Do contracts increase farmers' incomes and food security? Evidence from the rice value chain in Senegal.

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Abstract

The Quiet Revolution in Asia's domestic food supply chains (Reardon et al., 2012) seems to be on-going in Africa, with more integrated chains and new investments in food processing. In the Senegalese rice value chain, millers are implementing production and marketing contracts with small-scale producers. Numerous studies find that contracts increase incomes, but there is a need for further research, especially in the case of domestic grain chains. The purpose of this paper is to assess the impact of contracts implemented in the Senegalese rice value chain on farmer incomes and food security. We conducted a cross-sectional survey and obtained 550 valid questionnaires. We use propensity score matching and instrumental variables to correct for selection bias and to compare contracts and spot transactions. We find (1) no impact from marketing contracts on farmer incomes since there is no upgrading compared to the traditional value chain; (2) a significant negative impact from production contracts on farmer incomes due to an implicit insurance cost of credit; (3) contracted farmers engaging in spot transactions, which increase their profit; (4) marketing contracts having a positive impact on food security since they mitigate price seasonality.

Keywords:

Contract farming; vertical coordination; value chain; small-holder farmers; Africa; Senegal

1. Introduction

The quiet revolution observed in the domestic rice and potato food chains in Asia is characterized by the concentration of the midstream segment, which invests in new technologies, sets up new coordination modes with producers and becomes the driver of quality (Minten et al., 2013; Reardon et al., 2014, 2012; Reardon and Minten, 2011). It seems that similar pattern in food chain transformation is happening in Africa (Reardon et al., 2013; Soullier and Moustier, 2015).

The Global Value Chain typology (Gereffi et al., 2005) analyzes the distribution of skills and innovations in terms of quality with the distribution of value added along the chain. It integrates transaction cost economics and presents three specific types of governance between market transactions and vertical integration. The determining variables are the complexity of transactions, the ability to codify these transactions and the capabilities of the supply base. *Modular governance* concerns suppliers who are able to meet different forms of complex demand. R*elational governance* describes transactions, often informal, in which the actors are socially close. *Captive governance* includes the involvement of the leading firm in the operations of its suppliers, which become dependent.

Contract farming (CF) can reduce transaction costs rising from market imperfections at the purchaser (Jaffee and Gordon, 1993) and producer levels (Key and Runsten, 1999; Kirsten and Sartorius, 2002; Swinnen and Maertens, 2007). It is "a contractual arrangement between farmers and other firms, whether oral or written, specifying one or more conditions of production and/or marketing of an agricultural product" (E. P. Roy, 1963, cited by Rehber 2007, p33). CF has been developing since the 1960's in the private sector, driven by the demand for produce of higher quality, along with improvements in logistics and communication technologies (Prowse, 2013). It favors the participation of small-scale producers in modern value chains over traditional VCs in which market governance is based on price. CF may induce the upgrading of suppliers, i.e. the process of acquiring new skills and accessing new markets through participation in a particular value chain (Humphrey, 2004). The concept also concerns the access to improved inputs, agricultural advisory services and credit (Eaton and Shepherd, 2001; Gow and Swinnen, 1998; Jaffee et al., 2011; Prowse, 2013; Reardon et al., 2009). Contracts also specify quality criteria that must be met by producers. Such technological and organizational changes increase yields, the quality of produce and therefore incomes (Jaffee, 1987; Swinnen, 2007).

The first results which appeared during the 1990's highlighted negative impacts of CF on producers income: conflicts, imbalances of powers and rural inequalities between producers and their purchasers (Little and Watts, 1994), disguised proletarianization and self-exploitation (Clapp, 1988), greater exposure to risk (Wilson, 1986), corruption and unreliable sponsoring companies (Eaton and Shepherd, 2001). But over the last 15 years, the results have been more optimistic. Several studies find that contracts increase income in relation to market governance (Bellemare, 2012; Bolwig et al., 2009; Girma and Gardebroek, 2015; Leung et al., 2008; Maertens and Swinnen, 2009; Minten et al., 2009; Miyata et al., 2009; Rao and Qaim, 2011; Saenger et al., 2013; Simmons et al., 2005; Wang et al., 2014; Warning and Key, 2002).

Nevertheless, the relationship between contracts and farmers income is not clear yet (Swinnen and Maertens, 2007). Furthermore, less information is available regarding the impact of contracts on indicators of welfare other than income, including food security. Minten, Randrianarison and Swinnen (2009) find farmers participating in CF have shorter lean periods. Bellemare and Novak (2015) find similar results, with more pronounced effects for households with a larger number of children, especially girls.

The purpose of this paper is to assess the impact of different types of CF on farmer incomes and food security in the context of a domestic food chain. The hypothesis is that contracts improve farmer incomes and food security. Contracts enabling access to improved inputs and agricultural advisory services increase yields and quality. Food security may be improved through this income effect. The originality of this paper is that it concerns one domestic grain chain, whereas most of CF literature focuses on horticultural export value chains (Prowse, 2013; Soullier, 2013). Indeed, domestic value chains are a relevant lever to reduce poverty since they are often supplied by small-scale producers with food crop rationales (Diao et al., 2012). Furthermore, the impact of contracts on farmers' food security has little been addressed in literature.

This paper studies the rice value chain from the Senegal River Valley (SRV), where poverty and food insecurity are significant. Since the world food crisis (2007), this VC presents a pattern of modernization similar to that of the Quiet Revolution

In section 2, we present the empirical background of VC modernization and of farmer participation in contracts. In section 3, we describe the methodology we use to correct selection bias, data collection and calculation of indicators. In section 4, we present the econometric results, which we discuss in section 5. We finally conclude and present our research agenda in section 6.

2. Background

2.1 Funding of rice cropping and contracts:

Producers selling paddy by spot transactions to *banabanas* within the traditional value chain often benefit from credit from the national bank. They sell their paddy collectively through farmer organizations and then repay their loans to the bank. Market price plays a pivotal role in transactions, although relational proximity is strong. Prices vary according to the period of selling. The technology used does not require complex indicators of quality.

Certain factors favored the emergence of contracts within the VC. First, it was necessary to improve the quality of rice (moisture rate, impurities and sorting). Investment in new processing technologies had to be coupled with improvement of paddy quality and required big volumes of paddy to cover fixed costs. Second, the national bank had historically faced problems of non-reimbursement by producers, and needed to secure the system (Belières and Touré, 1999).

Marketing contracts were set up in 2010 by SAED and the national bank, and represented in 2014 5.55% of the SRV's paddy production. They were used in 2014 by 2,000 small-scale producers growing around 4,000 ha (primary data from SAED, 2015). Of these, 97.7% had access to bank credit. The national bank indicates to rice millers which POs to contact to buy paddy through marketing contracts. The contract price takes into account the price that was negotiated within the inter-professional organization and the quality of paddy: moisture rate, homogeneity of varieties and level of impurities.

