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**Influence of interlocked transactions on gum arabic production and
marketing in Senegal**

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Abstract

Interlocked relationships are characterised by traders' supply of inputs and cash to producers on credit, to be reimbursed at sale time based on a pre-defined price which is often lower than the prevailing market price. The study analyses determinants of choice of interlocking in the gum sector in Senegal and the effect of interlocking on market participation and gum production. Data from 422 gum producers in Northern and Eastern regions of Senegal are used. About 41% of respondents are involved into interlocking with village shop-owners or mobile traders. Interlocking positively influences market participation and production as found through a Heckman selection model.

1. Introduction

Gum arabic is the main product of the *Acacia senegal*, a tree species which is naturally suitable for the semi-arid regions. The Acacia tree is important for its environmental functions and its gum which is used in various domestic and industrial usages (Barbier, 1992:341; Fagg, 2004:56). Gum is traded in local markets and processed within the producing country but a large proportion of its produce is exported as a non-timber forest product. Sudan is the world's largest producer of gum arabic; it produces about 50 percent of the world's market which is estimated at about 45,000 tonnes. Sudan is followed by Chad and Nigeria. Senegal's exports account for less than five percent of the world market (DEFCCS, 2005:15). Despite this low production level, collection of gum arabic in Senegal is an important source of income next to pastoralism and agriculture and would lead to substantial improvements in the livelihoods of

gum collectors (producers) when access to markets would be secured. Such improvements would be further incremented through upgrading gum quality by way of cleaning, sorting and storing gum.

To the collectors, this activity has not been fully valorised: problems in collection include long distances to the collection areas, wildlife and wilderness, and injuries at the time of tapping (removing the bark to enable gum to exudate) or harvesting gum (removing the gum from the tree). There are also problems in marketing, including low and continually diminishing prices and exploitation by traders. These problems in marketing result from high marketing costs associated with market access, lack of information, and monetary and non-monetary transactions where gum arabic is supplied in exchange of money or commodities for daily consumption. Such transactions involve interlocked contracts/relations. Through these relations, the collector is offered 'on credit' household necessities, tools or cash that he repays as gum sales. The interlocking system often operates through strong friendship and parenthood ties and on the power that the trader can use to pressurize the collector to reimburse. On the other hand, interlocking is supported by the lack of an effective credit system in the rural areas where the collectors have to rely on traders who are the main holders of finance. However, the main disadvantage of interlocking is that the collector is exploited on the way, by being offered a lower price than the prevailing market price discussed at the time of contracting and he cannot freely make the decision regarding to whom he chooses to sell his product.

Our objective in this study is to analyse factors involved in the producer's choice for interlocked contract and to study the impact of the latter on his decision towards gum collection and direct market participation. The main hypothesis is that despite the negative

effect of interlocking on the price received by producers, interlocking has a positive effect on both production and market participation since producers have to repay their debts in a market where they are assured of having a buyer, this is the lender who has to recover the credit he offered.

We use data collected in Northern and Eastern regions of Senegal in 2009. The dataset includes responses from 422 gum collectors. Data includes information on personal characteristics of gum collectors and their households, details on gum collection and marketing and on the collector's trading partner and market where the collector sells his gum.

A probit model is used to analyse the choice of the producer to enter into interlocked relations based on the relative importance of transactions (related to gum arabic or other products), the need for credit and the relationships with the main trader. The gum production/collection and market participation decisions are analysed through a Heckman selection model. Besides the probability of interlocking, these two decisions are respectively based on (1) the gum production and producers characteristics and (2) distance to market and the transaction setting of market participation.

