Economics of the gum arabic value chain in Senegal

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Thesis

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Introduction

Gum arabic is the product of *Acacia senegal*, a tree species which is naturally suitable for (semi) arid regions. It is important for its environmental and various domestic and industrial functions (Barbier, 1992; Fagg and Allison, 2004; Wickens et al., 1995). Despite the availability of natural and synthetic close substitutes (e.g., ARS, 2007), gum arabic still has an important international market specially in the European Union. It has wide industrial usage in food and medicine such as being an additive in the food industry (in production of beverages like Coca-Cola, juices, and confectionary), in the pharmaceutical and cosmetic industry as well as in the production of paints, post stamps, matchsticks to name some (Rahim, 2006; Rahim et al., 2007). Although gum arabic is just used as one of the ingredients in these different industries, this does not make it less important. The current world annual demand of gum arabic is estimated between 60,000 and 70,000 tons but its annual supply only reaches around 55,000 tons and hence demand is currently not satisfied by the producer countries (Chrétin et al., 2008). Furthermore, smaller producer countries such as Senegal seem not to be able to increase their international market share which might be associated with problems of developing internal markets including the lack of necessary price incentives for the collection of gum.

Gum is generally collected in the dry season and hence the harvesting does not coincide with agricultural or pastoral activities thereby being an important additional source of income for the rural collectors (Chrétin et al., 2008). It enables collectors to diversify their activities and it is also a risk aversion strategy of rural households in face of crop failure, sudden death of livestock or other threats to household survival (Chrétin et al., 2008; Freudenberger, 1993a).

However, the viability of *Acacia senegal* and consequently of gum collection, is faced with institutional constraints: the lack of secure and clear property rights to land and *Acacia*

trees, difficult access to market, low prices due to high marketing and transaction costs, and supply of low quality. By taking the case of gum arabic collection and commercialisation, this research attempts to investigate factors influencing the performance of the supply chain. Two themes are the main focus: (1) market effectiveness: including on the one hand, the determinants of market access and its influence on collectors' decisions, and on the other hand, the performance of traders in market; and (2) market-driven production effectiveness: including the terms of institutionalisation of quality supply and of realising changes in resource governance systems.

1.1 Problem statement

Gum production and marketing is constrained by the difficult access collectors have to efficient markets and their strong belief of being exploited by traders in terms of fixing buying prices, unreliable quality of supplied gum and unclear organization of the collection systems. Local markets for gum arabic are often informal, with the largest proportion of gum intended for the export chain while a smaller proportion of the lowest quality gum or processed gum are locally consumed (e.g., in traditional healing, laundry starch, sweets). There are many actors at different levels of the gum supply chain: collectors; village traders involved in monetary and non-monetary transactions where gum is supplied in exchange of money and/or low-value commodities for daily consumption which are often taken ahead of harvest/collection; mobile traders who operate in weekly rural markets; transporters; a few wholesalers and even fewer exporters and processing companies (DEFCCS, 2005; Chrétin et al., 2008). In trading relations, collectors claim to be disadvantaged in terms of low prices associated with the lack of information, need for money to cover daily needs, access to markets and exploitation by traders. Obviously, as these constraints negatively influence the collectors' production incentives; it is important to understand how producers determine participation in a market.

The income of the collecting household will also be influenced by the price received from primary traders; this price depends on conditions under which traders can buy and sell gum and hence on factors of value distribution along the supply chain. Traders are reproached to retain excessive margins such that in the end collectors are paid low prices for their product. Yet, one needs to realise that traders also are subjected to marketing costs (e.g., transport, taxes, storage and grading) and transaction costs (e.g., search, information and monitoring, risk premium charged due to asymmetric information on quality supplied, losses due to commitment failures by producers and price uncertainty) in addition to the competition arising from coexistence of different structures: spot markets; interlocked contracts with village traders (exchange of daily commodities for harvested gum); and contracts between companies and large transporters. The performance of traders needs to be investigated in order to understand the factors influencing the value distribution along the chain and to substantiate the claims on their behaviour.

Senegal's gum is internationally recognized to be of good quality due to natural growing conditions of the Acacia trees; but to respect and maintain these high standards, high costs are spent at the wholesale and export level on sorting and grading. Such costs are made at the detriment of the income of the collectors who receive low prices partly because despite being sensitized on the quality issues, they continue to use inappropriate harvesting tools, to mix gum arabic with other types of gum (e.g., gum seyal which is more fragile), to not sufficiently dry and inadequately store gum which as a result loses its quality. If quality standards were enforced at the producers' level, costs at the higher levels of the chain could be reduced and collectors could get rewarded for supplying good quality gum in terms of higher prices. However economically sound this statement may be, enforcing such standards might not be directly relevant if quality improvements do not respond to the users' expectations and if no grading system is in place to guide collectors and traders. Therefore, it

is pertinent to establish a link between collectors and user in terms of quality specifications and investigate what determines supply of quality.

Furthermore, collection of gum is organized in communal or open access forests where land and tree rights are not well defined as reflected by numerous cases of thefts that were reported. Formal and customary rights' coexistence often lead to confusion: property rights for land and forest products in general are formally defined by the Forest code, however, indigenous acquisitions through lineage and kinship and tacit appropriations are also commonly found (Freudenberger, 1993a; DEFCCS, 2005). Such ambiguity may inhibit planting and management of *Acacia senegal* trees, constrain collection and lead to low quality of the collected gum. There are emerging cases of private collection systems either by individuals or companies which can be associated with efficiency both in terms of collection quantity and quality. Understanding the limitations to the transition towards such private tenure systems for gum collection helps to understand the reasons of continued wide prevalence of communal systems and appropriate conditions needed for changing towards these potentially efficient private systems.

The current research takes a market perspective for studying the effectiveness of production in response to market conditions. While the production of gum arabic largely depends on exogenous factors including environmental conditions, the market remains important as its incentives can determine the quantity and quality that is collected and supplied. The selection of Senegal as the study area is motivated as it is one of the gum producing countries that was historically trading its gum reputed for being of good quality, but that seems unable to increase its current production levels due to institutional market inefficiencies.

1.2 Study objective and research questions

The main research objective is to investigate factors that influence the performance of the gum arabic supply chain. Specifically, we investigate first the market effectiveness in terms of the behaviour and decision making process of gum collectors, and gum traders' behaviour and performance; and second the production effectiveness in response to market conditions in terms of quality aspects in marketing of gum and aspects of governance systems of gum collection.

The following research questions are formulated:

(a) with regard to market effectiveness,

- what are the determinants of the collector's decision to collect gum and the amount to collect, and consecutively of the choice of a market outlet (sale place)?
- what are the determinants of value distribution along the gum arabic supply chain in relation to traders' behaviour and performance?

(b) with regard to market-driven production effectiveness,

- what is the link between the quality supplied by collectors and users' quality requirements and what are the factors influencing the supply of quality by gum collectors?
- what are factors that influence the transition from communal organisation of collection to efficient private collection systems?

The above research questions are investigated in Senegal where two zones of gum production are purposely chosen for the study: the Northern zone which is sylvopastoral with traditional gum collection activities in the regions of Louga, Matam and Saint Louis and the Eastern zone which is agro-sylvopastoral with recent interest in collection of gum arabic in the region of Tambacounda.

1.3 Thesis outline

This thesis follows an outline consistent with the above research questions. Yet, before entering in their subject matter, the context of gum arabic collection and trade in Senegal is described in chapter 2. The chapter also highlights the livelihood setting of the study area and lists the constraints to gum marketing which also limit the people's incentives to collect gum.

Chapters 3 and 4 examine the behaviour and performance of market chain actors. Chapter 3 tests the hypothesis that if collectors were able to access 'better and more remunerative' market, it would give them more incentives to collect gum; this is because high transaction costs restrain collection and marketing of gum arabic. Results confirm that better returns from gum marketing increase collection and high proportional transaction costs restrict access to market. Chapter 4 focuses on the sequential chain of gum traders in an investigation of whether their oligopsonist structure leads to lower prices in a multiple marginalisation tendency. No evidence of oligopsonist power is found; rather the traders' margins positively depend on costs, idiosyncratic and systemic risk, and uncertainty.

Chapters 5 and 6 shift the focus to aspects that are pertinent to the production performance in the gum supply chain. Chapter 5 concentrates on quality of gum arabic. In the first stage, the quality assessment by collectors and primary traders is compared to the users' requirements that are measurable in a laboratory and in the second stage, determinants of quality supply in terms of two attributes namely the size and cleanliness of gum nodules are analysed. Quality as required by the user is not directly linked to the visible quality attributes in the field which are influenced, among others, by harvest and post-harvest practices, and by price expectations. Chapter 6 investigates factors that influence the currently slow transition from communal to private systems of gum collection with mixed systems of coexistence of both communal and private tenure found between these extremes. The shift towards private forestry systems is initiated when the tree resources are available, markets are developing,

labour for collection is available, competition for resources is high, forests where gum is collected were located near to the village or market prices are high enough to attract occasional collectors who reinforce the effect of competition.

Finally, in Chapter 7, the main results are discussed and conclusions are drawn from the study. Various policy interventions are identified with the purpose of improving the performance of the gum supply chain and consequently enhancing the livelihoods of collectors and other gum-dependent actors in Senegal. In the light of the limitations to the current study, potential areas for future research are suggested

The setting: *Acacia senegal* and gum arabic trade in Senegal

2.1 Introduction

Gum arabic is a natural exudate from Acacia trees. There are many types of gum but the best gum is produced by *Acacia senegal* (L.) Willdenow and *Acacia seyal* Delile; the former is considered to yield gum of better quality (Elmqvist et al., 2005). Gum arabic is a natural oil-in-water emulsifier (Aoki et al., 2007). It is used in production of soft-drinks, including cola-type drinks as well as in confectionary, pharmaceutics and photography. Small quantities are used locally as food, laundry starch and in traditional medicine (Elmqvist et al., 2005).

Worldwide, Sudan is the largest producer and exporter of gum arabic, followed by Chad and Nigeria, together they bring about 45,000 tons of gum arabic to the market each year (Partos, 2009). Senegal, which was once a large producer and exporter of gum arabic, has seen its market share significantly declined over the years: in the late 50's, Senegal's exports of gum arabic accounted for more than 10 per cent of the world exports; it is now in the rank of small producers whose exports totalise less than 5 per cent of world export (FAO, 1971; Marfaing, 1991; DEFCCS, 2005; ITC, 2008). Low exports imply low production and a loss of opportunity for collectors of gum arabic who now fail to improve their livelihoods through income that could be generated from larger sales of gum. Such livelihoods, in the arid and semi-arid regions where gum arabic is collected, revolve around short annual rains followed by long periods of drought. Economic activities in these regions are pastoralism, small-scale agriculture, and forest exploitation. Pastoralism mainly concerns grazing of animals in a pattern of transhumance while searching for water and pastures. Agriculture is limited by low soil fertility, insufficient water and declining rainfall (Hall, 2007). Exploitation of timber and non-timber forest products is done with the purpose of labour diversification and consumption smoothing (Ngugi and Nyariki, 2005). Gum arabic, produced by *Acacia senegal* fits into these livelihood strategies: pastoralists use the proceeds from gum sales to

rebuild livestock following decimations or thefts; farmers undertake collection of gum to compensate for crop failure; or for consumption smoothing (Barbier, 1992; Freudenberger 1993a; Wickens et al., 1995; Fagg and Allison, 2004; VALEURS, 2005; Chrétin, 2008). For producing countries, gum arabic also generates income through its exports thereby contributing to diversification of export products and consolidation of these countries' economies (Mbaye, 1988).

