

Gum arabic production and marketing in Senegal: interlocked transactions and supply chain implications

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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 pre-defined prices which are often lower than the prevailing market price. The study analyses determinants of choice for interlocking in the gum arabic sector in Senegal and the effect of interlocking on gum production and market participation; gum arabic is a natural exudates of *Acacia Senegal* trees that grow in the semi-arid lands of Africa. Data from 422 gum producers in Northern and Eastern regions of Senegal are used. About 45percent of respondents are involved into interlocking with village shop-owners or mobile traders. Interlocking has a negative effect on prices received by gum collectors. However, in the absence of effective credit markets, interlocking positively influences market participation and production as found through a two-step Heckman selection model by the provision of market assurance and safety for emergencies.

Keywords: interlocking, contracts, semi-arid lands, market participation, gum arabic

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 has various domestic and industrial utilities (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 the northern and eastern regions of 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) if 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 transaction 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 collectors are offered 'on credit' household necessities, tools or cash that they repay with 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 rural areas where 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 price discussed at the time of contracting which is often lower than the prevailing market price. Moreover, 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 an 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 decision of the producer to enter into interlocked relations based on the collector characteristics and his perception of the market (potential traders, payment date, and expected price). The gum production/collection and market participation decisions are analysed through a two-step Heckman selection model. Besides the probability of interlocking, these two decisions are assumed to be based on producers' characteristics and respectively on (1) the gum production and expected price; 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 such as the importance of the credit system in rural areas (e.g. Chakrabarty and Chaudhuri, 2001:6; Manig, 1990:214); problems 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 relevant to explain the behaviour of collectors in relation to 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 non-timber forest products could be further made.

2. Market and credit access and interlocked contracts

In a context of market failures 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 lack of 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 high 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 is intensified by the fact that potential clients live scattered and have limited collateral especially in areas with collective types of land tenure (Armendáriz & Morduch, 2005).

Apart from microfinance initiatives, the alternative solution for small-scale 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 made 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 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, a situation which is 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 producers because they 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 can obtain 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:

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

(1)with the determinants of quantity collected (Q_{coll}) being the production characteristics (P), presence of trees (Tree), the expected price (P_e), travel time (T) and having an interlocked contract (Ir). These variables are defined as follows: 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..

(2)The presence of trees (Tree): *Acacia senegal* trees are mainly found on communal forests and to a lesser extent on private plots. In these 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. Three variables are used to proxy the presence of trees, namely (a) a dummy variable that gum was harvested on a communal plot because of competition among producers and it has a high risk of theft; (b) the number of harvesters in the same plot competing for gum; (c) the number of days spent on tapping that gives 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. We use its two proxies namely (a) the distance to the collection plot/forest (in kms) and (b) 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 better access to credit and a secured market.

3.2 Gum market participation

The actual participation or entering in 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:

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

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

(1) Personal characteristics (P_c): these include (a) age, (b) household size, and (c) possession of a telephone that would ease the access to information regarding the market

(2) Distance to market (D): this is the physical distance estimated in kilometres from the collector's home to the town 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. 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.

(3) The transaction setting (T_s) includes several components: (a) number of buyers (i.e. traders) who may interact in a competition that raises the market price thereby increasing the probability of participation or 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), better information plays an important role for sellers (collectors) since they could better decide to participate in the market knowing the prevailing market price and requirements in terms of quality and other conditions; and, (c) 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 higher prices (through higher bargaining power). Producer groups also attract buyers more easily.

(3) Interlocked contracts generally imply market participation. However, not every collector that participates in the market is held by such contracts.

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. The determinants of having entered into interlocked relations are studied through a probit model. We assume that the probability of entering an interlocked contract is based on producer characteristics, the relative importance of transactions aspects related to gum arabic, the need for credit and the relationships with the main trader:

(1) Producer characteristics include (a) age; (b) education level; (c) household size; and (d) wealth in livestock value. The educated producers who could have other sources of income may not need to enter into interlocked contracts. Large households have many needs compared to the small households; consequently the probability for interlocking is higher with the large households. Livestock, as a direct important source of income, offers an opportunity to stay away from such interlocked contracts.

(2) The relative importance of transactions is estimated by producers' perceptions with regard to the significance of payment date and of potential buyers in the market in price determination: (a) 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 that incorporates the risk of exceeding the amount due to him. This excess has to be repaid by future sales, thereby increasing the probability to stay into interlocked relations; and, (b) importance of potential buyers: these buyers can lure producers into interlocking so that these buyers have a reliable source of gum supply. Producers were asked to give their perceptions on these items with scores of -1, 0 and 1 for high importance, neutral and low importance scores, respectively.