There is vast literature on credit market failures in developing countries related to formal and informal rural credit, contracts in general and interlocked product and credit markets in particular. This literature has mainly focused on aspects including the importance of the credit system in rural areas (e.g. Chakrabarty and Chaudhuri, 2001:6; Manig, 1990:214); issues related to access to credit (e.g. Atieno, 2001:14; Ortmann and King, 2007:6 ; Yaron, 1992:2); impact that credit or contractual relations have on production or market participation (Singh, 2002); and nature and impact of interlocking transactions (see Chakrabarty and Chaudhuri

(2001:213) for impact on interest rate or Sahu et al. (2004:220) for impact on price received by producers). To our knowledge, literature on interlocked contracts (including the studies mentioned above) merely describes these contracts without explaining how they arise in the first place and how they affect production and the choice of participating in market. Furthermore, understanding the interlocked relations in the context of the gum markets is very relevant to explain the behaviour of collectors in relation to the traders. This insight is highly important for understanding the constraints to production and marketing. It also sheds light on the organisation of the gum sector which is a step in improving the sector and ultimately the collectors' livelihoods. Gum arabic, being a non-timber forest, becomes a practical case from which generalisations to other nontimber forest products could be further made.

2. Market and credit access and interlocked contracts

In a context of failures in markets in rural areas, interlocking contracts are important arrangements for farmers to access inputs, in particular credit, and output markets. Access to credit has a positive impact on smallholder production by enabling producers to benefit from the use of productivity potentials (Spio, 2002 quoted by Randela et al., 2008:462). Credit also intervenes in the output market: access to credit has a positive relationship with the level of market participation (Heltberg and Tarp, 2001:5; Randela et al., 2008:462). In the developing world there are several difficulties and high costs of gaining access to credit (Rodale Institute et al., 2002:19). Randela et al. (2008:456) deplored the lack of credit for small-scale cotton farmers in South Africa; credit deficiency negatively impacted the farmers' ability to participate in markets through inflating transaction costs in input markets in Mozambique (Heltberg and Tarp, 2001:5); and credit also prevented farmers to acquire and utilize modern technology in Pakistan (Manig, 1990: 213).

While formal institutions could play a role in facilitating access to credit, the rural area is not often well served by formal credit. According to Yaron (1992:2) formal lending institutions generally focus on large-scale farmers and ignore small-scale farmers because of the significant cost of processing and servicing small loans and the prevalent belief that small entrepreneurs represent a greater risk than large ones. This fear for non repayment among the rural population increases by the fact that potential clients live scattered and have limited collateral specially in areas with collective types of land tenure (Armendáriz & Morduch, 2005).

Apart from microfinance initiatives, the alternative solution for smallscale farmers is to apply for credit through informal institutions such as close relationships of friends and family or through lending groups or moneylenders; the risk is however that the latter exploit farmers. Chakrabarty and Chaudhuri (2001:9) found that even if credit allocation in the rural sector is at a subsidized rate, the benefit of the subsidy is extracted by moneylenders. Cooperatives, whether formed exclusively for credit, agricultural or marketing purposes, also intervene in facilitating access to credit. If they function 'well', they provide a safer arrangement for the rural farmers in need of credit (Gaye, 1991a:4; Ortmann and King, 2007:7; Yaron, 1992:1). In addition to the above institutions, especially in cases of potential commercial transactions, product contracts are often interlocked with credit. For instance, in the Senegalese milk market, Dièye et al. (2005:7) report that dairies could offer credit to livestock owners to acquire inputs (livestock feed) in the dry season. Cash advances are also given to livestock owners either as individuals or collectively. These credits are reimbursed in kind: from the receipts of the milk supplied to the dairy, the loan amount is deducted before paying the livestock owner. Another example from Senegal is one of local traders in the vegetable sector. Traders are embedded in the village and have particular knowledge which facilitates

relationships with producers; they also offer inputs (fertilizers and seeds) on credit (Wade, 2009:144). As the producers are indebted towards such local traders, they reserve their produce to sell to these traders, in fear that if they default it will be impossible to access credit in the following season.

These contracts that interlock input and product markets are based on the ability of producer to repay because, as found by Wade (2009:145), the trader takes a portion of the supply by way of reimbursement and pays the remaining amount to the producer. Much more important, the contracts relate to the types of relationship between the farmer and trader in general or the pastoralist and the dairy manager in the case of milk market. Such relationships are held up through trust in absence of well developed regulatory legal environments typical in many developing countries. According to Fafchamps (2006:3) trust generally reduces opportunities for cheating in trade by misrepresenting quality (the seller) or running away without making payment (the buyer). However, the trust prerequisite remains greatly important in the interlocked contracts. This is because there is no material collateral and even if there might be family or friendship ties, the 'borrower' should be a potential supplier of his produce which is used for repayment (Dièye, 2006:89; Gaye, 1991b:6).