2.2 *Acacia senegal* and gum arabic

Acacia trees belong to the botanical family of *Leguminosae*, a predominant species of the group of *Mimosaceae*. There are more than two hundred species of Acacias, but only a few of them produce gums. The only species producing gum arabic, as per FAO definition, are *Acacia senegal* and *Acacia seyal* which have different properties and are also divided into several varieties: for instance *senegal, kerensis* or *rostrata* for *Acacia senegal* and *fistula or seyal* for *Acacia seyal* (FAO, 1971; Cossalter, 1991; Saint Sauveur, 1994; JECFA, 2006; Couteaudier, 2007). The current research specifically concerns gum arabic as the dried exudate produced naturally or by tapping from the trunk and branches of *Acacia senegal* trees.

Gum arabic exudes from cracks in bark of *Acacia senegal* trees. These cracks occur mostly in the dry season as a result of natural stress factors including high temperatures from the hot dry wind, insect or animal wounds, or cuts made into the bark (Giffard, 1966; Webb, 1985; Freudenberger, 1993a). Gum collection can be classified into simple gathering of nodules that have oozed from the tree or deliberate tapping of trees where the collector makes a cut and returns to the tree several days later to harvest the gum. Tapping is hence performed to ease exudation and extract the maximum quantity of gum from the tree; it however follows a particular technique aimed at preventing damage to the tree (Okatahi and Onyibe, 1999). Tapping is labour intensive but it is also harsh because of the dense spiny foliage of the gum trees; the Acacia thorns scratch the collector as he scrapes the bark (Webb, 1985). While

instances of wild gum gathering are still observed in certain gum producing countries (e.g., in Kenya (Wekesa et al., 2010) and Namibia (NASSP, 2006)), tapping is mostly practiced in natural or artificial plantations (e.g., in Senegal (AGC, 2007)), or in domesticated plantations (e.g., in Sudan (Rahim, 2006)). In Cameroon, wild collection coexists with domestication undertaken through agroforestry initiatives (Njomaha, 2008; Palou Madi et al., 2009).

The tree productivity of *Acacia senegal* ranges from 20 grams to 2 kg of gum arabic depending on the tree; it is on average, 250 grams per annum (Iqbal, 1993; Sall, 1997; ITC, 2008). The highest yields are observed on trees aged from 8 to 13 years (CNI, 2008).

The oldest records of gum arabic use date from 4000 BC in Egypt where it was used for mummification, medicine or making clothing and ink (Alland, 1944; Giffard, 1966; CNI, 2008). Nowadays, gum is used in food and non-food industries. Food industries absorb about 80 per cent of the gum market using it for instance as an adhesive, emulsifier, thickener, binding and stabilizing agent in confectionery, bakery, beverages, frozen dairy products, etc. (Wickens et al., 1995; Fagg and Allison, 2004; CNI, 2008; Phillips, 2012).

Non-food usage includes pharmaceutical applications in making syrups, tablets and as an ingredient in different treatments of haemorrhage, stomach ulcers, obesity, etc. (Khan and Abourashed, 2010). Ali et al. (2009) suggest a possible use of gum arabic in dentistry because it enhances dental remineralisation and has some antimicrobial activity. Ushida (2012) and Osman et al. (2012) propose the use of gum in obesity and gout treatment respectively. In photography, lithography, pottery, house building and cosmetics, gum is used to add strength and viscosity to raw materials (Barbier, 1992, 2000; Wickens et al., 1995). A substantial local market for gum arabic exists in Senegal where it is used as a starch for laundering ceremonial clothes (Fagg and Allison, 2004).

Studies in the 1970s predicted a dark future for gum arabic demand due to the availability of natural and synthetic substitutes such as modified starches, algae extracts,

xanthan gum, or corn fibber (FAO, 1971). However, these other gums did not fulfil the promise and despite that prediction, the wide range of uses explains the continued demand for gum arabic (DEFCCS, 2005; ARS, 2007).

Wood from *Acacia senegal* is a secondary product to gum. It is usually harvested at the end of the gum production cycle after 15 to 25 years. Wood is used for making roofing poles, lining wells or framing huts (Fagg and Allison, 2004). The tree also produces firewood and makes good quality charcoal (Chrétin et al., 2008). The bark of roots is twisted and commonly used as a rope and for making mats (Fagg and Allison, 2004).

Acacia senegal is rich in proteins and phosphorus (Cossalter, 1991). It is therefore an important source of fodder for the herbivores especially during dry periods (Wickens et al., 1995; Mallet et al., 2002; Fagg and Allison, 2004).

Acacia senegal trees are also important for the ecology of the arid and semi-arid zones. These trees help to fertilise the soil through the decomposition of leaves which reinforces the anti-erosive roots of the tree (Mallet et al., 2002). They fix atmospheric nitrogen, and serve for windbreak and dune fixation (Giffard, 1966; Gerakis and Tsangarakis, 1970; Cossalter, 1991; Barbier, 1992; Wickens et al., 1995).

Acacia senegal trees are prominently found in a production region called the ‘Gum belt’, a broad band stretching across sub-Saharan Africa from East to West over 15 countries (Figure 2.1).

Figure 2. 1. The Gum belt in Africa

Source: Assoumane et al. (2009)

Acacia senegal trees are also found in southern Africa, India or Pakistan (Cossalter, 1991; NGARA, 2008). In Senegal, the gum production zone corresponds to the northern Sylvopastoral Zone (SPZ) commonly called the Ferlo and the agro-sylvopastoral zone also known as Eastern Senegal (ES) (Figure 2.2)

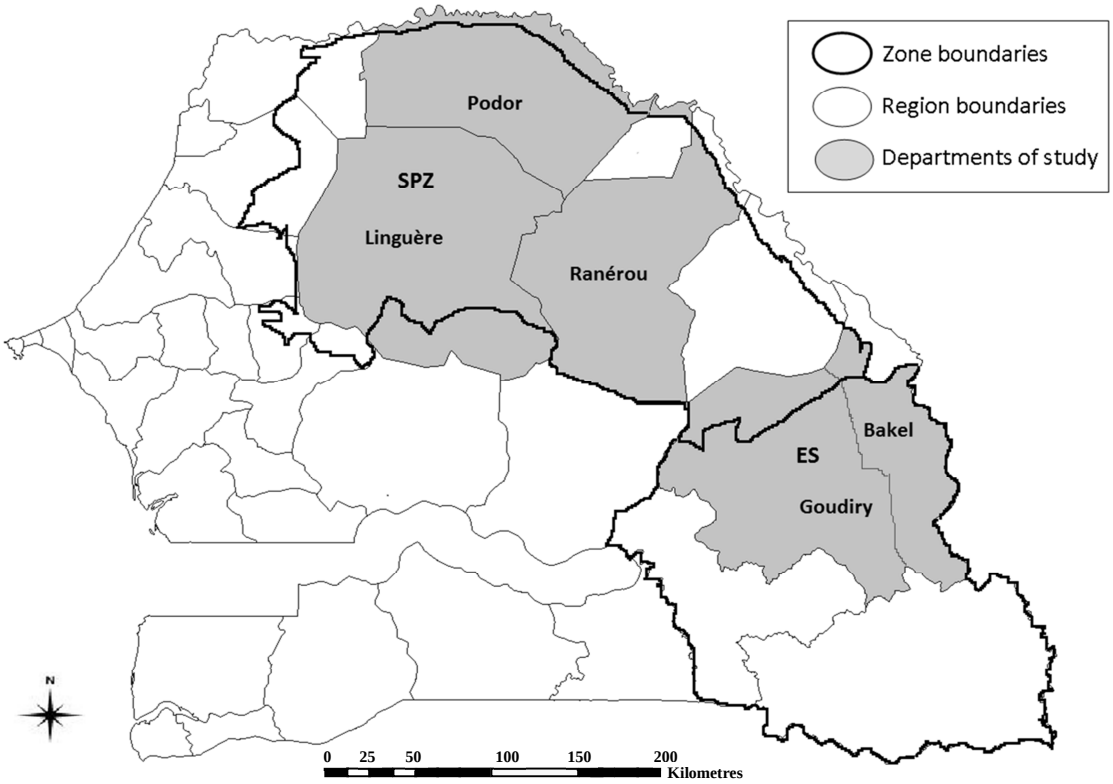

Figure 2. 2. Map of Senegal and study area (Edited)[1]

SPZ covers almost all parts of the regions of Louga, Saint Louis and Matam and ES covers the region of Tambacounda. ES has high potential for gum arabic but collection is not widely undertaken due to lack of knowledge on harvesting techniques. Furthermore, traders concentrated their procurement activities in the SPZ with the aim of minimising transport costs thereby maximizing their profits. Such choice was not to the advantage of producers in the landlocked ES who received low prices and had to abandon gum collection (Asylia Gum, Unpublished). Recent initiatives to revive the sector were undertaken by EXPERNA (*Entente intervillageoise pour la préservation et l'exploitation des ressources naturelles et agricoles du Boundou/Gadiaga*), a producer association established in ES. Its aim is to valorise the gum product by promoting the ownership and management of natural resources in general and *Acacia senegal* trees in particular (EXPERNA, 2006).

[1] Edited based on World Food Programme et al.'s (2011) livelihood zones of Senegal.

2.3 Historical context of gum trade in West Africa

Gum arabic has been traded for several centuries. Webb (1985) documented that before the European maritime revolution, gum arabic used in Europe had come from Arabia and South Sudan. Portuguese, French and British sailors discovered gum arabic on the West coast of Africa in the 15th century and by the 16th century, it was traded at the embouchure of Senegal river (Saint Louis) from where it began to reach European markets; it became an important commodity in barter systems together with cloth, sugar, tea and metals in exchange for gold, gum arabic and ivory (Commissariat de l'AOF, 1931; Webb, 1985; Sène, 1988).

From the second half of the 17th century, industrial uses of gum arabic in cotton calico textile printing factories and in engraving copper plates induced a steady demand for gum arabic; it was important such that it was given attention in the explanation of the mercantile system of Great Britain (Smith, 1776; Webb, 1995). According to Alland (1944) and FAO (1971), the Senegalese gum sector supplied more than 10 per cent of the world demand in the 17th century.

In the early 18th century, competition between British and French traders for control over gum trade was intense such that in the first half of the century this competition led into open hostilities during the 'Gum Wars' (Webb, 1997). Yet, gum exports from western Sahara continued to increase, from 500 or 600 tons per year in the early 18th century to nearly double that amount by the 1780s. Gum was the principal export product and its value even exceeded the value of the slave export trade (Webb, 1985, 1995). Industries in Great Britain and France were not the final users of much of the gum they imported; Webb (1995) confirmed that for instance of the gum shipped from Senegal in 1832, only 18 per cent was retained for use in France; the remainder was re-exported to other countries.

In the 1830s, gum exports from Senegal averaged 2,000 tons per year. This second doubling took place despite the discovery of the dextrin in France. Dextrin was produced at

less than half the price of gum but it was difficult to conserve and hence not suitable to several uses to which gum was put (Webb, 1985). By 1850s however, the importance of the gum sector in Senegal was gradually being eclipsed by the growth of groundnut cultivation, which was spreading from the Upper Guinean and Gambian coasts (Webb, 1985). The French tried to increase their area of control through conquests such as of the Djolof in 1890, in order to open the region to trade in gum arabic (Freudenberger, 1993a).