Production contracts were formalized in 2010 from interlinked relationships between producers and *banabanas*. Nowadays, they differ since they are written out, with explicit accountability. They are implemented by industrial millers. The inter-professional association may be the enforcement institution. Nevertheless, if a contract is breached, this is generally followed by new negotiations between producers and the rice miller. In 2014, production contracts were used by 71 POs growing around 3,500 ha and included around 1,500 producers. Production contracts concerned 5.6% of the production of paddy. These contracts

range from in cash credit advances to in-kind credit (including harvesting) and may include the rice miller having decision-making power over crop management. The measure of quality is the same as in marketing contracts.

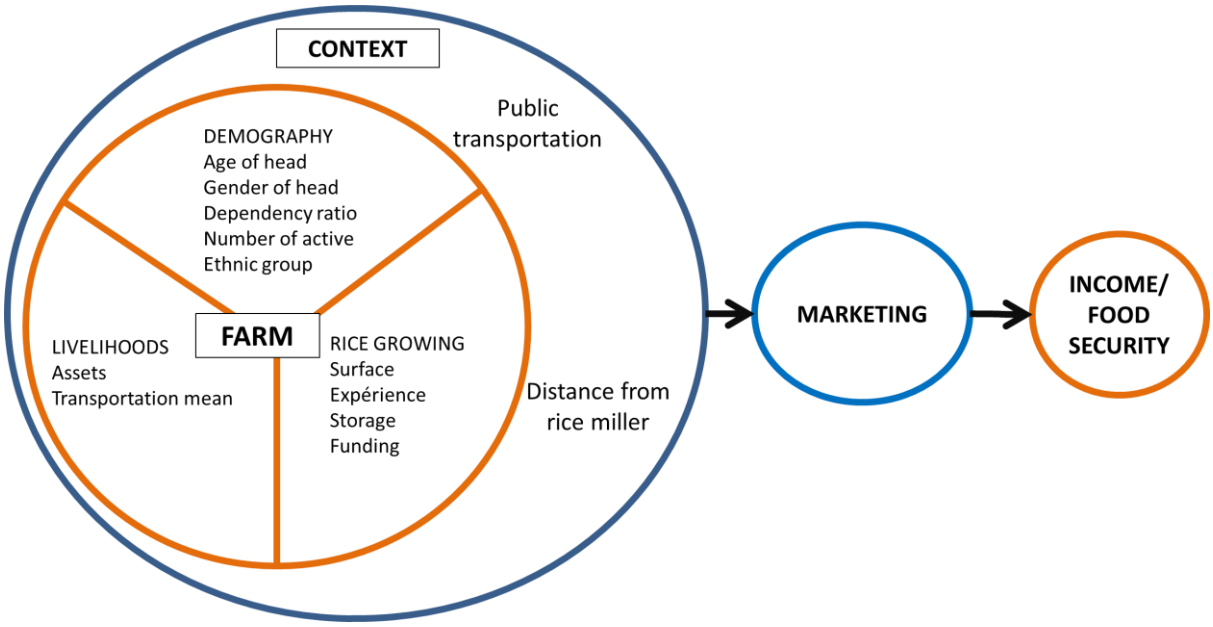
There is no major difference in production technical operations according to marketing strategies. The intensification of rice cropping started in 1973 (Legal, 1995) under state intervention. Land preparation was adapted to better manage water, using different schemes of management. The use of high-yield varieties, mineral fertilizers, chemical weeding and mechanized harvesters was promoted. Since that period, there has been no major change, even during the liberalization (Belières and Touré, 1999).

2.2 Farmer strategies

Small-scale farmers often combine two types of marketing. The first type aims at reimbursing the loan through collective selling. The price sets the volumes that producers must supply to reimburse their loans. The other part of the production is stored and gradually consumed or privately sold according to the needs of household.

Marketing contracts are strongly promoted by the bank and SAED. Nevertheless, farmers have the ability to refuse to engage in such contracts. Furthermore, the participation in production contracts seems less random since producers have the ability to self-select. Indebtedness prevents producers from access to bank credit and constrains them to identify other sources of credit, which are rare in the SRV. Indebted producers which are located in the collection area of rice millers implementing production contracts may engage in this contract.

Figure 1: variables affecting the inclusion of small rice grower in contracts



3. Methods and data

3.1 Models to correct selection bias

We use parametric and non-parametric models to correct selection bias. This bias may come from producer self-selection into contracts and selection of producers by millers based on their characteristics, including geographical factors (Maertens and Swinnen, 2009). The models include these characteristics (X_i), called covariates.

We provide one model per treatment (instead of including the two participation variables in one model) because certain variables may influence positively the participation in one type of contract and negatively the participation in the second type of contract. D is therefore a dichotomous variable of participation. Producers selling through spot transactions (D_0)—also qualified by negotiation or market governance—make up the control group. We estimate the impact of treatment (D_1). The outcome Y_i is the food security or income indicator (profit per hectare or kilogram, or price per kilogram) of observation i. The treatments are mutually exclusive: there is no producer participating under both a marketing contract and a production contract. All contracted producers who also sell through spot transactions are included in the treated groups. In the case of public intervention aiming at reducing poverty, the Average Treatment Effect on the Treated (ATT) should be estimated (Guo and Fraser, 2014; Heckman, 2005). It measures the difference between the average outcome of treated observations and the average outcome of these observations if they were not treated:

$$ATT = E[Y(1)/D=1] - E[Y(0)/D=1] \quad (1)$$

3.1.1 Propensity Score Matching

The first model we use to correct selection bias is propensity score matching (PSM). The problem in equations (1) is that in a cross-sectional survey it is not possible to observe the counterfact of a treated observation [Y(0)/D=1], that is to say the performance of this treated observation if it were not treated. The potential outcome mean solves this problem by calculating the probabilities of participation in treatment of individuals, based on observable characteristics: $PS_i = Pr(D=1/X_i)$. We use a probit density function to calculate propensity scores, and then match individuals with close probabilities of participation (Roy, 1951, p. 195; Rubin, 1974): $\min_{j \in C} \|PS_i - PS_j\|$, with *j* the observation from the control group matched with the individual *i* from the treated group. PSM may identify individuals *j* using different algorithms (Caliendo and Kopeinig, 2008). The nearest neighbor matching compares one treated observation with the closest one(s) in terms of probability of participation. We keep the five closest observations, and matching is carried out with replacement of observations. This algorithm reduces bias of estimation (Dehejia and Wahba, 2002) but increases its variance (Smith and Todd, 2005). Kernel matching reduces variance since it works out the counterfactual outcome by weighting the outcome of control observations according to their distance to the treated observation. Radius matching compares the treated observation to all observations within the caliper of the probability of participation specified. We fixed for both treatments the caliper at 20% of the variance of the propensity score, which minimizes the mean of the square of the error term (Austin, 2011).