Trust is further fostered by the ability to identify a particular trading partner who very often does not change because the screening and search costs for a new partner may be too high or the change may not result in a higher expected price than that of the regular partner (Eaton et al., 2007). Regularity with the trading partner extending over a longer period of time is also important: it leads to a certain level of comprehension and routines which can reduce transaction costs, e.g. in price negotiation and monitoring of informal agreements. Routines are supported by reputation which becomes an enforcement mechanism. Especially in cases

where one of the transacting parties has the potential to engage in opportunistic behaviour, reputation is strongly considered (Pint and Baldwin, 1997:3). Furthermore, in the context of contracts in general and interlocked contracts in particular, reputation with respect to non-commercial transactions is important. This refers to intervening in emergency cases or to offering intermediation between producers and input providers in case the trader himself does not supply inputs (Dièye et al., 2005:16).

As summarized by Dièye (2006:131) the importance of the interlocking contracts consists of regularity of transactions, market assurance (since the producers knows that his produce will be bought), and building a network of suppliers. In the case of the dairy examples, interlocking even facilitates quality control (Dièye et al., 2005:9).

The negative effects of interlocking of transactions mostly affect the producer. Producers remain price takers. Sahu et al. (2004:210) mentioned distress sales and associated loss of income by small farmers in Orissa (India) due to interlocked contracts. In general, while the producer could have a good price at the market, by interlocking, his bargaining power is greatly reduced as he has an obligation to sell to the trader in order to have credit in the future (Wade, 2009:186); the price that this producer gets, is indeed fixed at the time of choosing to enter into interlocked contracts (Sahu et. al, 2004:211).

It is important to note that interlocking runs both ways: it is not only the ‘borrower’ that has to produce in order to repay but also the ‘lender’ has to recover the expenses done through advances, hence he also has to buy from the producers which implies a market insurance for the producer (Dièye, 2006:132; Galtier 2003 quoted by Wade, 2009). Accordingly, depending on the opportunistic behaviour of the partners, there is risk of defaulting (Wade, 2009:155).

To reduce this risk, Gaye (1991b:6) suggests that a trader should be a permanent resident of the locality where he is offering credit so that he can (socially) ‘coerce’ the producer to repay. If not, he should at least regularly trade with this community, otherwise the probability of recovering the debt in the next period is low.

3. Methodology

Our analysis of the gum collectors’ behaviour towards the choice of interlocking and the effect of interlocking on gum production and market participation uses a quantitative approach. Formal and informal interviews were conducted from February to June 2009 through a combination of snowball and quota sampling in the Northern and Eastern regions of Senegal. In the Northern region, also known as the Sylvopastoral Zone, interviews were held with 183 producers. In the Eastern region, similar interviews were held with 239 producers. Gum arabic has been extensively collected in the Northern zone for over five centuries (Webb, 1985:4) while in Eastern Senegal, the collection activity has intensively started in the last five years through the intervention of EXPERNA, a collectors’ association. This is the only active association in the gum sector in Senegal; other associations remain at an embryonic stage. Private companies are involved in the Senegalese gum sector in production (Asyilia Gum), processing (Valdafrique) or just exporting (MCI).

3.1 Gum production function

Collectors of gum arabic belong to households engaged mainly in pastoral and agricultural activities. They undertake collection as a secondary activity in the dry season when no other agricultural activities are intensively going on. *Acacia senegal* trees are found in the semi-dry areas, mainly in natural forests or in artificial plantations realized by reforestation projects. Gum is exploited either communally or in private plots. Generally no tree management is done and inputs are limited to labour

The gum collection behaviour can be analysed through the following production function:

$$Q_{\text{coll}} = q(P, \text{Tree}, P_e, T, Ir) \quad (1)$$

The determinants of quantity collected (Q_{coll}) are:

(1) Production characteristics (P): these include (a) experience as one of the producer's characteristics which has a positive effect on the amount harvested and even on the quality of gum collected and (b) number of collectors in the household which would increase the total quantity of gum collected from the exudates from the bark of *Acacia senegal* trees. Exudation is either natural from the breaking of the bark by the heat or wind or by deliberate tapping. After 7 to 15 days when the gum has sufficiently matured, it is harvested from the tree. The number of collectors can also have relevance for labour division in the family: the older/more experienced producers can do the tapping while the younger collectors can harvest the gum from the tree.