In 1922, France imported about 7,000 tons of gum out of which about 4,000 tons were from Senegal and the remaining from Kordofan (Marfaing, 1991). Hence, despite the increased groundnut production, colonial administration continued to show interest in gum production. This interest is also illustrated by the different decrees promulgated by the colonial government in 1936, 1937, 1953, 1955 and 1956. These decrees aimed at (re)organising marketing of gum by determining the product chain, imposing prices and suggesting techniques for improving productivity (Dabo, 1988; Freudenberger, 1988). Following such measures, the gum sector continued to grow even after Senegal's independence: in 1971, gum exports were about 10,000 tons which made it the third producer on the world market (DEFCCS, 2005). However, in the droughts of 1968-1974 about 70 per cent of *Acacia senegal* trees perished (Poupon 1977 in Freudenberger 1993a). This led to drastic declines in gum production and exports: from 1974 to 1991, exports averaged only 550 tons (computed from DEFCCS, 2005) and in rare cases these exports exceeded 1,000 tons such as in 1974 and 1976. Reforestation efforts undertaken in the 1970s and 1980s by public and private projects paid off by the mid-1990s, Senegal's production levels and exports of about 740 tons in 1996 climbed to about 1,050 tons in 1997. However, these exports fell dramatically again at the end of the millennium mainly due to the lack of regeneration of trees as a result of low rainfall levels (Sène and Ndione, 2007).

2.4 Recent trends in gum arabic production and trade

World production of gum arabic potential is estimated at around 60,000 tons per annum, of which 50 per cent or more originate from Sudan. Nigeria and Chad alternately dispute the second and third ranks among the producing countries (Alter Africa, 2009). The remaining world market supply is shared between other countries including of Sahel West Africa and East Africa (Iqbal, 1993; ITC, 2008).

Almost all gum arabic in the Sahelian zone is exported as raw gum. Senegal is an exception, where in addition to raw gum exports domestic gum transformation is developed. The processed spray-dried gum is exported; sweets and gum of low quality are sold in local markets (DEFCCS, 2005). Figure 2.3 shows exports of gum from Senegal in the period 2000-2009 in comparison with those of Sudan[2].

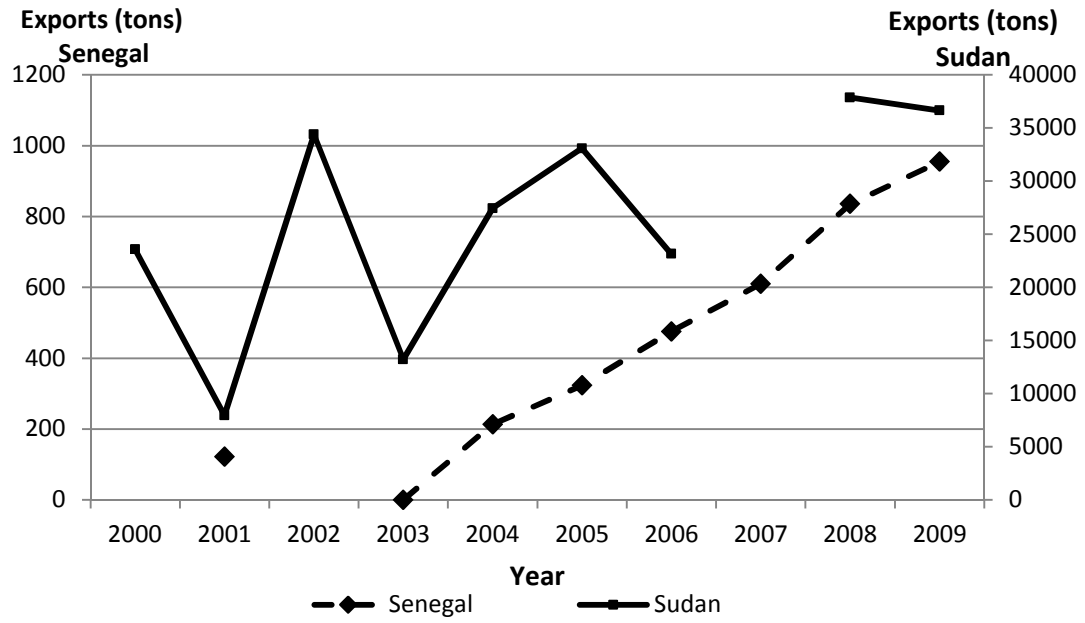

Figure 2. 3. Exports of gum by Senegal and Sudan (2000-2009)

Source: COMTRADE (2011), FAOSTAT (2011)

In the period 2000-2009, while Sudan's exports were high and rising even above 35,000 tons, exports of gum from Senegal remained low, below 1,000 tons and on average about 420 tons; they were at their lowest level in 2003 at below 1 ton of gum arabic. Sudan's exports are

[2] Exports data of Senegal are missing for 2000 and 2002; exports data of Sudan are missing for 2007.

fluctuating, whereas exports of Senegal were slowly but steadily increasing: about 955 tons were exported in 2009; indeed the sector's revival is taking place since 2003. Diop (2005) explained the low production level in Senegal was a consequence of (1) geographical factors in production zones including landlockedness and poor infrastructure that constrain transport and distribution channels; (2) marketing factors including that market structures may constrain transactions, prices, competition, quality, and information; (3) organizational factors including the lack of professionalism that constrain transparency and innovation in the gum sector; and (4) political factors including government policies, land tenure systems and financing that constrain the gum sector development. All these factors reduce incentives for collectors to harvest gum.

Europe remains the largest importer of gum arabic from Senegal accounting for more than 80 per cent of Senegal exports (Table 2.1).

Table 2. 1. Main importers of gum arabic from Senegal in 2000-2009

Country	Total imports (tons)
France	2,288.7
India	487.2
Brazil	69.7
United Kingdom	48.5
Germany	20.0

Source: COMTRADE (2011)

France is the largest market for Senegalese gum; imports are mainly realized through the IRANEX group and its subsidiary CNI (*Colloïdes Naturels International*). CNI is the largest gum trading company in the world specialising in importing, transforming and re-exporting gum (CNI, 2008). India is an emerging importer; it processes and re-exports gum to Europe and other Asian countries. Other main importers include Brazil, United Kingdom and Germany. There are also small occasional importers including Spain, Sweden, United States and Greece.

Important factors in the market of gum arabic are price, stability of supply, and quality. Exporters fix prices in local markets by considering the FOB price of gum and the local expenses for buying the gum (transport, packaging, cleaning, storing); the other actors in the supply chain apply the same principle in fixing prices in the production regions based on their own costs of commercialisation (Balarabe, 2000). FOB prices are determined in relation to the price of gum arabic from Sudan. Figure 2.4 compares export prices of gum arabic from Senegal to those of Sudan.

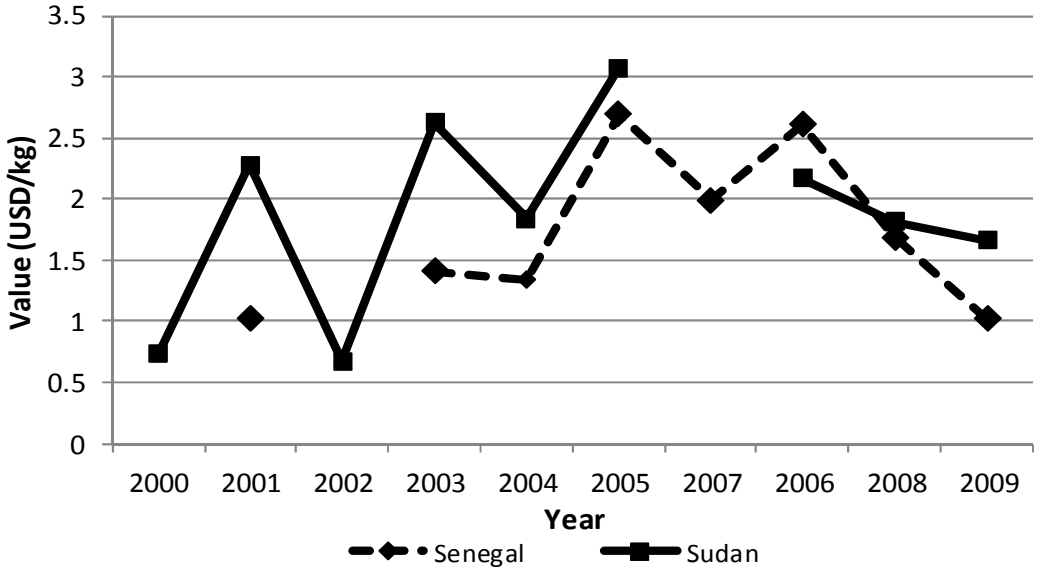

Figure 2. 4. Price trends in Senegal and Sudan (2000-2009); FOB prices

Source: COMTRADE (2011)

The gum from Sudan fetches the highest prices on the international market. Senegal prices of gum arabic follow closely the trends set by Sudan. In 2005, prices were at their highest level and subsequently decreased to the lower price levels in 2009. It can be noticed that in 2006, Sudan's price collapsed dramatically below the Senegalese level.

Supply levels affect prices as historical cases showed that world shortages led to high international prices (Fagg and Allison, 2004). The supply is affected by production and availability of stocks in the exporting countries; such stocks depend on stability of production (Mbaye, 1988). Quality requirements for gum arabic vary depending on the various uses of

gum; these requirements follow strict quality specifications (CNI, 2008). Grading of raw gum is done only at the export level, based on the form of gum nodules, their sizes and colour, but Senegal has not institutionalized a grading system as done in Sudan, Nigeria or Chad.

2.5 Organisation of the gum supply chain in Senegal

Better organisation of marketing chains has been recognised as a potential contributor to improving supply and quality of gum arabic which would be beneficial for countries and thereby collectors (Mbaye, 1988). At this moment, the degree of specialization in gum is low in Senegal at collection and marketing level: at the collection level, collectors collect in the dry season as a secondary activity, and at the market level, traders trade not only in gum arabic, but mainly in other goods (food, non-food and other non-timber forest products).

The supply chain in Senegal is still organised following the traditionally practices of colonial times. Private agents act on behalf of wholesalers, processors (Valdafrique) and exporters. The sale of gum by collectors to traders is often based on barter exchanges of gum in exchange of other commodities, or on informal contracts in which gum repays for credit or commodities received earlier in the season. The role of the government is limited to institutional support in terms of regulations which determine the supply chains, and fix commercial norms including prices (Commissariat de l'AOF, 1931; FAO, 1971; DEFCCS, 2005).

A schematic overview of the current gum supply chain in Senegal is given in Figure 2.5. The main actors are: (a) local gum markets between gum collectors and local and mobile traders; (b) transporters commonly called 'camionneurs' who own vehicles; (c) wholesalers; and (d) exporters and processing company. In addition, a small branch of the chain involves retailers for national consumption of the processed gum or gum of low quality. Each group is discussed in more detail below.