(3) Credit need measured by the producers' confirmation to have taken credit in the past would potentially lead to endogeneity because those who take credit might be the ones who choose to go for interlocking. For that, instrumental variables for credit are used. These are collector's characteristics including age (the young producers who would like to make acquisitions such as livestock or land might need to ask for credit), household size (the large households may have a wider range of needs than small households for instance nutrition, clothing, etc.), education (the more educated producers might have other income sources and therefore need not to take credit), wealth in livestock value (wealthier farmers may not need credit as they would have an income from livestock) and scores of -1, 0 and 1 for respective high, neutral and low importance of the relative ease of distance to reach the collection area and the relative ease of access to trees (these indicate whether the producer has indeed the possibility to collect gum in considering the difficulties involved in travelling to the collection areas and finding trees; the higher the relative ease, the higher will the probability for credit knowing that the collector will repay in terms of gum)

(4) Finally, the relationships with the trader also may have an impact on this choice: existing parental or friendship ties with the trader or the latter's reputation. This is checked with dummies of a score of one confirming the positive appreciation of producers respective to relationships and reputation of the trader.

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 two-step 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-five percent (45%) 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, selling 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 a functioning 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 with credit as an endogenous regressor (ivprobit). Descriptive values of interlocking variables and their expected effect are presented in table 1 and ivprobit results are presented in table 2.

Table 1: Interlocking variables: summary of descriptive statistics and expected sign

Variable	Mean	SD	Expected sign
Age (years)	44	11.487	+/-
Education level (1: formal education)	0.52	0.500	-
Household size (persons)	10	7.369	+
Wealth from livestock ('00000 CFA)	28.6	37.2	-
Importance of payment date (1: high)	0.76	0.632	+
Importance of potential buyers (1: high)	0.75	0.635	+
Credit (1: has taken credit)	0.39	0.489	+
Relationship to trader (1: high importance)	0.15	0.362	+
Producers with interlocked contract (percentage)	44.5	49.76	

Table 2: Ivprobit results¹ of the choice for interlocked relationships^a (1: interlocking; 0: no-interlocking)

Variable	Coef	SE
Age (years)	0.019	0.006***
Education level (1: formal education)	0.141	0.135
Household size (persons)	0.007	0.009
Wealth in livestock value(log)	0.027	0.017+
Importance of payment date (1: high)	0.313	0.133**
Importance of potential buyers (1: high)	-0.517	0.120***
Credit (instrumented)	1.422	0.294***
Relationship to trader (1: high importance)	0.547	0.203***
Constant	-1.802	0.342***

¹ Credit is instrumented by age, household size, education, wealth and perceived importance of ease in reaching the collection area and access to trees

Rho	-0.296	0.144
Sigma	0.413	0.014
Number of observation	422	
Wald chi2(8)	108.73***	
Log likelihood	-456.925	
Wald test of exogeneity	3.71*	

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

The factors that positively influence the probability to choose interlocked relations include: (a) the high importance given to the time of payment probably because of the need for money; (b) age: the older producers are more likely to choose for interlocking; (c) wealthier producers would surprisingly enter into such contracts probably because they also have a wider range of needs not only related to their households but also for animal wellbeing; (d) 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 a higher amount than to the person he is related to; and (e) credit need, because it becomes natural to go to the trader to request an advance; we note that the use of instruments lead to correcting endogeneity (Wald test of exogeneity is significant). The factor that negatively influences the probability to choose interlocked relations is the number of potential buyers. This was expected to have a positive effect because potential buyers would be trying to enlarge their supply network thereby luring producers into interlocked relations as suggested by Dièye (2006:132). The reason for the negative effect is that there many buyers are not inclined to enter into a contract and 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 including the price and the number of buyers.

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 market price and the estimated probability of interlocking, which is $r = -0.488^{***}$. The coefficient is significant at 1 percent, suggesting that interlocking negatively affect 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 of gum production and market participation consists of a two-step Heckman model where the probability of entering in interlocked markets is taken as an independent variable in both the participation decision and the production decision. Market participation is the selection function (equation 2) while gum production is the function of main interest only for market participants (equation 1). 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).

(a) *Participation in gum market*

Tables 3 and 4 respectively show the descriptive statistics of the variables used in the market participation function, their expected impact and the first-stage Heckman model results for the market participation (1 : participation ; 0 : no-participation). The explanatory variables are the producer characteristics, distance to market, proxies for the transaction setting and estimated probability of choosing interlocking relations.