The PSM technique relies on the strong ignorability hypothesis (Heckman et al., 1999). First, the common support hypothesis means that the overlap area between propensity scores of treated and control observations is sufficiently significant. Second, conditional independence means that there is no omitted variable, that is to say all variables influencing treatment and outcome are observed. Since certain variables in practices may be omitted and others may be difficult to measure, it is necessary to test the robustness of matching models to an unobserved variable. It can be done by using the Rosenbaum bounds test (Rosenbaum and Rubin, 1983). Another way is to use an instrumental variable model.

3.1.2 Ordinary Least Square and Instrumental variables

When using a parametric model to assess the impact of contract participation, the problem of endogeneity may be encountered, from measurement error, reverse causality and unobserved heterogeneity (see Bellemare and Novak 2015 for a discussion). The likelihood that measurement error happens is low since there is no interest for producers to misreport their participation, and we controlled that information at the level of PO's leaders and the level of agricultural advisors. But the two other causes of endogeneity may be present in our models. Reverse causality means that producers could take into consideration their income and food security levels to decide whether they engage in contracts. It is also possible that we omitted in this article certain variables, such as producer's risk preference or entrepreneurship, which requires sophisticated questions to be partially addressed (Bellemare, 2012). Furthermore, one main unmeasurable variable which influences participation is the indebtedness of POs. This variable is hardly measurable since the issue is taboo. Our local partners were not able to provide us with this information. We use an instrumental variable model to detect and correct endogeneity.

The basic model is an ordinary least square regression which includes covariates as a control function to correct for selection bias:

$$Y_i = \alpha_1 + \beta_1 . X_i + \gamma_1 . D_i + \varepsilon_i \qquad (2)$$

in which α is the constant, β is the coefficient associated with the individual characteristics of producers, D_i is the dichotomous variable for participation, γ is the coefficient associated with this treatment variable and ε is the error term. The ATT is the estimation of the coefficient γ.

We detect endogeneity using a two-stage, least square model in which Z_i is the vector of instrumental variables (IV) for the suspected endogeneous variable, which is in our case the participation dummy.

$$Y_i = \alpha_2 + \beta_2 . X_i + \gamma_2 . Z_i + \mu_i \qquad (3)$$

An instrument influences only the outcome through the participation variable. The condition of relevance means the covariance between the instrument and the treatment variable must be different from zero. The restriction of exclusion means the instrument is not correlated with the error of the structural equation (Wooldridge, 2010). We identified from a conceptual point of view the variables which only influence producers' income and food security through contract participation. The use of a credit from the national bank is mandatory to participate in marketing contract. Nevertheless, the bank does not influence the selling price. This variable seems to be a good proxy for producers indebtedness since the numerous producers' interviews we did in the framework of previous research (Soullier and Moustier, 2015) highlighted that credit by the national bank is the funding preferred by producers. We may deduce that producers which do not benefit from such credit were discarded from that formal system because of indebtedness. Such producers may fund rice growing through production contract, but only if they are in the radius of activity of the concerned rice millers. But millers declared they do not establish a negative link between distance and purchasing price. The connectivity to other part of the department by regular public transportation and the openness that provides a private vehicle may also influence the participation in contracts. Nevertheless, rice millers do not use marketing contracts to purchase at lower price in remote areas, or to isolated farmers, which is perhaps due to the negotiation of an indicative price within the interprofessionnal association. Therefore, instruments are the use of credit from the national

bank, distance from the closest rice miller implementing production contracts, the availability of regular[1] public transport in the village and the ownership of a private transportation mean.

3.2 Sampling:

The geographical area of this study covers the department of Dagana. This is the core area of rice production in the country and the only place where contracts were found in 2014. We conducted a cross-sectional survey. Sampling was carried out in three steps, using exhaustive databases provided by the national agency managing agriculture in the SRV, called *Société d'Aménagement et d'Exploitation du Delta* (SAED), and rice millers implementing production contracts. We first selected hydraulic unions bringing together small-scale producers. In the second step, we selected the POs. In 2014, the 1,105 POs included around 20,000 small producers who grew rice during the dry season (data from SAED). With the support of agricultural advisors, we stratified the POs according to the types of marketing they used: spot transactions, marketing contracts or production contracts. We oversampled the producers participating in contracts in order to have significant inferences: the ratio of both the treated sample to the treated population is around six times higher than the ratio of the control sample to the control population. Nevertheless, the control group is more important in absolute values in order to increase the likelihood of finding good matches. We corrected for oversampling of treated observations in data processing. We randomly selected 90 POs. Finally, among each PO, we randomly selected six producers. When one producer was not found, we selected the next one in the list of producers randomly selected. We collected 607 questionnaires. We used double keying in of data. We withdrew incomplete or inconsistent observations, and 12 observations with an exceptionally bad harvest, which influenced the results without any link to the coordination modes. We kept 550 valid questionnaires: 265 spot transactions, 130 marketing contracts and 155 production contracts.

3.3 Variables

We used the same broad questionnaire for all respondents. It queries the organization of rice production, financing, paddy processing, paddy marketing, household characteristics, sources of income, assets, use of paddy and food security.

Certain covariates can be influenced by outcome variables. These variables are the ownership of a transportation mean and the total value of assets. The values concerned are prior participation in order to ensure there is no reverse causality at this level. Furthermore, we use the 2014's developed surface (and not the cropped surface), which cannot be influenced by participation because of high land development costs.

[1] more than 10 times per day

3.4 Indicators

We use two income indicators: Profit (per kilogram sold or per hectare) and selling price per kilogram sold. Profit is the difference between sale revenues and costs, including manpower and capital depreciation. Since producers have a food crop rationale, we calculate their profit by withdrawing the share of costs concerning quantities sold (and not total costs) from revenue. Results in terms of added value (difference between revenue and intermediate consumption) are not presented in this paper since they yield similar results relative to the ones relating to profits. Producers may conduct numerous spot transactions since they are adapted to households' needs. The selling period which follows the harvest was divided into three sub-periods, and when needed we asked the average price per sub-period. The negotiated price is mean-weighted with volumes sold during the season. We furthermore calculated results of farmers selling both under contract and through spot transactions. In that case, we added income (and other indicators) from the contract and from spot transactions.