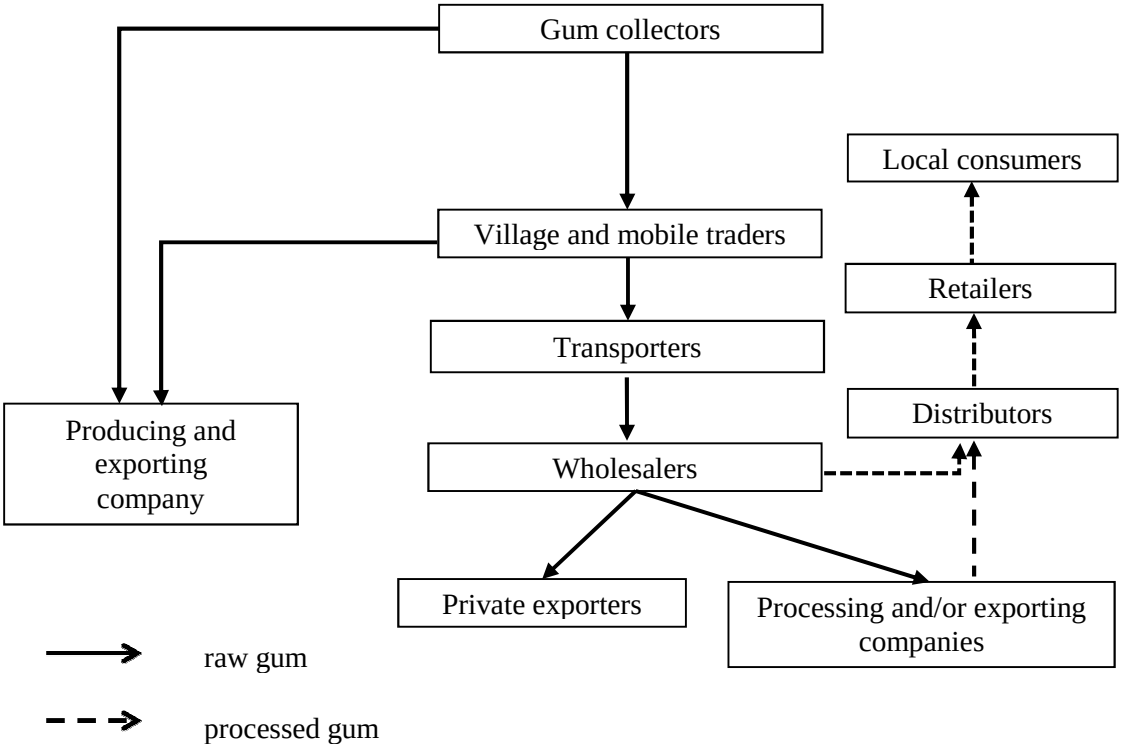

Figure 2. 5. Supply chain of raw and processed gum arabic

Source: Sène and Ndione (2007), Ndione et al. (2001). (Edited)

Collectors

The group of gum collectors is large and dispersed, apart from some initiatives to form associations and other groups for gum marketing. These group initiatives are still young. EXPERNA is the only formally registered collectors' association in ES.

Village and mobile traders

Village traders are distinguished from mobile traders. Village traders are also known as '*boutiquiers*' (literally small shop owners). They are established in gum producing villages and buy gum throughout the harvesting season. Mobile traders are known as '*banabana*'. They buy gum in producing villages, directly from collectors or from village traders. They also participate in rural weekly markets or towns neighbouring the production zones. As they move across villages or markets, *banabanas* use transport services; however on their own

they do not have the financial ability to own or hire trucks. *Banabana* can pre-finance the gum collection activities mainly through contracting with large collectors.

Transactions in the village are done either in cash or as part of interlocked contracts. These interlocked contracts result from traditional collaborations between gum collectors and shop owners. These collaborations are often based on ethnic relations, friendships, or appreciation for support in difficult times (Newbury, 1972; DEFCCS, 2005). Traders provide money and basic commodities (water, sugar, tea, rice, etc.) during the lean period (Njomaha, 2008). In exchange, collectors supply gum to traders at prices agreed upon at the time of entering into the contract; these prices are often lower than current market prices and they include important interest charges (Fagg and Allison, 2004).

Apart from the village and mobile traders, the Asylia Gum Company buys gum directly from the collectors. The Company is established in Senegal, Mauritania and Mali. In Senegal, it started its operations in 1999, not only with the purpose of marketing gum arabic but also producing it. Hence, in 2005, it established its own plantations of *Acacia senegal* on 12,000 hectares in the SPZ (DEFCCS, 2005). However, these plantations are not yet fully productive, and the Company may occasionally buy gum from collectors or primary traders (Ndiaye and Signaté, pers. communication).

Transporters

Village and mobile traders sell their gum to transporters. These transporters have the financial ability to own or hire trucks for transport and are hence commonly called '*camionneurs*'. As transporters, they can offer paid transport services to other market participants including *banabanas*. These transporters often operate in weekly markets. On these markets not only gum is traded, but many other products and commodities are also exchanged. Thus, these transporters use their trucks to bring all kinds of bulk products to the market (e.g., rice, sugar, cloths, and shoes), and they take non-timber forest products (gum arabic but also baobab

fruits and other gums), agricultural products (millet, groundnuts and others), and livestock products (goats and sheep) to the cities.

In buying gum, transporters often rely on brokers (commonly known as '*coxeurs*') whose function is to serve as informants and put the transporters in direct contact with gum sellers. With regard to gum arabic sales, *camionneurs* are often connected to large wholesalers established in larger cities. Wholesalers may advance the necessary money or goods to be taken to the market by transporters.

Wholesalers

Large traders/wholesalers are located in towns or on key trading routes. There are a few wholesalers involved in the Senegalese gum sector: entry is primarily limited by high capital requirements for the purpose of specialization. Investment costs include the high cost of setting up storage houses or for acquiring transportation modes, and the need to acquire business skills and build close business relationships. Wholesalers buy bulky gum from the transporters and they usually have an annual contract with exporters or processors. They build up stocks of gum and they clean, grade and repackage gum (Mallet et al., 2002); the excess stocks or gum of low grade is sold to retailers for local use.

Exporters and processing company

As of 2009, there were three individuals and three companies that export gum arabic out of Senegal (Niang, pers. communication). The companies are, besides Asylia Gum Company, Management Communication International (MCI) and Valdafrique. Individual exporters are established in Dakar and in Touba. They sort and grade the gum before exporting it. Asylia Gum Company, as mentioned, has its own plantations and buys from collectors and primary traders. The exact amount of exports by private operators or Asylia Gum Company is not known.

MCI is a private company that exports gum arabic and other forest products (e.g., gum karaya, powder made from baobab fruits). MCI exports on average 120 tons of gum arabic per year; it get supplies from wholesalers established in the city of Touba from SPZ and from EXPERNA in ES.

Valdafrique is exports raw gum and processed gum powder. It started its operations in 1943. Valdafrique specializes in the processing of gum into final products (sweets, medical tablets, etc.). It also transforms gum into a semi-raw material product; this is the spry-dried gum powder for the gum-using industries. To maintain its supply, Valdafrique deals directly with large wholesalers established in Dahra and Linguère with whom the Company signs a contract on an annual basis. Valdafrique buys on average 200 tons per year in Senegal (Sakho, pers. communication). The raw gum and powdered gum are exported to Europe and to the Valda Company in Brazil. The final products from gum and gum of low quality are sold in the local markets.

The lack of organisation of chain actors and the absence of any protection measure for collectors has led to unequal distribution of margins, and collectors continue to receive low prices which discouraged them from further collection.

2.6 Description of study area, livelihoods and gum arabic collection

Data for the current study were collected in SPZ in departments of Linguère (region of Louga), Podor (region of Saint Louis), and Ranérou and Matam (region of Matam) and ES in departments of Goudiry and Bakel (region of Tambacounda); these are the regions where *Acacia senegal* trees are found and gum arabic is commercially exploited. The survey in the SPZ excluded the Djolof because gum is no longer produced in the sub-zone; a southward movement of the production zone has been noticed due to changes in climatic conditions (Ndiaye, personal communication, 2008). The departments of Bakel and Goudiry have the

highest potential for gum arabic exploitation in ES although throughout ES harvesting activities are limited due to a lack of knowledge about harvesting techniques (Figure 2.2).

SPZ is the area located at the south of the Senegal river valley; it covers an area of 54,380 sq. km (Mbaye, 2008). Administratively, SPZ covers the regions of Saint-Louis, Louga and Matam. Based on ecological characteristics of rainfall, soil type, and vegetation, SPZ can be subdivided into five ecological sub-zones including the Basse Vallée Ferlo, Grands forages, Djolof, Southern Ferlo and Eastern Ferlo (ISRA/BAME, 1999). Dione and Sall (1988) had a wider classification that extends the zone to the east of the groundnut basin, and the southern floodplain of Senegal river.

ES is the region around Tambacounda which covers an area of 42,706 sq. km (ANSD, 2010d). It is an agro-sylvopastoral zone (van den Breemer et al., 1993). Both SPZ and ES are sparsely populated, population densities range between 15 and 47 inhabitants per sq. km (ANSD, 2010a,b,c,d).

SPZ is characterised by two main soil types: clay and sandy soils. These soils are suitable for rain fed agriculture (millet, groundnut, *niébé*); the sandy soils are however easily depleted by intensive livestock herding and cultivation due to their fragile nature whereas the clay soils suffer from leaching and erosion due to rains (ISRA/BAME, 1999; Mbaye, 2008). ES's soil types include sandy-clay soils and rocky soils. These rocky soils are inherently fragile, low in carbon and poor in plants nutrients. Due to high wind erosion, soil fertility constantly deteriorates and hence the area suitable for agriculture is reducing in the zone (Dione and Sall, 1988; van den Breemer et al., 1993; Manlay et al., 2002; ANSD, 2010d).

SPZ has a long dry season of nine months and a rainy season of three to four months; the average annual cumulated rainfall is between 210 and 520 mm. The rainy season in ES is longer, of four to five months; hence the rainfall is higher, between 460 and 680 mm (ANAMS, 2011). Variable rainfall in SPZ or ES implies that drought periods are frequent;

woody species and herbaceous shrubs that are thorny and adapted to drought (including Acacias) are the prominent vegetation.

In SPZ, pastoralism is important; pastoralists possess both cattle and small ruminants. The abundance of forage plants and their essential contribution to the diet of livestock make the zone suitable to livestock rearing. The pastoralists' livelihoods are essentially based on the sale of livestock products; hunting is prohibited by law (Ndione et al., 2001; WFP et al., 2011). In ES, agriculture and small to medium scale livestock herding are both practiced; rain fed crops include cereals and groundnut; vegetables are grown in small irrigated fields (van den Breemer et al., 1993; WFP et al., 2011).

The average incidence of poverty ranges between 36 per cent to 56 per cent of households in Louga (SPZ) and Tambacounda (ES) respectively. The moderate incidence of poverty is mainly due to remittances and livestock breeding (DPS and World Bank, 2004). There are variations within these departments across districts (e.g., the percentage of households who live below the poverty line is as high as 60 per cent in Ranérou (Matam) whereas in other districts of the same department, the incidence of poverty is 49 per cent (ANSD, 2010c)).

Because of the low and variable rainfall and scarcity of soil nutrients, SPZ and ES are characterized by a cyclical insecurity in resource availability (ISRA/BAME, 1999). Natural ecosystems and livelihood systems adapt to such harsh conditions of arid and semi-arid areas. Plants and animals adapt through evolution or by shifting geographic range; human societies adapt by evasion (e.g., by seasonal transhumance) or endurance (e.g., through forage management, varying livestock types and numbers, water and soil conservation, or finding alternative sources of income) (Mortimore, 1998; DPS, 2005; Mbaye, 2008; Running and Mills, 2009; Seymour and Desmet, 2009). Collection of non-timber products is also practiced for the purpose of adaptation; it enables households to generate off-farm income as these

products are widely marketed. Apart from gum arabic *werek* (*Acacia senegal*), non-timber products collected in the SPZ and ES include soump (*Balanites aegyptiaca*), bouy or monkey bread (*Adansonia digitata*), mbep (*Sterculia setigera*), and jujube (*Ziziphus mauritania*) (ISRA/BAME, 1999). Note that the proportion of the non-timber forest products used at home is very small.