Table 3: Participation variables: summary of descriptive statistics and expected sign

Variable	Mean	SD	Expected sign
Interlocked relations (estimated probability)			+
Age (years)	44	11.487	+/-
Household size (persons)	10	7.369	+
Possession of telephone (1: yes)	0.647	1.128	+
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	+
Trading group/association (1:yes)	0.657	0.023	+
Producers that participated in market	0.927	0.261	

Table 4: Heckman results for the market participation (1: participation; 0: no-participation)^b

Variable	Coefficient	Standard error
Probability of interlocked contract	0.223	0.147 ⁺
Age (years)	-0.026	0.011 ^{**}
Household size (persons)	-0.022	0.015 ⁺
Possession of a telephone (1: yes)	0.198	0.141 ⁺
Number of buyers	0.015	0.049
Distance to market (kms)	0.002	0.006
Access to information (1: yes)	-0.042	0.264
Group marketing (1: sold through	0.816	0.258 ^{***}
Constant	2.380	0.644 ^{***}
Rho	-2.107	
Sigma	1.436	
Inverse Mills Ratio (lambda)	-3.026	

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

We find a positive effect of interlocked relations on market participation implying that such relationships indeed encourage collectors to participate in the market. One would also stipulate that being interlocked ‘forces’ the collector to sell his gum. In a way this would be the case if the collector totally depends on the trader(s) especially when the latter are few; however the analysis has not found any influence of the number of these traders on participation. Group marketing also has a positive effect on market participation: this is because the group can bargain a good price in addition to providing a market assurance. Furthermore, the possession of a telephone has a positive influence on market participation.

The other statistics computed are rho (correlation between errors) and sigma (standard deviation of the errors). These statistics are used to calculate the Inverse Mills ratio ($\lambda = \rho \cdot \sigma$).

(b) Gum production

In the second stage of the Heckman model, the quantity produced is determined by the independent variables and the inverse Mills ratio. Tables 5 and 6 show the descriptive statistics of the variables

used in the production function, their expected impact and the second-stage 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 5: Production variables: summary of descriptive statistics and expected sign

Variable	Mean	SD	Expected sign
Quantity collected (kgs)	431.055	684.070	
Interlocked relations (estimated probability)			+
Collection experience (years)	18.194	35.694	+
Collectors in household (persons)	0.557	1.435	+
Collection plot management (1:common)	0.780	0.021	-
Number of harvesters in same plot (persons)	13.360	11.100	-
Tapping days	7.705	21.746	+
Expected price (log)	6.343	0.424	+
Distance to plot (Kms)	7.338	9.405	-
Number of carts	0.587	0.899	+

Table 6: Heckman results for the quantity collected (Log)^c

Variable	Coefficient	Standard error
Probability of interlocked contract	0.234	0.080***
Collection experience (years)	0.012	0.002***
Collectors in household (persons)	0.027	0.027
Collection plot management (1: common)	-8.251	2.173***
Harvesters in the same plot (persons)	-0.000	0.110
Tapping duration (days)	0.011	0.004**
Tapping duration*Number of harvesters	-0.000	0.000
Expected price (log)	-2.226	0.356***
Expected price*Collection plot management	1.347	0.371***
Number of carts	0.324	0.072***
Distance to plot (kms)	-0.001	0.005
Constant	18.550	2.168***
Inverse Mills Ratio	-3.025	0.574***
Number of observations = 390		
Censored observations = 21		
Wald chi2(10) = 379.45***		

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

As hypothesized, interlocked relations have a significant positive effect on the quantity collected. Also, 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. However, competition exists as confirmed by the negative effect we observe after combining the tapping duration and the number of harvesters per plot.

Unexpectedly the peak price of the previous season has a negative effect on the quantity collected. This finding is not surprising because in the case this price is going to be high, harvesters rush to 'the common plots' to collect gum and through this competition the individual quantity reduces; communal management has indeed a negative effect on the quantity collected.

The test that interlocking influences both production and market participation equations confirmed this to be the case. The LR test that the disturbances of both equations are not correlated (i.e. the null hypothesis of $\rho = 0$) was not significant.

5. Conclusion

The general hypothesis for our analysis is that interlocked transactions influence producers' choice of producing gum and participating 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 with credit as an endogenous regressor. We found that the factors increasing the probability for choosing interlocking include wealth, age, the high importance given to the time of payment, the relationship with the trader through family or friendship and the need for credit. However, the importance given to number of potential buyers negatively influences the choice for interlocking.

The estimates from this probit, together with other relevant variables were used in a two-stage 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. This buyer is 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. They are alternatives to the spot market or contracts. However, to participate, the market should be accessible. The possession of a telephone helps in accessing information regarding the market.

Apart from interlocking, gum production is positively influenced by the possibility to reach the collection place through having cart(s), the collectors' experience and duration of tapping which reflects the size of the plot. However this size has to be taken into account together with how it is managed because common plots lead to a negative influence through competition. The price to be received by the producer the previous year negatively affects the quantity collected due to the communal management of the plot.

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 is a second-best solution because the credit system is not working properly and the transaction costs in the gum market are high. 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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