Food security is measured with the Household Food Insecurity Access Scale (HFIAS) (Coates et al., 2007; Swindale and Bilinsky, 2006), which focuses on the respondent's perception of the access dimension of food security. HFIAS measures very different estimates of food insecurity than other frequently used indicators,[2] but is also correlated with them (Maxwell et al., 2014; Pérez-Escamilla and Segall-Corrêa, 2008). The indicator is based on nine questions addressing three facets of food insecurity: anxiety, quantity and quality. Each question is associated with three frequency modalities. It enables calculation of the indicator which ranges between 0 (perfect food security) and 27 (maximum food insecurity). We also break this indicator down to highlight the aspects of quantity and quality in food insecurity.

4. Results

We compare the characteristics of treated farms with the characteristics of control farms (Table 1). The t-test shows that contracted and negotiating farms are very different. They are only similar in terms of age of head, storage and ownership of a private vehicle. The group of farms selling by marketing contracts has similar performance to control farms in terms of profit per kilogram, and profit per hectare when the additional spot transaction is included. Their food security seems to be better. The group of farms selling by production contracts has lower income indicator and higher food security indicators. All these preliminary performance results are not corrected for differences in farm characteristics.

[2]Other indicators are mainly: Coping Strategies Index (CSI), Household Hunger Scale (HHS), Food Consumption Score (FCS), Household Dietary Diversity Scale (HDDS) and a self-assessed measure of food security (SAFS).

Table 1 : Mean values of variables used in analysis according to treatments

	Spot transactions N = 265	Marketing contracts N =130	Production contracts N =155
Demography			
Age of head	48.3	49.8	48.4
Female headed household (woman=1)	12.8%	1.54%***	1.93%***
Dependency ratio[3]	68.28%	67.15%	57.12%***
Number of active member	2.78	3.15**	4.16***
Ethnic group (Wolof = 1)[4]	67.2%	76.1%*	64.5%
Rice growing			
Developed area (ha)	1.50	1.54	2.71***
Experience in rice growing (years)	17.52	19.08**	18.24
Storage outside	22.2%	18.5%	18.7%
Credit from national bank	53%	97.7%***	0%***
Livelihoods			
Value of non-land assets (FCFA) in 2010[5]	1,795,347	1,294,650*	1,838,887
Ownership of vehicle in 2010	62.6%	64.6	67.1%
Context			
Public transport available in the village	50.6%	76.1%***	40%**
Distance from production contract rice miller (km)	50.9	30.9***	28.1***
Marketing			
Share of production sold under contract	0%	49.8%***	47.4%***
Share of production sold	63.71%	71.7%***	71.32%***
Share of producers selling through spot transactions	100%	88.46%***	98.71%**
Performance[6]			
Profit per kilogram (contracts) [7] (FCFA)	44.30	44.74	24.26***
Profit per kilogram (contracts + spot) [8] (FCFA)	44.30	44.95	29.22***
Profit per hectare (contracts) (FCFA)	210,662	146,429***	88,451***
Profit per hectare (contracts + spot) (FCFA)	210,662	219,925	162391***
Price per kilogram (contracts) (FCFA)	124	126.2**	103.9***
Price per kilogram (contracts + spot) (FCFA)	124	126.5**	108.84***
Food Insecurity (HFIAS)	5.83	4.02***	4.22***
Food insecurity-quantity	0.86	0.18***	0.62
Food insecurity-quality	4.01	3.13***	2.8***

Note: For each row, the two last columns present the results of a t-test of the null hypothesis that the means are equal in both samples. * Difference in means that is significant at the 10% level; ** Difference in means that is significant at the 5% level;* ** Difference in means that is significant at the 1% level.

3 Number of dependents (children below the age of 15 and members unable to work) over the total household size.

4 Wolof is the major ethnic group in Senegal.

5 We listed the assets owned by the households in 2010 and valued them at the price they could be sold.

6 Opportunity costs are: FCFA 40,000 per hectare for Land rental, FCFA 500 for manpower per day during the whole season except for harvest, when it costs FCFA 1,500 per day. Transportation of seed, fertilizer and herbicide is zero but transportation of bags of paddy is FCFA 50 per bag. Seasonal workers are often given room and board, which costs FCFA 5,000 per month. The opportunity cost of in-paddy payment is FCFA 75 per kilogram. This value is important since threshing represents around 10% of production.

7 For producers selling under contract, we only take into account the volumes they sold through contracts.

8 For producers selling under contract, we also take into account the volumes they sold through spot transactions.

4.1 Factors influencing participation

We select the variables which are correlated to treatment and/or outcome variables to compare the observations (Caliendo and Kopeinig, 2008). The probability of participation is worked out using the following probit models (Table 2)

Table 2 : Probit models of participation in marketing and production contracts

	Production contract		Marketing contract	
	Coefficient	Standard Error	Coefficient	Standard Error
Developed area	.1218215***	.0407003	-.0858799	.0831096
Number of active member	.1168234*	.0653973	.5265174***	.0996272
Experience in rice growing	.0229001**	.0114841	-.023607**	.0107217
Age of head	-.031240***	.0105519	.0024361	.0093555
Value of non-land assets in 2010	-5.50e-08	3.38e-08	3.85e-08	2.87e-08
Dependency ratio	-1.52917***	.5686913	1.070907	.7440097
Female headed household	-1.47592***	.4384219	-1.73986***	.4508346
Ethnic group Wolof	-.2912369	.1932753	.2358169	.2082924
Storage outside	.3865662*	.2215856	-.6083869**	.2516577
Ownership of vehicle in 2010	.0646357	.1834723	.0278694	.1861129
Public transport available in the village	-.09596	.1756991	.2304931	.2092495
Credit from national bank	-2.87224***	.3601255	3.785725***	.4388752
Distance from production contract rice miller	-.039806***	.008307	.041992***	.0074229
_cons	2.625597***	.7119401	-6.35673***	.930073
N	420		395	
LR chi2	240,95		224,23	
Prob > chi2	0.0000		0.0000	
Pseudo R^2	0,4356		0.4480	
Log likelihood	-156,07		-138,13	
Percentage of correct prediction	82.38%		82,78%	

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level

4.2 Impact of contracts on income and food security

We find (Table 3) that (1) the impact of marketing contracts on producer incomes is not significant, (2) production contracts have a negative effect on producer incomes, (3) the involvement in spot transactions of contracted farmers decreases the negative impact of contracts and (4) marketing contracts increase producer food security.

The effect of marketing contract on producer incomes is not significant. Indeed, none of the models finds a significant impact on the profit per kilogram. There is nevertheless a tendency towards a negative effect since all the models find a negative impact of this type of contract on the profit per hectare. This negative impact is explained by higher costs per hectare but not by a difference in yields.

Production contracts have a significant negative impact on profit per kilogram sold and per hectare. According to the matching algorithms used, the loss of profit per kilogram ranges between 50.2% and 51.1%, and the loss of profit per hectare ranges between 56.75% and 57.8%. The parametric model identifies similar results. It is explained by lower selling price (around 16%). We do not find any difference in terms of yields.