Data collected among 422 collectors of gum arabic in SPZ and ES during February-May 2009 showed that collection of gum arabic is undertaken mainly as a secondary activity to pastoralism (68 per cent of respondents in SPZ and 5 per cent in ES) or agriculture (28 per cent of respondents in SPZ and 82 per cent in ES). Other activities practiced include petty trade and sales of timber (although this is normally regulated by law (Ndione et al., 2001; DEFCCS, 2005)). Non-farm remunerated jobs and remittances also contribute to the household income (respectively 6 per cent and 3 per cent in SPZ and 3 per cent and 4 per cent in ES).

Ndione et al. (2001) found that revenues from gum sales are used by households for consumption smoothing and to buy live animals and seeds; this pattern is still followed whether for the purpose of coping with emergencies or accumulating wealth: collectors use the income from sale of gum arabic mainly to buy food items (46 per cent of respondents in SPZ and 52 per cent in ES), buy livestock (18 per cent in SPZ and 6 per cent in ES), buy seeds and other agricultural inputs (4 per cent in SPZ and 10 per cent in ES). Other expenses made from gum income include acquisition of household necessities and clothing, payments for health services, building houses and even paying-off debts.

The contribution of gum income to the household's food access is important as households may not be able to sufficiently meet their food requirements especially because, the Senegalese society being polygamous, households are quite large. On average, households are composed of 9 to 11 members of whom 5 to 7 of these are children. While in rural

systems ‘the marginal utility of each additional child is normally strongly positive’ as children can assist in home and farming activities (Gould and Brown, 1996 in Mortimore, 1998), in gum collection, these children are not an extra source of labour as collection is undertaken only by the adult (male) members of the household (the youngest collector in the sample was 20 years old). This is because of the need to acquire knowledge and skills associated with tapping and collection and also due the thorny structure of Acacia trees. These skills are mainly acquired through experience which is on average 21 years in SPZ and 6 years in ES.

Gum collection is indeed a recent activity in ES and collectors learnt about the techniques of tapping and collection through trainings organised by EXPERNA (56 per cent of respondents) or from their neighbours (37 per cent). In SPZ, collectors mainly learn from their parents (82 per cent). Only 4 per cent of respondents in SPZ had attended a training on gum collection. Instead of such formal trainings, collectors in SPZ mostly rely on informal advices provided by forest agents (71 per cent) or other collectors (26 per cent). The latter are also sources of information related to gum marketing including on prices or availability of buyers.

The main constraint of collecting gum in Senegal is that forests where Acacia trees are found are mainly community/open access zones which make the allocation and enforcement of the rights to ownership and use difficult (Sall, 1997). These forests are located at long distances from villages, not easily accessible (as reported by 34 per cent of respondents in SPZ and 7 per cent in ES), and insecure due to human or animal attacks (reported by 25 per cent of respondents in SPZ and 49 per cent in ES). Due to unclear property rights, thefts cases are frequent where after tapping the gum is picked by another person (9 per cent of respondents in SPZ and 16 per cent in ES reported being outraged by cases of theft). Such cases may even lead to conflicts (Freudenberger 1993a, Sall 1997). Furthermore, livestock migration also leads to destruction of trees and other abuses to trees inflicted by shepherds

(Cissokho, pers. communication); these actions lead to forest degradation and some collectors reported that indeed trees are becoming very sparse or even extinct. Bush fires are another big problem especially in ES according to 17 per cent of respondents. If these fires are not controlled, they lead to considerable damage both to natural resources and the human habitat (CSE, 2009).

Factors that constrain gum marketing include low prices (reported by 77 per cent in SPZ and 49 per cent in ES), difficulties to reach the market (reported by 9 per cent in SPZ), and in certain cases there is not even a buyer (20 in SPZ and 9 per cent in ES). Due to low quantities bought each year, traders' strategies are to restrict their area of operation to accessible zones in order to reduce transportation costs. Producers in other locations may therefore have no access to the market. They are compelled to accept the low prices offered by local traders. The consequence of such strategy is that collection in remote areas is discouraged.

Quality is another problem in gum marketing. Collectors deplore the weight loss of gum arabic at the time of marketing (63 per cent in SPZ and 3 per cent in ES). Such loss occurs often when gum is harvested before it sufficiently matures. This is just one aspect of quality deficiency as for instance gum may also be not cleaned of its impurities such as barks of trees or dust when picked from the ground.

The supply chain is not sufficiently developed to pay the collectors according to the quality of the gum supplied. They are currently only paid on quantity and hence there is little incentive for them to present cleaner gum or to grade the gum.

Market considerations for gum arabic collection in Senegal

Abstract

Low returns from marketing of non-timber forest products (NTFP) such as gum arabic restrict their collection. In this chapter, a hypothesis is tested that access to 'better and more remunerative' markets would give collectors more incentives to collect and market gum. IvTobit models analyse the determinants of gum collection including the endogenous expected price. A conditional logit model analyses the determinants of the choice of market outlet including proportional transaction costs of marketing gum. Data was collected in Northern and Eastern regions of Senegal from 422 gum collectors. Results show that gum collection is responsive to price and hence market incentives, by expanding and securing the collection area, and by factors improving labour productivity. The choice of a market outlet is positively influenced by price but negatively influenced by collectors' competition or the preference for a particular trader, and high proportional transaction costs especially associated with transport.

Keywords: transaction costs, market choice, IvTobit, conditional logit, semi-arid lands, gum arabic.

3.1 Introduction

Marketing of agricultural products has been the subject of several studies that viewed the farmers' limited participation in markets as a constraint to market-based development strategies. These strategies aimed at facilitating wealth creation and poverty reduction (Makhura et al., 2001). Goetz (1992), Key et al. (2000), Holloway et al. (2001) and Bellemare and Barrett (2006) focused on the market participation decision that involved a choice of whether to participate in the market (buy, sell, or remain autarkic), and the volume to transact. Their studies assumed that production was already optimized by all households. Recently, Burke (2009) insisted on the need to recognise that products may not be produced by all

households. This is because households make a conscious decision regarding whether to produce or not, which is a step prior to any market related decision. His expanded framework thereby addressed the possibility that market participation can partially be determined by exogenous factors, as production decisions are made on what and how much to produce.

We analyse the decision making process of gum collectors as an important non-timber forest product in the research area: the participation decision is the decision to collect or not and next, the choice is made of where to sell among the available alternative markets. A particularity with regards to the collection decision is the open access to forests that a majority of the collectors enjoy. The decision to collect can be made instantly at harvest time, with labour being the main input. Underlying the decision to collect is the decision to sell because of the absence of the own consumption conditions that are found e.g., in Goetz (1992) or Bellemare and Barret (2006): in the current study, collection of gum arabic is "always" associated with the intention to participate in the market as the household's own consumption of gum is very minimal. The decision to collect hence results in the quantity to collect conditional on which, actual market participation takes place. Here collectors choose where to transact i.e., in the village or market; this is a decision of the market in which this gum is sold. The hypothesis tested in this paper is that if collectors (producers) were able to access a 'better' market, this will give them more incentives to collect (produce) and market gum (their products).

High transaction costs were found to be key reasons for the failure of farmers to participate in markets (e.g., Skoufias, 1995; Key et al., 2000) or for the choice between different governance structures or different markets (Williamson 1991, 1998; Hobbs, 1997; Fafchamps and Hill, 2005; Gong et al., 2006). Transaction costs create deviations between the effective buying and selling price (e.g., Sadoulet et al., 1998, Burke, 2009). They also have

adverse effects on the amount traded (e.g., Skoufias, 1995) and productivity (e.g., Lanzona and Evenson, 1997).

A distinction can be made between proportional and fixed transaction costs: proportional transaction costs vary with the quantity traded whereas fixed transaction costs are independent of the quantities traded and are household specific (e.g., de Janvry et al., 1991; Goetz, 1992; Allen, 2000; Key et al., 2000; Holloway et al., 2001; Vakis et al., 2003; Irle and Sass, 2006). Fixed transactions costs include search, information, bargaining and monitoring costs (Goetz, 1992; Vakis et al., 2003). Goetz (1992) also included in these costs the physical distance to the market and use of transport mode. Proportional transactions costs include, for instance, the transport cost per unit of product (Vakis et al., 2003). In market participation, a decision to trade is affected by both fixed and proportional transaction costs: economies of scale can be gained in fixed transaction costs as quantities increase, whereas, once the fixed transaction costs are covered, the extent of participation (i.e., amount traded) depends on proportional costs.

Relationships between trading parties are the instruments of reducing transaction costs. They contribute to lowering the risk of opportunistic behaviour by one or more of the trading partners such as misrepresenting quality or running away without making payment (Fafchamps and Gabre-Madhin, 2006). Relationships are fostered by the ability to identify a particular trading partner. Yet, this trading partner does not very often change because the search and screening costs for a new partner may be too high or the change may not result in higher prices than those offered by a regular partner (Eaton et al., 2007). Regularity with trading partners extending over a long period of time is also important as it leads to a certain level of comprehension and ‘routines’ (Slangen et al., 2008). These routines can reduce transaction costs such as in negotiating price or in monitoring informal agreements. Routines

are supported by reputation which then becomes an enforcement mechanism (Pint and Baldwin, 1997).

The theory of transaction costs provides a framework for the analysis of gum collectors' decision making process in respect to collection/production and marketing: we assume that high transaction costs not only constrain the marketing decision but also collection. This is especially relevant in the case of open access resources and where the time lag between collection and market decision is short. We assume that fixed transaction costs influence the decision to collect and market simultaneously. Therefore, the decision to collect and quantity of gum collected depend on collection/production factors (the accessibility of trees and the labour effort exerted) and on important fixed transaction costs. We impute proportional transaction costs to the market choice stage as the collector, having made the choice of collecting gum, is faced with the choice of selling gum either in the village or in a distant market. This choice is based on the level of proportional transaction costs.

In sum, we argue that transaction costs play an important role both at the level of collection (production) and the choice of market outlet. A combination of both types of transaction costs is of interest from a practical as well as a theoretical point of view. Fixed transaction costs which were previously found to have an effect on whether to trade or not, may influence the collection decision as this decision is directly associated with the intention to participate in the market. Once the fixed transaction costs are covered and the collector decides to 'collect' a certain amount of gum, the collector needs to sell the gum. Proportional transaction costs which were previously associated with the quantity traded, may, in the current case, be extended to the choice of market. This is because the quantity to trade is already known from the optimisation of collection but markets have different transaction costs structures.

In Senegal, gum arabic is collected during the dry season from natural forests or artificial plantations. Collectors often tap trees (*Acacia senegal*), by making incisions on the branches following specific tapping techniques (see Okatahi and Onyibe (1999) for details). Collectors experience problems in collection because of long distances to the collection areas and long hours of labour in harsh, dry, dusty and hot sub-Sahel conditions. In marketing, problems include difficulties of finding a competitive market (in the few gum markets, traders are suspected to exhibit exploitative tendencies), and low and continuously diminishing prices. Price incentives to produce more gum or to upgrade its quality are also lacking. The objective of this study is to investigate whether better markets are conducive to production in terms of the gum collector's behaviour related to the collection of gum and the amount to collect, and consecutively on the choice of a market outlet, i.e., a local village or a more distant market. The decisions to collect and market gum influence each other and are almost taken simultaneously, but in this study, they are dealt with in separate models. The current study takes the case of gum arabic collection, but the investigation is broader as it could pertain to production and marketing decisions in other non-timber forestry or agricultural sectors.

3.2 Methodology

A theoretical model for analysing gum collection and selling

In this section, a general theoretical model is developed with the aim of setting the economic basis for the collector's decision process to collect and sell gum.

Consider a household involved in gum collection: the quantity of raw gum collected in a certain period (Q) depends on labour hours (h), the local presence of gum trees (N), and on trading expectations such that:

$$Q = f(h, N, T), f' > 0;\ f'' < 0 \quad (1)$$

With $f'$and f'' as the first and second order conditions respectively.