(2) The presence of trees (Tree): *Acacia senegal* trees are mainly found on communal forests and to a lesser extent on private plots. In the natural stands, it is quasi impossible to know the density of the trees in the plot let alone the actual number of trees on which gum was harvested. Hence two proxies are used namely (a) a dummy variable that gum was harvested on a communal plot: collection of gum on a communal plot would entail competition among producers and it has a high risk of theft; it has a negative effect on the produce in terms of quantity or quality (as the gum is not left to mature sufficiently); (b) the days spent on tapping give an indication of the size of the plot.

(3) Expected price (E): the current gum price is most often determined by the trader depending on his estimation of marketing and transaction costs but also on the quantity that is expected

to be supplied in relation to demand. There are variations in price associated with variations in quantity throughout seasons. Irrespective of these variations across the years, the highest price obtained in the previous season should give an indication of what can be expected by the producers.

(4) Travel time (T): as mentioned, collection occurs in the forest. Depending on its location, producers spend half, whole or even several days in the forest. However the location itself may not matter in case the producer has some means of transport. Hence, time as such cannot be totally imputed to the collection but we use its two proxies namely the distance to the collection plot/forest (in kms) and the ownership of cart which is used for transport (number of carts). While long distances discourage collection, the ownership of a cart, showing the facility to travel to the collection place, has a positive effect on collection.

(5) Interlocked contracts: we assume that being involved in interlocked contracts increases production because of a better access to credit and a secured market.

3.2 Gum market participation

The actual participation of entering the gum market depends on a comparison of the market price and the cost involved in harvesting, post-harvest and sales. These costs include the direct cost of travelling to the market and transaction costs that depend on the transaction setting as expressed in the market participation function below:

$$\text{Participation} = f(D, T_s; I_r) \quad (2)$$

The influencing factors of the decision to participate in market (participation) are:

(1) Distance to market (D): this is the physical distance estimated in kilometres from the collector's home to the market. The collector normally takes the gum to his home for cleaning or drying before bringing it to the market, hence it is more realistic to consider this distance than the distance from the field to the market. We prefer the distance measured in km over the monetary transport costs as this greatly depends on the means of transport available. Moreover, long distance between the collector's home and the market indicates high transaction costs in access to information on prices, market supplies, possible buyers and so on.

(2) The transaction setting (Ts) has an impact on participation. It includes several components:

(a) number of buyers whose effect on participation is controversial: many potential buyers (i.e. traders) may on the one hand interact in a competition that raises the market price thereby increasing the probability of participation. Yet, the buyers may also collide to lower the price especially if there is no strict demand for gum at higher levels of the marketing chain;

(b) access to information: given high costs of searching, screening and negotiation (detailed in Bellemare and Barrett, 2006:10) and the controversial presence of buyers as described above, better information plays an important role for sellers (producers) since they could better decide to participate in the market knowing the prevailing market price and requirements in terms of quality and other conditions;

(c) frequency of sale arguably has a positive effect on participation by reducing the cost of transacting through the relationships established with the trader as proposed in literature (details found for instance in Williamson, 1991 and Ménard, 2004; 2005); and,

(d) selling through an association or producers' group has scale advantages of market assurance (the association or group might have already secured a sale contract with a

company or exporter) and better price (through higher bargaining power). Producer groups also attract buyers more easily.

(3) Interlocked contracts obviously improve market participation as they provide for a secured buyer of the product.

3.3. Determinants of participation in interlocked contracts

As hypothesised in this study, interlocked relations influence production (equation 1) and market participation (equation 2). This is because the producer who has already contracted credit, must repay. For livestock owners gum constitutes an easy way of raising money rather than selling animals as their constitute a major form of security.