Spot transactions mitigate the negative impact of contracts. In the case of production contract, the nearest neighbor algorithm gets a decrease in the loss profit per kilogram (from 50.2% to

40%) and the profit per hectare (from 57.54% to 22.2%). This is due to the reduction of the difference in the average selling price (from -16.1% to 12%). The models find marketing contracts have no longer an impact on farmer incomes per hectare when we consider the additional spot transactions.

The marketing contract decreases producer food insecurity. It is mainly the quantity facet of food security which is affected by this reduction. It ranges between 1.36 and 2.13 points over a scale which varies between 0 and 27. The food insecurity level of the control group is small, so the small impact in absolute values corresponds to high impact in relative values.

Table 3: Results of model assessing the impacts of marketing and production contracts on the income and food security of small-scale producers

Indicators of performance			Parametric models		Non-parametric models					
			Type of model	Impact	Nearest Neighborg matching		Kernel Matching		Radius Matching	
					ATT absolute value	ATT percentage	ATT absolute value	ATT percentage	ATT absolute value	ATT percentage
Production contract	Food security	HFIAS total	OLS	-1.05**	NS		NS		NS	
		HFIAS quantity	OLS	NS	NS		NS		NS	
		HFIAS Quality	OLS	-.91***	NS		NS		NS	
	Contract only	Profit per kilogram	OLS	-20.5***	-24,7***	-50,2%	-24,8***	-50,3%	-25,7***	-51,1%
		Profit hectare	IV 2SLS	-170216***	-121721***	-57,54%	-117705***	-56,75%	-123081***	-57,8%
		Price of selling	IV 2SLS	-27.9***	-19,9***	-16,1%	-19,8***	-16,0%	-20,1***	-16,2%
	Contract and spot	Profit per kilogram	OLS	-15.5***	-19,7***	-40,0%	-19,8***	-40,1%	-20,6***	-41,1%
		Profit hectare	IV 2SLS	-88268***	-46931**	-22,2%	-42644**	-20,6%	-48290**	-22,7%
		Price of selling	IV 2SLS	-22,1***	-14,9***	-12,0%	-14,9***	-12,0%	-15,1***	-12,2%
Marketing contract	Food security	HFIAS total	OLS	-1.36***	-1.75**	-31,9%	-1,95***	-34,3%	-2,13***	-36,3%
		HFIAS quantity	OLS	-0.55***	-1.11***	-84,1%	-1,17***	-84,8%	-1,25***	-85,6%
		HFIAS Quality	OLS	-0.57**	NS		NS		NS	
	Contract only	Profit per kilogram	OLS	NS	NS		NS		NS	
		Profit hectare	OLS	-73229***	-82014***	-36,7%	-90820***	-39,1%	-89905***	-38,9%
		Price of selling	IV 2SLS	-12,6**	NS		NS		NS	
	Contract and spot	Profit per kilogram	OLS	NS	NS		NS		NS	
		Profit hectare	OLS	NS	NS		NS		NS	
		Price of selling	IV 2SLS	NS	NS		NS		NS	

NS: Not Significant; * Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level

4.3 Robustness tests

Results of Propensity Score Matching are valid if models respect both hypotheses of common support and conditional independence (Heckman et al., 1999; Rosenbaum and Rubin, 1983). First, all observations must have a propensity score ranging between 0 and 1, and sufficient observations must have the same probability of participation (Appendix 1). At least 96.82% of the production contract observations find a counterpart in the control group, and this rate is at least 82.3% of observations in the case of marketing contract observations (Appendix 2). Conditional independence is tested with Rosenbaum bounds for hidden bias (Becker and Caliendo, 2007; DiPrete and Gangl, 2004). This test simulates one or more omitted covariates which would influence the propensity score. It allows us to identify the percentage of variation of this score which changes the significance of the estimation, or changes the sign of the effect.

CF provides producers with certain inputs. In the case of marketing contract, it is mainly the credit. In the case of production contracts, it often includes seeds, fertilizers, weeding and sometimes mechanized services. One could object that these inputs should not be used as covariates since it is a component of contracts. We run the matching models excluding the variable "funding from the national bank". We do not find any difference in terms of significance of results. Furthermore, the results are even more robust since the overlap areas are larger (see

Appendix 3).

We use the Durbin-Wu-Hausmann test to identify endogeneity in the parametric models. This test measures the difference of the impact of participation between two models. In the first model, participation is treated as endogenous and instruments are not included. In the second model, participation is considered as exogenous, and instruments are included (Hayashi, 2000). The difference between the two models is an indicator of endogeneity. We find endogeneity in the models assessing the impact of production contracts on the price of selling and on the profit per hectare. We also find endogeneity in the model assessing the impact of marketing contract on the price of selling. When there is no endogeneity, results are from ordinary least square models. When detected, we correct for endogeneity using instruments. We also test these instruments (**Erreur ! Source du renvoi introuvable.**). First the condition of exclusion restriction states instruments are not correlated with the error term, and excluded instruments are correctly excluded from the estimated equation (Sargan-Hansen test). Second, we test the relevance of instruments. The under-identification test (Kleibergen-Paap rk LM statistic) checks if excluded instruments are correctly excluded, that is to say if they are correlated with the endogenous repressor. Finally, the weak identification test (Cragg-Donald Wald F statistic) checks that instruments are sufficiently correlated with the endogenous repressor.

5. Discussion: Impact pathways

The results of our research are different from the trend highlighted in the literature about contract farming. Most of research done in the last 15 years finds positive income effects. The pathway they highlight is an upgrading of produce through access to improved inputs and agricultural advisory services, in addition to credit (Eaton and Shepherd, 2001; Gow and Swinnen, 1998; Jaffee et al., 2011; Prowse, 2013; Reardon et al., 2009). It enables an increase in quality and in yields, and therefore in incomes (Jaffee, 1987; Swinnen, 2007).

Contracts in the SRV rice value chain do not bring this kind of upgrading. As explained earlier, the intensification of rice cropping started in 1973 (Legal, 1995) and there was no major change in inputs since that period. Producers participating in contracts use the same inputs from the same networks as producers selling through spot transactions. They also get the same agricultural advisory services from the same agents. Rice millers implementing production contracts are an additional intermediary between input providers and producers, and their advisors recommend the same technical operations as public advisors. We use the non-parametric nearest neighbor model to compare the inputs used by treated and control farms: quantity of seed, use of certified seed, quantity of chemical fertilizers, use of manure as fertilizer, and use of weeding (Appendix 4). In the case of marketing contract, we do not find any difference between treated and control groups. In the case of production contract, the only differences are in terms of certified seeds, cost of fertilizer and use of chemical fertilizer. We also find no difference in yields.