The inclusion of labour assumes that there are no other physical inputs used as is typically the case for open access resources. The market wage could be determined seasonally; but generally only family labour is involved in gum collection.

Collectors are mainly members of pastoral communities and gum is collected in the dry season when crop production activities are low and livestock has migrated. Hence, the problem of competition in terms of labour hours that could jointly involve collection with herding activities seldom occurs. As a consequence, collection can only be considered as a supplementary activity to pastoralism. Moreover, a 'professional' collector is often a person different from the herder and other occasional (non-professional) collectors. While the active professional collectors know and apply the techniques for sustainable gum collection; occasional collectors are interested in immediate gains that may accrue when gum prices are high. Herders do not fall in either category, especially due to their young age and inexperience. They just wildly 'pick' the gum.

An implicit opportunity cost of labour is leisure in terms of the trade-off between the inconvenience of collection and the income that can be generated from collection (Beshai, 1984).

The trading behaviour of collectors is examined in steps corresponding to three types of transaction costs namely transport costs, search for buyer and frequency of transactions or repeated sales

Place/outlet of sale – town market versus village:

The gum collected in the period must be sold. It might be sold in the village in which the collector resides (distance $d \approx 0$), at price p_v and no extra work such as grading is needed. In this case the return to the labour hours is $p_v Q_v$. If the opportunity costs are w, the household will extend efforts such that:

$$p_v f' = w \qquad (2)$$

The gum might also be sold in a distant 'town' market, without additional work on the product, at a price p_t. Assume that the village price p_v is lower than the town market price p_t $(p_v < p_t)$; travelling to the town is therefore a way to improve the price that a collector gets. (In some cases, however, a unique price may be offered in village and town with the purpose of strengthening relationships and maintaining a 'clientèle' in gum transactions.)

Let the difference between village and town price be written as:

$$D = (p_v - p_t) \quad (3)$$

If D is positive, then the collector will sell his gum in the town market and if D is negative, the collector will remain in the village. However, D should take into account costs of transporting to and selling gum in town by collectors or of buying gum in the village by traders as well as costs incurred in making the transaction.

Transport costs:

Let transport costs be:

$$c = \lambda Q^{\alpha} \quad (4)$$

Where λ is the unit cost of distance for a standard quantity of 1: the transport costs vary with the quantity transported through $\alpha \in [0, 1]$. At constant λ and at $\alpha = 0$, the transport cost is not affected by the (small) quantity; at $\alpha = 1$, the cost is proportional to the quantity.

Total transport costs depend on the distance that the collector or trader has to travel (d). Furthermore, there is a time (r) involved in going to town by the collector or to the village by a trader. This time should be multiplied by an opportunity cost of labour (w), the foregone leisure. For a trader, another opportunity cost is the foregone earnings from other villages/markets he could visit (v). If transactions are made in town, we assume that the trader will not go the village but he waits for the farmers to come to town; in this case, his cost of going to buy in the village is higher than the cost of buying in the market and the collector bears the transport costs.

Search for buyer:

The choice of a buyer involves search costs. Suppose for simplicity that the prices prevailing in town (with different traders) are distributed homogeneously, over a range from p_s to p_t. Randomly selecting a trader yields the price:

$$m = \frac{1}{2}\ (p_s + p_t) \tag{5}$$

If the collector goes to see two traders, the expected price improves from $p_s + \frac{1}{2}(p_t - p_s)$ to $p_s + \frac{2}{3}(p_t - p_s)$. For n visited traders, the expected price improves to:

$$p_n = p_s + \frac{n}{n+1}(p_t - p_s) \tag{6}$$

If each visit would cost the collector b hours and each hour cost w, then the trade-off of going to town or not is the difference between the expected benefits and opportunity costs:

$$[p_s + \frac{n}{n+1}(p_t - p_s)]Q - [(nb + rd)w] \tag{7}$$

For the optimal n, it should hold that:

$$\frac{1}{(n+1)^2}(p_t - p_s)Q - bw = 0 \tag{8}$$

or

$$n = \sqrt{\frac{(p_t - p_s)Q}{bw}} - 1 \tag{9}$$

Thus, the number of traders visited should increase with larger price ranges and with quantity for sale; but it diminishes with wage and time needed to visit a trader. Furthermore, if the expected price at town level is not much higher than the expected net price at village level i.e., when the value added of going to town is low in comparison to the trade-off between benefits and costs of going to town; then logically, collectors will not go to town because this will not bring in any extra benefits.

Note that b can also be interpreted in terms of transaction cost attributes such as uncertainty associated with price offers, regularity of transactions or specificity of the asset to sell. For instance, when the collector sells his gum in the village, the price offered is assumed

to be known, at least negotiable without costs, as the collector sees the village trader often enough and hence uncertainty with regard to price is low. In such a situation, a single or few traders are present who are the actual buyers of gum in the village and collectors have frequent transactions with this (these) trader(s).

From the above derivations, we see that the value added of going to town i.e., expected benefits minus costs over selling in the town, with n buyers visited and the best price offer taken, is:

$$(p_n - p_v)Q - [(nb + rd)w + \lambda Q^{\alpha} d] \quad (10)$$

A decision of going to town is positive only if (10) is positive:

$$\left[p_s + \frac{n}{n+1}(p_t - p_s) - p_v\right] Q - [(nb + rd)w + \lambda Q^{\alpha} d] > 0 \quad (11)$$

or

$$\frac{n}{n+1}(p_t - p_s)Q - nbw > (p_v - p_s)Q + rdw + \lambda Q^{\alpha} d \quad (12)$$

This expression shows how a decision of going to town can be influenced by the quantity to transact: increasing Q increases the left hand side (LHS) with increments almost equal to the price range in town, and the right hand side (RHS) with increments equal to the difference between the village price and the lowest price in town (this may even be negative) plus transport costs.

For $n = 1$, the expression shows that :

$$\frac{1}{2}(p_t + p_s)Q - bw > p_v Q + rdw + c_i \lambda Q^{\alpha} d \quad (13)$$

Or that the expected returns to visiting one trader in town should exceed the price paid in the village plus the costs of going to town. For larger n, the LHS of equation (12) increases by an ever smaller share of the spread in sale revenues in town and continuously decreases by the fixed costs of visiting extra traders. If the LHS started as positive, then for some n it must turn negative. The optimal, feasible n is determined by the minimum of the optimal price difference between village and town, as defined by equation (9).

Repeated transactions:

As a final step in the reasoning, I consider repeated transactions. A collector may go to town once, find out that prices are unattractive compared to the village shop and decide to sell to the village shop for a while. Only after some time, he will undertake another exploratory visit to town to see if this would pay off.

Furthermore, a collector who strikes a good bargain in town may go there again, and will not have to incur the costs of finding the best bargain (at least, not until he starts having doubts about his counterpart); hence the expenditure on selecting the best trader is regarded as an investment. In this case the comparison is made about the quantity of gum to sell and between one visit in town and selling to the village shop. We would observe collectors who sell in the village because their quantities are too small, their search cost is high, who had no luck in finding a better deal in town, or whose opportunity costs of time are too high.

The model developed above assumes that choice of selling in village or travelling to a town market is mutually exclusive. However, collectors may participate in both outlets by deciding on distributing the quantities across the different outlets. This decision is not included in the current study. The general model also leaves out the quality aspects by which the collector could obtain a price premium for e.g., cleaning and grading which may differ between the village and town. The quality aspect will be explored in the next chapter (findings in the case study area suggest that traders (in the village or town) do not provide any quality premium).

Operationalisation of the model

The model is operationalised by investigating factors that affect the decision to collect gum and amount collected and subsequently the choice of sale outlet. The decision to collect is associated with an intention to sell gum but the subsequent actual sale decision is associated with the choice of a sale place. We argue that these decisions are affected by a different set of

transaction costs: fixed transactions costs have to be covered in the collection decision whereas proportional transaction costs affect the extent of participation in terms of the choice of sale outlet (as predicted by the model).

Defining Q

Collection of gum begins with the exudation that occurs from about four years of tree growth depending on exogenous conditions such as rainfall, humidity, temperature, or soil conditions. *Acacia senegal* trees are found in the semi-dry areas, mainly in natural forests and in artificial plantations realized by either reforestation projects (majority), or by private companies and individuals (Dione, 1998; AGC, 2007; CNI, 2008). Gum is harvested in the dry season. Exudation occurs when the bark of the tree breaks due to heat or wind, or by deliberate tapping of trees. After 7 to 15 days when the gum has sufficiently matured, it is harvested from the tree. Apart from exogenous factors such as heat, wind, or rainfall (and consequently the tree water retention), the actual amount of gum collected in a specific location depends on factors such as the density of trees and the labour effort involved in collection (Equation (1)).

For a single collector, the number of trees harvested depends on factors such as tree availability, tree accessibility, and distance to plot:

- *availability of Acacia trees* is indicated at village level by two variables: (a) *Area of Acacia senegal* which was obtained from the Global Land cover network (GLCN) database of Senegal (GLCN, 2009). *Acacia senegal* trees are found in the classification of trees and shrubs taking into account the vegetation distribution within a radius of 15 kilometres around the village and (b) *Rainfall* which is the average of the cumulated rainfall during June-October in the period 1991-1998; it gives an indication of the normal long-term rainfall level in the village (UMR HydroSciences, 2005). While the large *Acacia senegal* area shows a high propensity for gum collection, a high normal rainfall decreases the amount collected due to low environmental stress (Blunt, 1926, Elrayah et al., 2012).

- *access to trees* refers to private or common ownership of gum trees and/or plots. Private plots are found with collectors who have planted their own *Acacia senegal* trees or through permanent ownership by inheritance, requests from village chiefs, or formal acquisitions from local authorities. Communal plots are harvested through formal or informal agreements, with or without permit from the forestry service. Field visits do not suggest differences in technical management between private and common plots. In the analysis, individual tree accessibility is captured by a dummy variable of *harvesting on a communal plot*, and a variable giving *the number of collectors who harvest gum in the same plot* because competition among producers leads to a high risk of theft and hence is expected to have a negative effect on the individual quantity of gum collected.

- *distance to the plot:* collection at distances closer to the village involves more competition than at longer distances. Due to insecure ownership and required protection, collection at longer distances may yield smaller quantities than collection at distances closer to the village. Furthermore, such long distances have an effect on travel time.

Furthermore, the quantity harvested will also depend on the collector's productivity. Two variables related to labour productivity are used, namely:

- *collectors' experience*: with more experience, the collector does not spend unnecessary time in the plot; he can tap a lot faster with efficient tapping techniques. Hence experience has a positive effect on the amount harvested through the potential knowledge acquired over time.

- *number of adult collectors in the household* has a positive impact on the quantity collected through labour division in the family: the older/more experienced producers can tap and the relatively younger collectors can pick the gum from the tree. This division of labour would increase the total quantity of gum collected by the household.

An indication of alternative occupation to gum collection is also included as a proxy of the opportunity cost of labour:

-*livestock values: w*ealthy pastoralists may not need any income supplement from collecting gum as they are already better off; hence for them gum collection might just be a secondary activity. For the less wealthy, gum collection may generate substantial revenues that could contribute to improving their livelihoods; hence they may keep gum collection as a principal activity and realize substantial quantities. Both activities might remain complementary especially because they do not involve labour competition.

Factors influencing expected gum sales-Defining the RHS of equation (12)

Apart from the above factors directly influencing the quantity of gum collected, a decision to collect gum is based on expectations from trading associated with the intention to participate in the market. The expected price is a proxy of trading expectations.