The probability of choosing interlocked relations is studied through a probit model. We assume that the probability of entering an interlocked contract is based on the relative importance of transactions (related to gum arabic or other products), the need for credit and the relationships with the main trader.

(1) The relative importance of transactions are producers' perceptions with regard to the regularity of sales of gum arabic or other products, the significance of payment date and the potential buyers in the market in price determination.

(a) importance of the regularity of sales, mainly of gum arabic or other products indicate the opportunities for interlocking. These opportunities reflect the ease to take or offer a debt; hence their high importance leads to higher probability of choosing for interlocking contracts.

(b) importance of payment date. For a producer who has sold his gum, having to wait for a long period before receiving his payment, increases the urge to spend the money he does not

yet have and so is the risk of exceeding the amount due to him. This excess has to be repaid by his future sale, thereby increasing the probability to get into interlocked relations.

(c) importance of potential buyers

Producers were asked to give their perceptions on these items with scores of -1, 0 and 1 for highly important, neutral and low important scores, respectively.

(2) Credit need is measured by the producers' confirmation to have taken credit in the past (with a score of 1 or otherwise not with a score of 0) and access to remittances as a proportion to his wealth (value of livestock).

(3) The relationships with the trader also has an impact on this choice: trust that the producer has in the trader existing parental or friendship ties, the trader's reputation and his readiness to offer advances and general finances in cases of emergency. This is checked with several dummies for which a score one confirms the positive appreciation of the producers respective to trust, reputation and financing.

The estimates of the probit for the choice of interlocking are further included in the determination of production and market participation. Similar to Makhura et al. (2001) and Jagwe et al. (2009), this is done through a Heckman selection model. In a first step of the model, the probability of market participation is modeled (equation 2). This probability is entered in the second step, namely the model of quantity produced (equation 1). This second step only takes into account producers who have participated in the market (selected group).

4. Results and discussion

4.1 Interlocked relations in the Senegalese gum sector

Interlocked relations are not imposed but remain the choice of the producer. In the gum market in Senegal, the producer has the choice of keeping such relations with a main trading partner as a village shop owner or regular mobile trader who moves from one market to another, commonly known as '*banabana*'. Forty-one percent (41%) of the respondents have chosen to be in such interlocked relations. The other options open to the collectors include the spot market transactions in weekly markets, to intermediaries of wholesalers/exporters, companies or selling through the association (EXPERNA is currently the only active association in the gum sector).

According to a report by the *Direction des Eaux, des Forêts, de la Chasse et de la Conservation des Sols* in Senegal (DEFCCS, 2005:20), the choice for being in interlocked relations is close to a general rule: almost each household producing gum is affiliated to a regular trader who is often a village shop owner or an experienced mobile. This affiliation results from traditional collaborations and is based on ethnic affiliations, appreciation for support in difficult times and friendship. In this context, traders finance gum arabic harvesting activities and other economic operations by providing capital, tools and other basic commodities (water, sugar, tea, rice, etc.) for the households to get by during the lean season (Njomaha, 2008:31). Gum collectors generally pay back in kind at prices integrating important credit charges (Fagg, 2004:61): all the harvested gum of the household is sold to that trader if prices on the market are more or less uniform. In case market prices are competitive, producers sell a good part of their produce to the trader offering the highest price. However such transactions should be unknown to the regular trading partner who gets a small part of the produce in order to maintain trust and good relations (DEFCCS, 2005:20).

These transactions continue to occur due to the absence of functional market and credit system in the rural Senegal (Lesourd, 2001:4, Rodale Institute et al., 2002:19). The probability of interlocking choice in the gum sector is analysed through a probit model. Its results are presented in table 1.