The failure of the formal credit market brings about the emergence of production contracts, which is less effective in terms of producers remuneration. We discussed with producers (15 interviews) and rice millers (5 interviews) the issue of producers' participation in production contracts, which are less remunerative than spot transactions. Non-parametric models show that the lower profits are due to lower selling price of paddy. As explained, there have been acute problems of non-reimbursement in the SRV in the past and producers commonly enter production contracts because they were discarded from the formal credit system. But this problem of non reimbursement is also faced by rice millers. Three of them declared that the

reimbursement rate was around 70% in 2014. To solve this problem, they include in the purchasing price of production contracts an implicit insurance cost against this risk of non-reimbursement. When one producer does not reimburse the rice miller, a new contract is often set-up. The insurance funds the closer follow-up of this producer during the next season in order to enable him to reimburse his previous credit and the new one. This insurance also includes the financial compensation of rice millers losses when no reimbursement is possible during the following season. The lower purchasing price could also include an insurance against price variations. There seems to be no insurance against risk over input provision: farmers declared that problems (such as quality) are sometimes higher in production contracts than spot transactions. Finally, we may wonder if the lower purchasing price does not also result from an imbalance of negotiation power between rice millers and producers. Indeed, indebted producers have few opportunities of funding, and the structure of the market on which millers purchase paddy by production contracts is oligopsonistic.

Another puzzling question is the positive impact of marketing contracts on producer food security. Since these contracts have no effect on producer income (with a negative tendency), we could suppose that they have no impact or even a negative impact on farmers' food security. The explanation lies in the seasonality of selling. Negotiated prices have strong seasonal variations whereas prices within marketing contracts are steady. For the period during which the negotiated price is lower than the marketing contract price, producers have to supply less paddy when marketing within contracts to reimburse the same amount of credit. It enables them to put aside more paddy, which will be used according to household needs, including food consumption. In other words, most of producers sell the paddy to reimburse their loan during the two months following the harvest, when the price in marketing contracts is higher than the spot market price. It enables these contracted producers to keep more paddy for self-consumption.

6. Conclusion

The Quiet Revolution is characterized by the concentration of the midstream segment, which invests in new technologies, sets up new coordination modes with producers and becomes the driver of quality (Minten et al., 2013; Reardon et al., 2014, 2012; Reardon and Minten, 2011). It seems that a similar pattern in food chain transformation is happening in Africa (Reardon et al., 2013; Soullier and Moustier, 2015). It is assumed that the appearance of CF reduces transaction costs (Jaffee and Gordon, 1993) and induces the upgrading of suppliers, through access to improved inputs, agricultural advisory services and credit (Eaton and Shepherd, 2001; Gow and Swinnen, 1998; Jaffee et al., 2011; Prowse, 2013; Reardon et al., 2009). CF enables an improvement of quality, and an increase in yields and income (Jaffee, 1987; Swinnen, 2007).

The purpose of this paper is to assess the impact of contract farming on farmer incomes and food security within the rice value chain of the Senegal River Valley. The hypothesis is that contracts improve farmer incomes and food security. The originality of this research is to study the impact of contracts within a domestic grain value chain, whereas most literature focuses on the contract within export value chains of horticultural products. We compare the performance of producers selling through spot transactions, marketing contracts and production contracts. We use propensity score matching, ordinary least square, and two stages least square models. We conducted a cross-sectional survey and obtained 550 valid questionnaires.

We find (1) no impact from marketing contracts on farmer incomes since there is no upgrading compared to the traditional value chain; (2) a significant negative impact from production contracts on farmer incomes due to an implicit insurance cost of credit; (3) contracted farmers engaging in spot transactions, which increase their profit; (4) marketing contracts having a positive impact on food security since they mitigate price seasonality.

The usual criticisms regarding the assessment of contract impact on producers performance concern our work. Firstly, there could be contagion effects, that is to say that the price negotiated in spot transactions could affect, or be affected by, prices implemented within contracts. Second, we did not include a risk preference variable, which can be one source of endogeneity. Third, production contracts are often the only way for producers to fund rice growing. We could have compared these producers with producers not growing rice as a control group, in which case the impact of production contracts would be positive. Finally, we only provide in the paper a static analysis of the participation of small-scale producers in CF.

We wish in the future to address several questions. First, it is still unclear whether production contracts impact the sustainability of agricultural practices since we did not collect our data in order to answer that question. Furthermore, agribusinesses are vertically integrating rice production, which can also impact practices. Our research agenda will address the impact of change in governance over the sustainability of agricultural practices. Second, producer participation within traditional and modern value chains must be analyzed with a dynamic approach. Indeed, it seems that POs adapt their marketing strategies according to certain contextual factors, such as the season considered or public interventions. Third, we will continue to study the impact of the combination of plural forms of governance, for which there is a growing interest (Ménard, 2013).

