		(0.138)	
Female non-dependents	0.025		0.008		−0.055	
	(0.024)		(0.048)		(0.136)	
Share of literate male non-dependents	−0.103		−0.179		−0.410	
	(0.071)		(0.145)		(0.413)	
Share of literate female non-dependents	−0.053		−0.162		−0.711	
	(0.082)		(0.165)		(0.471)	
Total livestock units	−0.001		−0.003	*	−0.003	
	(0.001)		(0.002)		(0.005)	
Land holdings	−0.002		0.004		−0.009	
	(0.004)		(0.008)		(0.022)	
Access to electricity	−0.165	**	−0.022		−0.659	
	(0.078)		(0.158)		(0.452)	
Access to sanitation	−0.121	*	−0.222	*	−0.590	
	(0.065)		(0.132)		(0.376)	
2016	0.089	***	0.240	***	−0.026	
	(0.033)		(0.067)		(0.192)	
Constant	1.015	***	1.243	**	5.356	***
	(0.238)		(0.481)		(1.375)	
Number of observations	922		922		922	

Significant effects are indicated with $p < 0.1$*, $p < 0.05$**, $p < 0.01$***. Standard errors are reported between parentheses. Variables are described in Table 3.

The positive effects in our study can be explained through low competition for resources on the one hand and female empowerment on the other hand. There is low competition for labour between production for the export sector and the domestic market, which contributes to a higher indirect access to food for households with employees. Income per capita is higher for households with employees in 2016, and the wages of these employees constitute the main source of household income; 43.2% on average (Table 3). The timing of activities in the export companies and the own farm is depicted in Fig. 3. Employment in the horticultural export sector is mainly seasonal, as production occurs mainly from October to May, when horticultural production in Europe is less competitive. In June, July and August activities are reduced to a minimum. This is also reflected in the type of contracts that employees have: 61% of the men are employed on a daily or seasonal basis while this is 86% for women. Employment in the own farm mainly occurs during two peak harvest moments: one during June-July when irrigated rice is harvested, and one during September-October when rain-fed crops are harvested. We need to note that we only have data on the timing of harvesting and not on other farm activities. Employment in the export sector alternates with family labour on the own farm, and competition for labour is fairly low. Wages earned in the export sector are particularly important for bridging the season when own farm production is low.

Competition for land between the export sector and domestic food production is a contentious issue. On the one hand, the direct competition for land between export companies and local household is limited. In 2016, horticultural export companies cultivated approximately 2700 ha in total in the departments of Dagana and Saint-Louis. They do not possess this land but lease it from the rural communities. Before the land lease deals, most of this land was common pasture land and extensively used by (semi-)nomadic pastoralists, particularly during the rainy season (from June until September). Fig. 1 shows the location of the horticultural export companies in the rural communities: while smallholder cultivation mainly takes place next to the rivers, horticultural production is located more inland. Smallholder farmers are not able to produce crops on these lands during the dry season as they are located too far from a river or lake for small-scale irrigation. Additionally, companies use surface water from the Senegal river or one of its tributaries for irrigation. Hence, there is no groundwater depletion and smallholders' access to water is not hindered by these companies. On the other hand, we observe a substantial reduction in farm-size and livestock holdings for the sampled households between 2013 and 2016 (Table 3). Whether this is due to the growing horticultural export sector or to other factors, such as an increased population pressure, a decreased use of livestock as savings mechanism or a transition from extensive grazing on common pasture lands towards intensive zero-grazing systems, or an interplay between these factors, remains to be revealed through further research. Even with this reduction in land and livestock assets, households were able to substantially increase farm income, which points to an intensification of cropping and livestock rearing (Table 2). If competition for land and water access between smallholders (particularly livestock holders) and export companies increases with further expansion of horticultural export production or increased population density, it is unclear how smallholders will be affected in the future.