The *expected price* is the average price obtained from the previous gum harvesting season. 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 supplied in relation to demand. Moreover, there are variations in price throughout seasons and across years. Irrespective of these variations, the average price obtained by the collectors in the previous season may give an indication of the price on which the producer bases his decision. The inclusion of the price implies that the collector makes a choice of collection knowing that he wants to sell his gum: a collector intends to access a market as he has made the necessary investments in fixed transaction costs so that he can reach this market based on the price he expects to get for the produce.

The expected price may be economically endogenous: in the context where access to markets improves collection because better prices are offered, reverse causal effects exist whereby the quantity supplied on markets is the basis for market development. Statistical instruments for the price are *: (a) distance to town*: this is the physical distance estimated in kilometres from the village to the nearest rural town. It indicates that the price to the collector

is determined in reference to how remote his village is, the farther the village from town, the lower would be the price; (b) *interlocked relation*s: a dummy variable refers to whether the collector is involved in interlocked transactions with traders. These traders finance gum arabic harvesting activities and other economic operations by providing capital, tools and other basic commodities (water, sugar, tea, rice, etc.) for households to get by during the lean period (Njomaha, 2008). Collectors pay back in kind at equivalent prices topped-up with important credit charges (Fagg and Allison, 2004). Such interlocked relations imply that the market where to sell gum is already chosen in advance for the purpose of reimbursing the credit; (c) *fixed transaction costs* arise due to household resources that must be devoted a priori to the decision to participate in the market (Holloway et al., 2001). In this study, three variables are used to account for these costs: (i) *a dummy variable for possession of transport mean*: whether a bicycle, horse or donkey cart that would facilitate transport to the plots specially if they are situated at a long distance from the village, the long distances normally prevent the collector from doing frequent visits and if the collector does not possess such means, he may be able to collect only in plots located nearby the village; (ii) *access to information*: given high search costs for a buyer and negotiation costs, easy access to information plays an important role in the collectors' decision to collect gum and participate in the market, this dummy variable refers to whether or not the collector said he has had information on market conditions (the market price and other market requirements, e.g., delivery conditions); and (iii) *a dummy variable for selling through producers' group:* because the group gives a market assurance (e.g., the association or group might secure a sale contract with a company or exporter) and better prices (e.g., through higher bargaining power).

Economically, better collectors may group with each other and being in a group may entail high production; this would imply a self-selection choice of being in the group. Thus, the choice of participating in a group is instrumented by age (older producers may be attracted

by the group due to the experience acquired); household size (large households may need not to participate in a group as they have power on their own); education (relatively more educated farmer can correctly evaluate the advantages of group marketing); and dummies for the perception of whether it is easy to collect gum in terms of distance to the collection plot or access to trees. It is assumed that becoming part of a group is a response to perceiving such accessibility problems. Hence, these dummies indicate whether the collector has indeed the possibility to collect gum given the difficulties involved in travelling to the collection areas and finding trees, but also that he can expect to be the collector of the gum exudating from the incision made by him with relatively low risk of theft. The higher the perceived ease, the higher will be the probability of belonging to a group.

Market choice behaviour

Similar to other non-timber forest products, gum is traded in relatively small volumes and production is dispersed over wide areas; hence the quantity and quality of these products can be very unreliable within and across season (Belcher and Schreckenberg, 2007; Ros-Tonen, 2011). As collection of these products is done in remote areas, with poorly developed communications and transportation infrastructure, it makes it difficult and costly to move products to distant physical markets. Sales may be made in the village if a village buyer is there or an itinerant buyer is willing to come to the village.

The gum chain in Senegal comprises of three components (Figure 2.5): transactions are made between (a) gum collectors and village/mobile traders; (b) village/mobile traders and transporters (c) transporters and wholesalers and (d) wholesalers and private exporters or processing companies. A small branch of the chain involves the distribution of processed gum through retailers for national consumption. Local markets are the entry into the gum supply chain. These markets include exchanges in the village or at distant markets in rural town.

Village traders are the established shop-owners (*boutiquiers*); mobile traders go to different villages or markets, buying directly from farmers or boutiquiers.

More than 70 per cent of transactions in gum arabic are done on weekly markets, held in relatively commercialized rural towns (Diop, 2005). Apart from gum arabic, village inhabitants in general take the opportunity to participate in such weekly markets in order to sell their products (from farming or handicrafts). In exchange, they obtain from mobile traders, commercial goods including rice, sugar, salt, shoes, cloth or items related to livestock keeping, etc. These mobile traders form a link between the remote villages and the rural towns. They attend several markets in a week mainly depending on the accessibility of these markets and possibility to minimize transport costs. The markets are also a time for social gathering.

As predicted by our theoretical model, collectors will choose to sell either in the village or distant town market by comparing the respective net benefits in terms of convenience and economic profitability to the cost of transacting. Fafchamps and Hill (2005) dealt with a similar decision of market outlet by farmers whether to sell at farm-gate or to transport their produce to the market. They found that the preference to go to the market entails a higher price for the crop in relation to wealth (wealth was measured as the value of all non-land wealth of the household including the value of buildings), but that one has to consider the quantity to sell, the distance to the market and the cost associated with transportation.

Factors influencing the choice of gum sales place- determining the LHS of equation (12)

Having collected the gum, an actual decision of going to the market or staying in the village is made. Following our theoretical model and in light of literature, the variables included to investigate the choice of sale place are categorized into choice specific variables, proportional transaction costs and individual related variables:

- *choice specific variables* are the variables that do not vary between individuals but with respect to the specific option of selling in the village or at a distant town market. These variables are (a) *sale price*: as the model would predict, a higher sale price at any selling point, *ceteris paribus,* is more attractive to the collector; (b) *number of potential buyers* is the total number of traders in a physical market or village who trade in gum arabic. It indicates buyers' competition which raises the price thereby increasing the probability of selling. Yet, buyers may also collude and offer a lower price especially because they have higher bargaining power in comparison to collectors; and, (c) *number of sellers* in the market is the approximate number of other collectors who regularly sell in the village or at the market.

- *market specific proportional transaction costs* are calculated per unit of the quantity supplied. They include (a) *transport cost per unit of product* which was calculated by assuming that a collector would hire a donkey cart for transporting his gum to the market and taking into account the distance to the selling place at an estimated flat rate of 75 CFA per kilometre divided by the quantity to transact; (b) *transaction time per unit of product*: this is the time spent delivering a unit of the product to the market obtained by the square of the reported time (in minutes) divided by the quantity to transact. The squared time indicates that time is expected to be a decreasing function of the quantity supplied; and (c) *frequency* of sale which is the reported number of times of transacting with a buyer. Frequency has the effect of reducing the cost of transacting through the relationships established with the trader as proposed in literature (Pint and Baldwin, 1997; Eaton et al., 2007; Slangen et al., 2008). Note that the transport cost per unit of product and transaction time per unit of product are potentially endogenous because they are inversely proportional to the quantity to transact which would then be a determinant for the market choice. In the absence of proper instruments of these variables, a careful relational interpretation is therefore more appropriate.

- *individual specific variables* are the variables that vary across individuals but remain unchanged for the specific market choice. The variables include (a) *household size*: the collector may make the choice between the market and village based on other commodities the household needs. Arguably, a large household has a wide range of needs for food, medicines, and other products. This will increase the probability to go to the market where he will acquire them; and (b) *age*: we assume that the old collectors might prefer to stay in the village.

Table 3. 1 summarizes the factors influencing gum collection and choice of sale outlet.

Table 3. 1. Summary of factors influencing gum collection and choice of sale outlet

Variable	Expected influence
1. Decision to collect and quantity collected	
Availability of A. senegal (village variables)	
Area of *A. senegal (sq.km)*	+
Average rainfall ('000 mm)	-
Access to trees	
Common plot management (1:common property)	-
Number of collectors in same plot (persons)	-
Distance to plot (km)	-/+
Labour productivity	
Collection experience (years)	+
Number of adult collectors in household (persons)	+
Wealth of livestock ('00000 CFA)	-/+
Expected price (CFA/kg)	+
2. The choice of sale place	
Choice specific factors	
Sale price (CFA/kg)	+
Number of potential buyers (person)	+
Number of sellers (person)	-
Proportional choice specific transaction costs	
Transport cost per unit (CFA/kg)	-
Time to transact (minute/kg)	-
Frequency of sale (1: more than one time transaction)	+

Individual specific factors	
Household size (persons)	+
Age (years)	-

Econometric modelling

The model design follows stages in the collector's decision. In the first stage, the collector decides about whether to collect or not based on an intention to participate in the market and simultaneously, the optimal quantity to collect. In the second stage, having collected gum, the choice is about actual market participation that involves a choice of sale place (outlet).

The decision to collect and quantity collected can be assumed to be a single decision such that collectors are solving an optimization problem of the amount to collect based on the net price (as the expected returns minus all costs). Thus, Q is an observable outcome that takes on the value 0 with positive probability. Hence it is a continuous random variable over strictly positive values; for some of these collectors, the optimal choice will be the corner solution i.e., $Q = 0$. As Wooldridge (2002) explained, censoring is not the issue in such context as there are no unobservable characteristics associated with the particular decision of whether to collect or not. Yet, least squares estimations cannot be applied as they may produce negative predictions and are not efficient. A Tobit type 1 model should be used. In this study, an instrumental variable tobit (IvTobit) model is applied where the amount collected is determined by the production factors and the endogenous expected price.

In the second stage, the choice is made of actual market participation whereby the collector decides of a sale place (whether in the village or at a distant market). A binary choice model would normally be used to analyse the determinants of such choice. Here, we take advantage of availability of information on variables related to both market alternatives and not just on the chosen alternative, and estimate a conditional logit model. As clarified by McFadden (1974), the choice behaviour in conditional logit is specifically explained by the

attributes of alternatives available to individuals making the decision and characteristics of these individuals.

The conditional logit model follows a random utility model (Greene, 2008): there are J alternatives among which a choice is made; Y_i represents a vector of choice-specific attributes such that the utility level of choosing j for an individual i is

$$U_{ij} = \beta Y_{ij} + \varepsilon_{ij} \quad (14)$$

β is constant across choices. Hence j is chosen if it has the highest utility among all J choices:

$$U_{ij} > U_{ik} \text{ for all } k \neq j \quad (15)$$

The choice of place to sell is influenced by characteristics of the sale place (distance, price) and proportional transaction costs associated with the outlet (such as transport per unit). In addition, this decision might also be influenced by the collector's characteristics. Because these individual-specific variables do not change within each case, the alternative-specific conditional logit is used.

Data and sampling

Data was collected during February-June 2009 in the Sylvopastoral Zone (SPZ) and Eastern region of Senegal (ES). In the Sylvopastoral zone, the survey focused on town markets, sixteen such markets were visited. In Eastern Senegal, three town markets and thirteen villages were also visited. Structural interviews were held with 183 producers in the Sylvopastoral and 239 producers in the Eastern region.

3.3 Results

A large percentage of collectors of gum arabic had decided to collect in the 2009 season but they differ in terms of collection variables. Differences between SPZ and ES are also observed (Table 3.2).