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APPENDIX

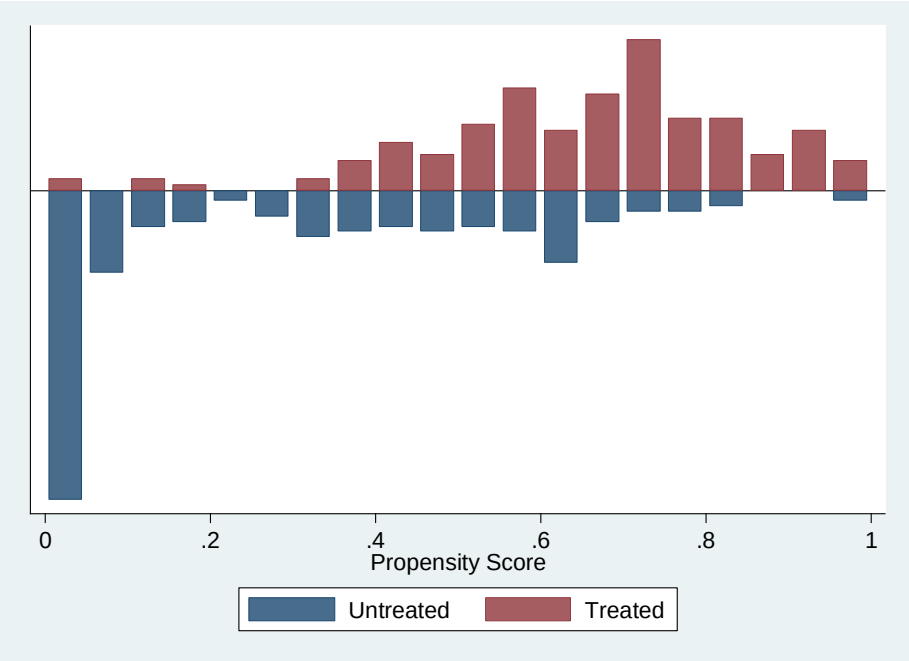
	Production contract								
	Food Security			Contract only			Contract and spot		
	HFIAS total	HFIAS quantity	HFIAS Quality	Profit per kilogram	Profit hectare	Price of selling	Profit per kilogram	Profit hectare	Price of selling
Production contract	**-1.05413****	**-.1195533**	**-.9061015*****	**-20.46794*****	**-170216.5*****	**-27.87661*****	**-15.46411*****	**-88268.81*****	**-22.10616*****
Developed area	.1410526	.073022	.0367531	-.7161432	-3899.285**	.0676352	-.7636076	-3232.393	.0001886
Number of active member	-.4062465**	-.0607961	-.2493967**	.1974842	5827.412*	.1597477	-.1084893	-304.9066	-.1789021
Experience in rice growing	.0231617	.0104293	.020798	.1890536	516.1735	.1008635**	.2099078	1076.343	.1230154**
Age of head	-.1090674***	-.0306234**	-.0688016***	.1709786	-9.450846	-.0526289	.219327	48.56312	-.0033031
Value of non-land assets in 2010	-1.47e-07***	-4.54e-08**	-8.10e-08**	-2.04e-08	-.0004854	6.49e-08	3.84e-09	-.0002152	9.38e-08
Dependency ratio	-1.033524	.2385768	-1.235748	-.8658593	-16126.39	-8.574299***	-4.995064	-44346.01	-12.56451***
Female headed household	1.684091**	.7607346	.7802326*	-3.914134	-62980.81***	-.9268811	-3.832356	-35635.78	-.5597994
Ethnic group Wolof	.4694074	.3420241	.024332	1.630338	12772.51	-1.141052	1.148683	17191.43	-1.601078*
Storage outside	2.039313***	-.0560553	1.815115***	-10.91466***	-33540.96***	-.2913413	-9.480263**	-49033.25***	1.145297
_cons	11.59357***	1.816048***	8.076109***	35.71979***	238413.2***	135.9539***	36.70975***	256502.2***	136.3192***
Type of model	OLS	OLS	OLS	OLS	IV 2SLS	IV 2SLS	OLS	IV 2SLS	IV 2SLS
Number of observations	420	420	420	420	420	420	420	420	420
Prob > chi2	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0.0005	0,0000
Adjusted R2 (centered R2)	0.2033	0.0756	0.2469	0,1809	0,2597	0,5114	0.1283	0.0647	0.3553
Endogeneity test of treatment variable (prob)					8,293 (0,0040)	28,177 (0,000)		4,439 (0,0351)	25,613 (0,0000)
Weak identification test (Cragg-Donald Wald F statistic):					146,986	118,605		146,986	118,605
Underidentification test (Kleibergen-Paap rk LM statistic):					135,103	116,764		135,103	116,764
Sargan statistic (overidentification test of all instruments):					0,437 (0,5088)	1,082 (0,2982)		0,496 (0,4814)	0,449 (0,5028)

	Marketing contract								
	Food Security			Contract only			Contract and spot		
	HFIAS total	HFIAS quantity	HFIAS Quality	Profit per kilogram	Profit hectare	Price of selling	Profit per kilogram	Profit hectare	Price of selling
Marketing contract	**-1.358955*** **	**-.553047*** **	**-.5754118** **	**-.8700044**	**-73228.65*** **	**-12.64531** **	**-.2015363**	**2625.557**	**-7.718311**
Developed area	-.312072**	-.0262023	-.1941095*	.1339761	3764.98	-.6177283	-.0325593	4634.138	-.7879824**
Number of active member	-.477806***	-.2012335***	-.1963766	-.044233	4572.555	.4893271	-1.059839	-2026.401	-.7117305
Experience in rice growing	-.0081035	.0073508	.0016359	-.129879	-703.1934	.020191	-.1184328	-2468.116**	.0363503
Age of head	.0062618	.001836	-.0090745	.1873548	220.6985	.0934825*	.0647428	389.7843	-.0350985
Value of non-land assets in 2010	3.59e-08	2.75e-10	5.37e-08	3.03e-07	.0021951	-2.21e-07	7.89e-08	.0022111	-3.95e-07**
Dependency ratio	-5.097324***	-1.784138***	-3.060881**	-9.156041	-81319.28**	2.948794	-18.39731**	-125915.3**	-6.721631
Female headed household	1.208804	1.040509*	.1829144	-14.12019**	-75188.13***	-8.259408*	-15.57344***	-111608.9***	-7.604841*
Ethnic group Wolof	.3320167	.2516466*	.1327322	-1.031239	8995.709	1.576929	-4.045346	-15026.97	-1.771336
Storage outside	4.973209***	-.4462313***	5.40646***	5.421048***	31535.91**	9.766883***	6.154318***	29474.99**	10.90505***
_cons	9.395165***	2.251862***	5.934618***	44.45613***	242154***	125.0579***	62.00765***	333632.7***	140.5485***
Type of model	OLS	OLS	OLS	OLS	OLS	IV 2SLS	OLS	OLS	IV 2SLS
Number of observations	395	395	395	395	395	395	395	395	395
Prob > chi2	0,0000	0,0011	0,0000	0,0012	0,0000	0,0000	0,0003	0,0000	0,0000
Adjusted R2 (centered R2)	0.3274	0.1010	0.4906	0,0444	0,1753	-0,20,34	0.0526	0,082	0,0613
Endogeneity test of treatment variable (prob)						10,552 (0,0012)			4,422 (0,0355)
Weak identification test (Cragg-Donald Wald F statistic):						11,197			11,197
Underidentification test (Kleibergen-Paap rk LM statistic):						25,927			25,957
Sargan statistic (overidentification test of all instruments):						0,617 (0,4320)			0,061 (0,8052)