Our results point to gender differences. Despite incomes of households with male employees being significantly higher than incomes of households with female employees, male employment does not contribute to food security while female employment does. This indicates that preferences and expenditure patterns differ by gender, and that women are more likely to spend money on food. This does not rule out that men spend their wages on other 'useful' goods; e.g. Maertens (2009) documents how wages in the Senegalese horticultural export sector are spent on investments in the own household farm. Higher food expenditures by women have been shown before for other West-African countries; e.g. Ghana (Doss, 2006) and Côte d'Ivoire (Duflo and Udry, 2004). Our results fit both a cooperative household model, in which spouses bargain to spend money on different items, or in a non-cooperative model, in which separate spheres of decision-making are assumed. Through increasing their share of total household income (28.9% in households with female employees compared to only 8.1% in households without female employees), it is assumed that women's bargaining power increase as well. Even if women do not need to bargain over food expenditures – which is likely the case in Senegal, as women are responsible for food preparation (Sow, 2010) – employed women earn more than non-employed women and are thus able to spend more on food.

6. Conclusion

This paper is the first to provide quantitative evidence on the link between horticultural exports and food security. We investigate food security effects at the macro- and micro-economic level in Senegal, one among several African countries that witnessed a sharp growth in horticultural exports. We find that at the macro-economic level, food availability improved over time, while horticultural exports, domestic food production and food imports increased as well. These trends do not imply any causation, but they suggest that horticultural exports contribute to a country's capacity to import food, and that they do not necessarily jeopardize food availability. At the micro-economic level,

we find that female wage employment in the horticultural export sector is conducive for households' perceived food security; it reduces the probability of being food insecure, improves quality of food consumption and shortens the hunger season. These effects count for both the intensive and extensive margin of employment, and are largely robust when controlling for unobserved heterogeneity. We do not find a significant effect for male wage employment. These effects are likely related to the higher income levels of households with employees, differences in expenditure patterns across gender and a low competition for land and labour resources between production for the export sector and the domestic market.

Detailed panel data allow a causal analysis on different food security components at the micro-economic level, with measures for access to food, utilization of food and stability in food security. We use indicators based on the HFIAS and MAHFP that have been proven to be easy to collect and to provide valid measures for impact evaluation in different contexts (Gebreyesus et al., 2015). We did not measure food consumption and could not calculate daily calorie intake or micronutrient deficiencies, which are often put forward as the golden standard to measure households' food and nutrition security (de Haen et al., 2011). Also, with three-year panel data, we did not capture food security dynamics and stability – nor environmental effects – in the long run; we rather focus on intra-annual variability in access to food.

Our findings for Senegal have wider implications for other horticultural export countries. There are a number of factors that contribute to explaining the positive effect of horticultural export growth on food security, which might be similar in other countries. First, the horticultural sector in Senegal is characterized by large-scale and labour-intensive production. Private sector investments in horticultural exports have created a boom in off-farm wage employment opportunities in rural areas, especially for women. This female wage employment is an important factor in creating positive food security effects. In most other horticultural export countries in SSA, the sector is comparable; i.e. large-scale and labour-intensive systems with an important share of female workers. Second, the core of the horticultural export season in Senegal does not coincide with the main rainy season and therefore horticultural export production interferes with farm production for the domestic market (or own consumption) to a limited extent. In general, horticultural export production in Africa is very demand-driven with a particularly competitive export window during European winter time. This export window might coincide with the main agricultural season in some climatic zones, which might reduce a beneficial effect on food security because of increased competition for labour. Third, horticultural export companies in Senegal operate on land leased from rural communities. As these lands were not used by smallholder farmers but rather as extensive pastures, competition for land is limited in the case of Senegal. When competition for land is stronger, for example when smallholder farmers are evicted from their land because of land lease deals with large export companies, food security gains among agro-industry workers may come at the expense of food security losses among smallholder farmers. The implications of horticultural export growth for local food security can be less positive (or even adverse) in regions where these conditions differ strongly. More research remains necessary to fully understand the direct link between horticultural export growth and food security.

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