Table 1: Probit results of the choice for interlocked relationships^a (1: interlocking; 0: no-interlocking)

Variable	Estimates	Standard Error	Marginal effect
Regularity of gum transactions (1: high importance)	-0.031	-0.132	-0.012
Regularity of other products transactions (1: high importance)	-0.153	-0.094*	-0.061
Importance of payment date (1: high importance)	0.431	0.129***	0.172
Importance of potential buyers (1: high importance)	-0.453	-0.133***	-0.181
Credit need(1:yes)	0.818	0.151***	0.316
Remittances * wealth	0.000	0.000	0.000
Trust to trader (1: high importance)	0.094	0.158	0.037
Relationship to trader (1: high importance)	0.716	0.204***	0.271
Reputation of trader (1: high importance)	0.116	0.170	0.046
Finance ability of trader (1: high importance)	0.294	0.195+	0.116
Constant	-0.463	-0.212**	
Number of observation = 421 (N ₀ = 248 and N ₁ = 173)			
LR chi2(10) = 102.50			
Prob > chi2 = 0.000			
Log likelihood = -240.564			
Pseudo R2 = 0.176			
Probability of interlocking = 0.502			

^a *** significant at 1% level, ** significant at 5% level; * significant at 10% level, + significant at 15% level.

The model predicts well the probability of interlocking as 0.502. The factors that positively influence the probability to choose interlocked relations include: (a) the high importance given to the time of payment because of the need for money; (b) credit need, because it becomes natural to go to the trader to request an advance; (c) relationship with the trader through family or friendship because he is part of the community and can anticipate the need

of the producer. Furthermore he can even give to the producer an 'extra hand' meaning higher amount than to the person he is related to; and (d) if the producer knows that the trader has the ability to advance him, then he will go to make the request. Even if this ability is not deterministic that his request will be accepted, it is an important factor as the producer knows that a request might be accepted. This can be the case as indeed many contacts may be unfruitful (in Gaye, 1991a:6).

The factors that negatively influence the probability to choose interlocked relations include: (a) the regularity of transactions on other products which implies that the producer may not need the advance that he will have to repay in gum arabic terms. There are two explanations: either the producer is self-sufficient or he can reimburse through other products he brings to the trader. These products include other forest products, agricultural products or even livestock; (b) the number of potential buyers was expected to have a positive effect as potential buyers would be trying to enlarge their supply network thereby luring producers into interlocked relations as suggested by Dièye (2006:132). The alternative reason however might be that these potential buyers will compete in the market thereby increasing the price at which they buy the gum; in this case the producer will hold on as much as possible to his gum so that he can have a better deal rather than being paid a lower/agreed price. The possibility to benefit from this assessment assumes that the producer has perfect information on the market price including the price and the number of buyers.

Before moving to the influence of interlocked relationships on the production and marketing behaviour, we check the negative impact of interlocking contracts on the price received by the trader as suggested by literature. For this purpose, we check the Pearson correlation between the current price and the estimated of probability of interlocking, which is $r = -0.127^{**}$. The

coefficient is small but significant at 5 percent, which suggests that interlocking, as a way of repaying for credit, negatively affects producers' bargaining power thereby leading to lower prices compared to the case where there would not be such relationship. There are other variables that could be explored in explaining the price such as the trader's power on the ability to fix the price which includes his experience and the number of markets he is operating in; this side is not explored in the current study. The risk on the side of the traders involved in interlocking transactions is also not explored here.

4.2 Analysing gum production and participation in gum market in Senegal

The analysis consists of a Heckman model where the probability of entering in interlocked markets is taken as an independent variable in the participation decision and in the production decision. Market participation is the selection function (equation 2) while gum production is the function of main interest (equation1). The model shows coefficients for the explanatory variables, their standard errors and how significant they are in their influence on the quantity of gum collected or market participation (the dependent variables). Furthermore, it illustrates the marginal effects at sample means.

(a) Participation in gum market

Tables 2 and 3 respectively show the descriptive statistics of the variables used in the market participation function, their expected impact and the Heckman model results for the market participation (1 : participation ; 0 : no-participation). The explanatory variables are the dummy for gum production zones, estimated probability of interlocking, distance to market,

proxies for the transaction setting, and estimated probability of choosing interlocking relations.