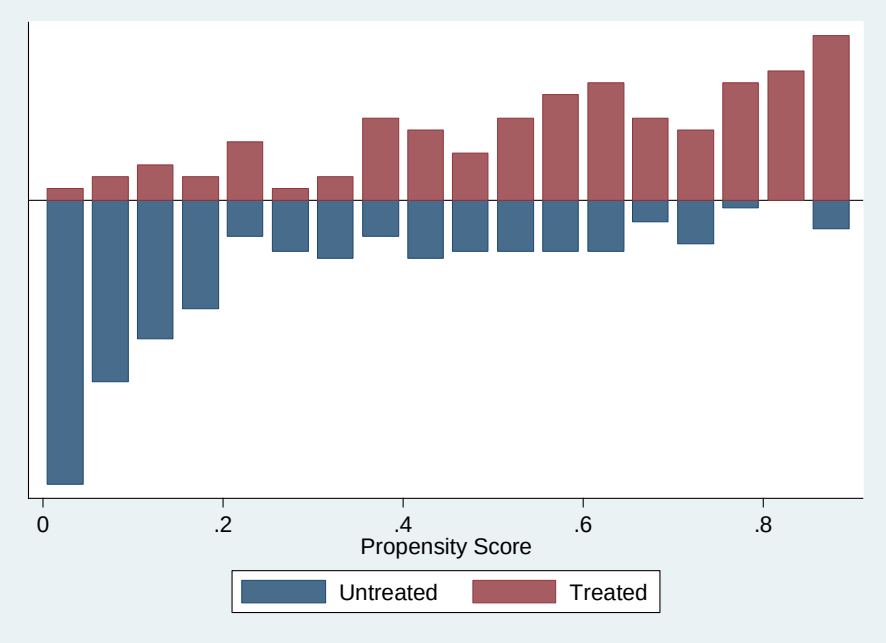
* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level

Appendix 1 : Common support according to treatments[9]

PRODUCTION CONTRACT



MARKETING CONTRACT



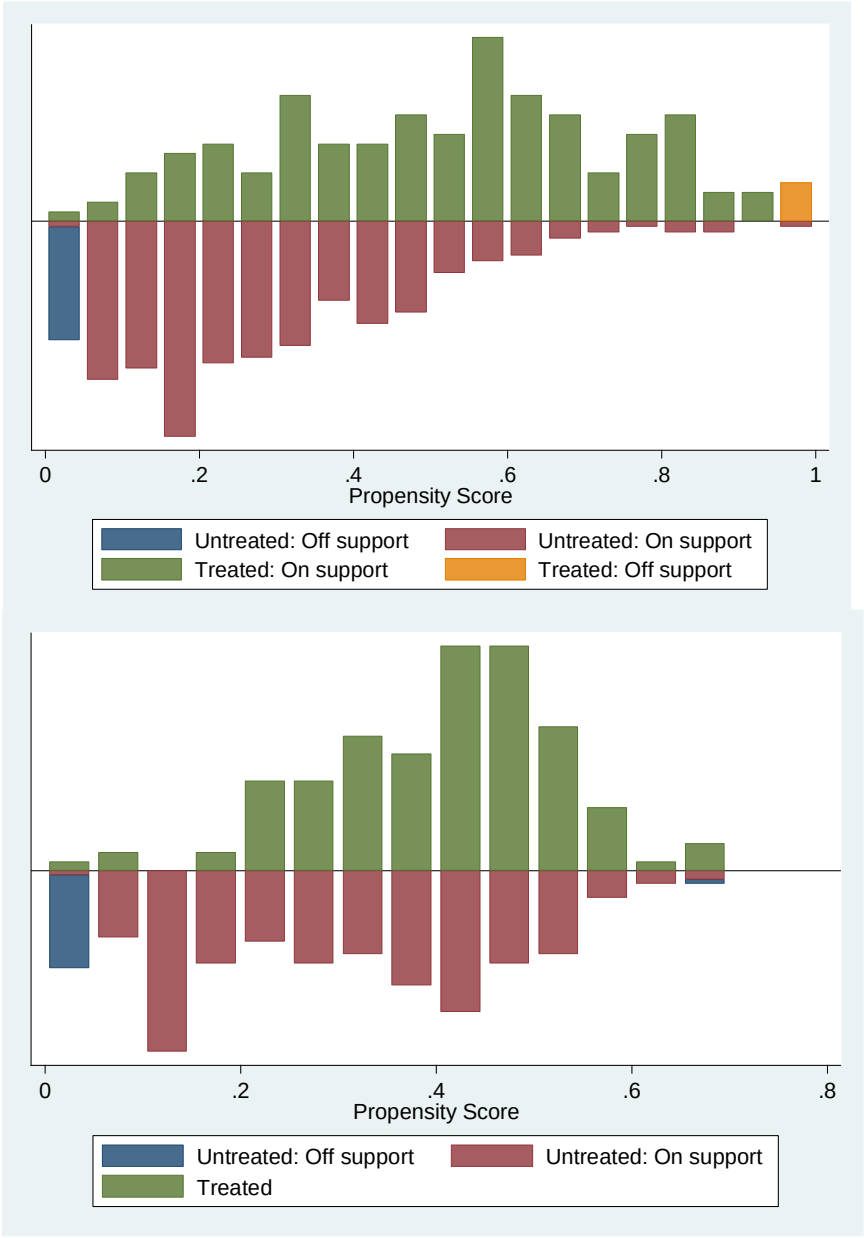
[9] We only provide the charts of common support concerning the algorithm of nearest neighbourg since the Kernel and Radius algorithms yield similar charts.

Appendix 2: Numbers and percentages of observations matched per treatment and algorithm

	Number of treated observations	Number of control observations	Number and percentage of observation on common support					
			Nearest neighbor		Kernel		Radius	
			Treated	Control	Treated	Control	Treated	Control
Production contracts	155	265	150 (96.8%)	176 (66.4%)	152 (98.1%)	180 (67.9%)	150 (96.8%)	176 (66.4%)
Marketing contracts	130	265	107 (82.3%)	173 (65.3%)	107 (82.3%)	173 (65.3%)	107 (82.3%)	173 (65.3%)

Appendix 3 : Common support without the covariate “funding at the national bank”

PRODUCTION CONTRACT



Appendix 4 : Impact of contracts on the intensity of agriculture (Nearest Neighbourg Matching)

Type of contract	Indicators of agricultural intensity	Control	Treated
Production contract	Certified seeds (%)	71,96%	96%***
	Quantity of seeds per ha (kg)	132,12	130,23
	Cost of weeding (FCFA) per ha	17795	25563***
	Quantity of organic fertilizer (manure) per ha	0	0
	Quantity of chimical fertilizer 1 (18/46) per ha	83,64	100,2*
	Quantity of chimical fertilizer 2 (urea) per ha	284	295,5
	Mechanized harvest	3,06%	4,66%
	Yield (kg/ha)	6510	6850
Marketing contract	Certified seeds (%)	95,60%	96%
	Quantity of seeds per ha	124,13	132,16
	Cost of weeding per ha	23894	24153
	Quantity of organic fertilizer (manure) per ha	0%	0%
	Quantity of chimical fertilizer 1 (18/46) per ha	109,3	107,07
	Quantity of chimical fertilizer 2 (urea) per ha	282	300
	Mechanized harvest	0%	1,73%
	Yield (kg/ha)	6710	6446

Results of a t-test of the null hypothesis that the means are equal in both samples. * Difference in means that is significant at the 10% level; ** Difference in means that is significant at the 5% level;* ** Difference in means that is significant at the 1% level.