Table 2: Participation variables: summary of descriptive statistics and expected sign

Variable	Mean	SD	Expected sign
Distance to market (kms)	5.992	6.683	-
Number of potential buyers (persons)	2.369	3.736	+/-
Information access (1: yes)	0.795	0.020	-
Frequency of sale (1: multiple transactions with same trader)	0.645	0.023	+
Trading group/association (1=yes)	0.657	0.023	+
Interlocked relations (estimated probability)			+

Table 3: Heckman results for the market participation (1: participation; 0: no-participation)^c

Number of observations = 408			
Censored observations = 24			
Wald chi2(10) = 730.07			
Variable	Coefficient	Standard error	Marginal effect
Zone (1:Eastern Senegal)	-0.455	-0.289+	0.138
Probability of interlocked contract	0.598	0.563	0.217
Access to information (1: yes)	0.177	0.245	0
Number of buyers	-0.033	-0.068	0
Frequency of sale (1: multiple transactions with same trader)	0.046	0.061	0
Group (1: sold through group or association)	0.708	0.228***	0
Distance to market (kms)	-0.028	-0.012**	0
Constant	1.170	0.522**	
Athrho	-0.627	-0.250**	
Lnsigma	-0.341	-0.042***	
Rho (ρ)	-0.556	-0.173	
Sigma (σ_v)	0.711	0.030	
Lambda	-0.396	-0.132	

^c *** significant at 1% level, ** significant at 5% level, * significant at 10% level, + significant at 15% level.

There are differences in the probability of market participation across zone: the sylvopastoral zone in Senegal has higher probability since it has been the interest of many buyers who concentrated their procurement activities in this accessible zone with the aim of minimising transport costs thereby maximizing their profits (AsyilaGum, Unpublished). We find a significant positive effect of only the membership in trading in group or association: this is because the group can bargain a good price in addition to providing a market assurance. The distance to market, as expected, reduces the probability to participate in the market: when the distance becomes longer, it discourages participation in the market because this is not accessible. As expected the interlocked relations have a positive effect on market participation, however this was not found to be very significant.

(b) Gum production

Tables 4 and 5 show the descriptive statistics of the variables used in the descriptive statistics of the variables used in the production function, their expected impact and the Heckman model results for the quantity collected (estimated in log), respectively. The explanatory variables are the dummy for production characteristics, proxies for the presence of trees, expected price and estimated probability of interlocking.

Table 4: Production variables: summary of descriptive statistics and expected sign

Variable	Mean	SD	Expected sign
Distance to plot (kms)	7.338	9.405	-
Number of carts	0.587	0.899	+
Collection experience (years)	18.194	35.694	+
Collectors in household (persons)	0.557	1.435	+
Collection plot management (1:common property)	0.780	0.021	-
Tapping days	7.705	21.746	+
Expected price (log)	6.343	0.424	+
Interlocked relations (estimated probability)			+

Table 5: Heckman results for the quantity collected (Log)^b

Number of observations = 408

Censored observations = 24

Wald chi2(10) = 730.07

Variable	Coefficient	Standard error	Marginal effect
Zone (1:Eastern Senegal)	-1.468	-0.143***	-1.468
Probability of locked contract	0.443	0.196**	0.443
Number of carts	0.216	0.060***	0.216
Collection experience (years)	0.005	0.001***	0.004
Distance to plot (kms)	-0.002	-0.004	-0.002
Collectors in household (number of persons)	-0.039	-0.038	-0.039
Tapping days	0.013	0.004***	0.013
Collection plot management (1: common)	0.518	0.110***	0.518
Expected price (log)	-0.280	-0.111**	-0.280
Constant	7.036	0.719	0.000

Athrho	-0.627	-0.250**
Lnsigma	-0.341	-0.042***
Rho (ρ)	-0.556	-0.173
Sigma (σ_v)	0.711	0.030
Lambda	-0.396	-0.132

^b *** significant at 1% level, ** significant at 5% level; * significant at 10% level, + significant at 15% level.

There is a significant difference in the quantity collected across the zone; this is much lower in the Eastern Senegal where gum has not been traditionally encouraged. As hypothesized, interlocked relations have a significant positive effect on the quantity collected. The number of carts possessed by the household has a positive effect on gum collection. The experience in collecting increases the quantity, as the producer has then the skills and also knows where he can get much gum (more productive places). The collection features that have significant and positive effect on the quantity are the tapping days and communal plot management. The tapping days reflecting the size of plot indeed confirm that as the producer can increase his gum harvests by enlarging his plot; assuming that he can do so (indefinitely), meaning that competition over space is still low. Similarly, communal management has a positive effect;

however an in-depth exploration of the property rights will reveal this (through on-going study). The distance to the plot, although not significant has a negative effect on the quantity collected as expected.

Unexpectedly the price has a negative effect on the quantity collected. This finding is not surprising however because there are differences in zones. The Sylvopastoral zone is more traditionally productive but unorganized; hence it has seen the gum prices continuously falling over the years (Asyila Gum, Unpublished). In Eastern Senegal, although production is still low (DEFCCS, 2005:6) producers have organised themselves in an association (EXPERNA) through which their bargaining power has increased which lead to higher prices. Furthermore, the negative effect can be attributed to the common management: in the case this is going to be high, harvesters will rush to 'the common plots' to collect gum and through this competition the individual quantity reduces.

Although estimated together, the production and market participation equations remained independent. The LR test that their disturbances are not correlated (i.e. the null hypothesis of $\rho = 0$) gives the $\chi^2(1) = 4.21$ with a p-value of 0.0396. Hence this null hypothesis is rejected confirming that the equations are independent.

The variables common to market participation and production functions include the dummy for gum production zones in Senegal (Sylvopastoral zone and Eastern Senegal), and the estimated probability of interlocking. A test for the joint null hypothesis that the coefficients on the variables (zone and estimated probability of interlocking choice) that are common to both decisions regarding production and market participation are equal in the two equations was also done. The test result is $\chi^2(2) = 10.58$ with a p-value of= 0.0051. It shows, with a

significant difference at the 0.1 % level, that the hypothesis of common parameters for common variables can be rejected.

5. Conclusion

The general hypothesis for our analysis is that interlocked transactions influence producers' choice of producing gum and participate in the market despite that such relations negatively affect the price received by producers. We started by analysing the factors leading to interlocking relations in a probit model. We found that the factors increasing the probability for choosing interlocking include a longer payment delay, the need for credit, the relationship with the trader through family or friendship and the financial ability of the trader. However, the regularity of transactions of other products and a high number of potential buyers negatively influence the choice for interlocking.

The estimates from this probit, together with other relevant variables were used in a Heckman model reflecting the simultaneous self-selection of collectors for market participation and associated production. Indeed interlocking has a positive effect on both market participation and production since producers have to repay their debts in a market where they are assured of finding a buyer being the lender who has to recover the credit he offered; in order to have something to sell, producers have therefore to collect gum. Market participation also seems to be positively influenced by participation in trading in groups or associations which can bargain a good price in addition to providing a market assurance. However, to participate, the market should be accessible.

Gum production increased by the possibility to reach the collection place through having (a) cart(s), the collectors' experience, the size of the plot and how it is managed. The distance to

the plot and unexpectedly the price to be received by the producer negatively affect the quantity collected.

The study confirms the general idea that interlocking relations are negatively related to the price received by the producers; their bargaining power is hence reduced. However, in exploring the alternative effects that these interlocking relations have on market participation and production we find that such relations have a positive outcome; for instance (1) they can provide market assurance which is in fact a prerequisite for motivating the producer to collect gum; and (2) they can create a safe environment for the producer that through the contacts and relationships he has, his emergency periods will be covered. However, it should always be kept in mind that interlocking are a second-best solution because the credit system is not working properly. Hence, the role of policymaking should be that care is taken of the institutional environment to avoid that the producer be held indefinitely and unwillingly out of lack of other sources of credit into these relations. This is because he would be dependent on the trader, who is just an economic agent interested in profit (and hence not altruistic). This trader might exploit the producer and prevent him to benefit from the prevailing market prices, especially if these are higher than the price agreed-on at the time of entering into interlocking. Furthermore, the sector should be re-organised so that buyers can be encouraged to participate in the market. These opportunities will reduce the dependency of the producer to a single trader but more importantly, through competition, they will increase the price to the producer which would translate into an incentive for improved production and subsequently his livelihoods.

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