Table 3. 2. Overview of mean values of determinants of gum collection, group membership and choice of sale place by region[a]

Variable	Senegal (422)	SPZ (183)	ES (239)	Equality test[d]
[b]Quantity collected (kg)	*446.4*	*875.2*	*120.7*	*164.93***
	(693.08)	*(879.39)*	*(115.60)*	
Tree availability (village variables)				
Area of *A. senegal* trees (‘000	*0.33*	*0.64*	*0.16*	*30.19***
sq.km)	*(0.890)*	*(1.321).*	*(0.192)*	
Rainfall (‘000mm)	*0.53*	*0.42*	*0.62*	*1419.57****
	(0.113)	*(0.055)*	*(0.051)*	
Access to trees				
Common plot management	0.78	0.51	0.98	127.76***
(1:common property)	(0.418)	(0.501)	(0.156)	
Number of collectors in same plot	13	8	20	107.091***
(persons)	(11.100)	(9.199)	(10.406)	
Distance to plot (km)	9.4	11.3	7.9	11.26***
	(10.432)	(13.244)	(7.338)	
Labour productivity				
Collection experience (years)	12.3	20.8	6.0	275.66***
	(11.616)	(11.745)	(6.213)	
Number of adult collectors in	1	2	1	51.32***
household (persons)	(0.986)	(1.281)	(0.556)	
Wealth of livestock (‘00000 CFA)	*28.6*	*45.6*	*15.6*	*79.39****
	(37.249)	*(42.442)*	*(26.239)*	
Expected price (CFA/kg)	*626.0*	*425.9*	*777.7*	*206.62****
	(303.803)	*(86.394)*	*(321.4330*	
Distance to nearest town(km)	47.07	70.36	29.24	188.83***
	(36.632)	(38.274)	(22.744)	
Interlocked relations (1: yes)	0.41	0.61	0.25	64.98***
	(0.491)	(0.489)	(0.485)	
Fixed transaction costs				
Possession of transport mean	0.67	0.96	0.46	115.695***
(1:yes)	(0.469)	(0.206)	(0.499)	
Access to information (1:yes)	0.78	0.73	0.81	4.51**
	(0.418)	(0.448)	(0.391)	
Trading through	0.65	0.43	0.82	70.07***
group/association (1:yes)	(0.477)	(0.496)	(0.384)	

[c]Age (years)	44	46	43	7.79 ***
	(11.487)	(12.276)	(10.672)	
Education level (1: formal	0.52	0.50	0.49	1.62
education)	(0.500)	(0.499)	(0.501)	
[c]Household size (persons)	10	9	11	6.19**
	(7.369)	(5.182)	(8.609	
Perception of relative distance (1:	0.76	0.57	0.90	62.61***
easy to reach the plot)	(0.430)	(0.497)	(0.301)	
Perception of relative access to	0.31	0.49	0.18	47.68***
trees (1: easy access)	(0.463)	(0.501)	(0.381)	

[a]Mean values for continuous variables (percentage for categorical variables) are given and their corresponding standard deviations (standard errors) are indicated in parentheses.
[b]Mean quantity is computed on actual collection (N=403)
[c]Age and household size are also individual-specific determinants of sale place.
[d]Equality test refers to ANOVA test for continuous variables and Pearson chi-square test for categorical variables.
*** significant at 1% level, ** significant at 5% level; * significant at 10% level, + significant at 15% level.

In SPZ, the quantity of gum collected is much higher than the quantity collected in ES. The differences in the quantities are probably due to differences in tree availability but also in the interest, experience and motivation to collect gum. According to an unpublished report by Asylia Gum Company (AGC, 2007), gum exploitation in ES was not widely undertaken due to lack of knowledge about harvesting techniques but also because of the landlockedness of this production zone that discouraged traders to get their supplies in this region. As a result, collectors just abandoned the activity. Through recent initiatives, collection in the region is being revived.

The area of *Acacia senegal* is larger but rainfall is lower in SPZ than in ES. The proportion of collectors who collect gum in communal plots is higher in ES where the number of persons collecting in the same plot is higher than in SPZ. In SPZ, collectors travel longer distances to the collection plots than collectors in ES. In SPZ, collectors are more experienced in tapping, involve more household members and seem to be more involved in pastoralism as the value of their livestock is higher than in ES.

Collectors of gum in ES have a higher expectation on the price they would receive if they sell their gum. This is mainly due to the presence of the association EXPERNA that bargains sale contracts on behalf of collectors. Consequently, they also have easier access to information and a higher proportion of them is trading or has traded through the association or any other group than in SPZ. In SPZ, a higher proportion is involved in interlocked relations with traders than ES. Moreover, a higher proportion of these collectors in SPZ own some transport mean (e.g., donkey cart, horse cart, and bicycle) than collectors in Eastern Senegal.

Apart from differences in production variables, collectors in ES and SPZ also differ in terms of characteristics and behaviour towards gum marketing. The proportion of collectors who sell their gum in villages is lower in SPZ than in ES, this may be due to sampling. Table 3.3 shows descriptive statistics for the choice-specific variables.

Table 3. 3. Overview of mean values of choice-specific determinants of the choice of sale place by region and sale place[a]

Variable	Village			Market			Equality test[b]		
	Senegal (422)	SPZ (183)	ES (239)	Senegal (422)	SPZ (183)	ES (239)	Region	Sale place	Region X Sale place
Main sale place	0.72 (0.022)	0.55 (0.038)	0.82 (0.025)	0.28 (0.022)	0.45 (0.038)	0.18 (0.025)	35.7***		
Sale price (CFA/kg)	865.5 (553.043)	548.2 (130.301)	1108.4 (625.629)	813.4 (402.099)	544.7 (112.563)	1019.2 (422.225)	329.1***	2.4+	112.1***
Number of potential buyers (person)	2 (1.874)	4 (1.904)	1 (1.118)	5 (2.329)	6 (2.008)	4 (2.029)	218.5***	344.0***	275.7***
Number of sellers (person)	10 (4.136)	9 (4.860)	10 (3.458)	21 (7.853)	20 (7.582)	22 (8.022)	3.2*	700.5***	236.8***
Transport cost per unit (CFA/kg)	66.1 (85.256)	27.1 (57.905)	96.0 (90.716)	179.4 (223.199)	116.6 (165.726)	227.4 (248.551)	63.05***	95.4***	3.4*
Time to transact (minute/kg)	1.5 (2.314)	0.8 (0.848)	2.1 (2.864)	1.6 (2.144)	1.0 (1.126)	2.1 (2.571)	64.93***	0.38	0.30
Frequency of sale (1: more than one time transaction)	0.56 (0.498)	0.45 (0.499)	0.64 (0.483)	0.44 (0.498)	0.55 (0.499)	0.36 (0.483)	0.02	6.93***	28.8***

[a]Mean values are given and their corresponding standard deviations are indicated in parentheses.

[b]Equality test refers to ANOVA test for continuous variables and Pearson chi-square test for categorical variables.

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

Table 3.3 shows that village and market characteristics are different across zones. In general, against all expectations, the price received in the village is on average 6 per cent higher than in the market. This observation is probably affected by the different functioning of markets in ES. In SPZ, almost the same average price is offered in the village and market. However, the village price in ES is higher presumably because of the presence of the association EXPERNA that has agents in the villages; the price variability in ES is also higher because of the small number of traders. On the number of market participants, we observe that potential buyers (i.e., traders) in the village are fewer than in the market in either zone; and sellers (i.e., collectors) in the village are fewer than in the market.

With regard to the proportional transaction costs, transport costs per unit are obviously higher in travelling to the market than to the village. Scale economies can be significant in SPZ where this cost is lower than in ES (either in the village or market) despite that the longer distances in SPZ are higher than in ES. This is because the quantities transacted are larger in SPZ than in ES. The time to transact a unit of the product (i.e., conclude a transaction) in village is generally smaller in SPZ than in ES in both markets. On average, transactions are more frequent in the village than in the market especially in ES whereas in SPZ, repeated transactions are more frequent in the market than in the village. Individual-specific variables used in this model were described in Table 3.2: collectors in the SPZ are older and have smaller households than collectors in ES.

As we have observed that the characteristics and behaviour of collectors of gum in SPZ are significantly different from collectors in ES, the model results are presented both for a pooled sample of Senegal by including a regional dummy and for the two regions separately.

Group membership

A preliminary estimation is done for the choice of group membership because of the possibility of self-selection in relation to the choice of group and consequently in gum collection. A probit model for group membership is estimated and generates results that are used in estimating the quantity collected (Table 3.4).

Table 3. 4. Probit results of the choice for being in a group (1: being in a group; 0: not being in a group)

Variable	Marginal Effect (Standard error)		
	Senegal	SPZ	ES
	(422)	(183)	(239)
Age (years)	0.007***	0.009**	0.002
	(0.002)	(0.003)	(0.002)
Education level (1: formal education)	0.020	-0.059	0.067+
	(0.049)	(0.077)	(0.048)
Household size (persons)	-0.006**	-0.005	-0.004*
	(0.003)	(0.008)	(0.003)
Perception of relative distance (1: easy to reach the plot)	0.079	0.101+	0.026
	(0.064)	(0.077)	(0.090)
Perception of relative access to trees (1: easy access)	-0.085+	-0.027	-0.148*
	(0.057)	0.077	0.085)
Region (1: Eastern Senegal)	0.396***		
	(0.051)		
Log likelihood	-224.670	-117.20803	-104.210
LR chi-square	93.27***	12.46**	13.78**
Pseudo R square	0.172	0.051	0.062
Predicted probability	0.68	0.42	0.84
Correctly classified (percentage)	72	61	81

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

The model correctly classifies 72 per cent of the cases in pooled Senegal sample, 61 and 81 per cent in SPZ and ES respectively. With regard to the determinants of the choice of group marketing by collectors in overall Senegal, we first notice that collectors in the ES are more likely to be in a group, these results confirm the presence of a strong producer association in the area. Age is the other significant variable that positively influences the choice for being part of

the group while the group choice is negatively affected by the size of the household and the perception of easy accessibility. In other words, the choice of the group would be associated with the expectation that a group would provide easier access to the trees for gum collection while large households, especially with young (perhaps more energetic) collectors, can harvest and market substantial quantities on their own.

Across the regions we observe that in SPZ group membership is significantly more attractive to older farmers and collectors who can relatively easily reach the collection plots. In ES however, we observe a positive influence of education on the choice of group membership and a negative influence of ease of accessibility and large households, similar to the findings presented above for the pooled sample of Senegal.

Gum collection

Estimation of gum collection is done with a Tobit type 1 model (Tobit) for the amount collected with instrumental variables for the expected price. The IvTobit was performed both for the pooled data and over the collection zones of Senegal (Table 3.5).

Table 3. 5. Estimation results for gum quantity: IvTobit model (quantity collected (log))[a]

Variable	Senegal	SPZ	ES
Expected price (log)[b]	5.264* (3.026)	1.623+ (1.892)	1.968* (1.880)
Area for *Acacia senegal* (‘000 sq.km)	0.751 + (1.203)	2.16 4+ (1.152)	0.866+ (.582)
Rainfall (‘000mm)	-4.007+ (2.974)	-0.033 (2.517	-3.142 + (1.241)
Common plot management (1:common property)	0.982** (0.460)	0.177 (0.426)	-1.609** (0.658)
Number of collectors in same plot (persons)	-0.000 (0.016)	-0.044* (0.025)	-0.006 (0.011)
Distance to plot (km)	-0.003 (0.014)	0.007 (0.009)	-0.001 (0.015)
Collection experience (years)	0.016* (0.016)	0.008* (0.012)	0.005+ (0.023)
Number of adult collectors in household (persons)	0.050 (0.165)	0.057 (0.112)	0.022 (0.183)
Wealth from livestock (‘00000 CFA)	0.006 (0.035)	0.086 (0.151)	0.013 (0.019)
Region dummy(1:Eastern Senegal)	-0.447 (0.921)		
Constant	-27.614 (19.389)	-6.524 (12.337)	-7.596*** (11.210)
Wald Chi-square	54.98***	23.24***	21.05**
Wald test of exogeneity	12.02***	5.41+	2.31**
Amemiya-Lee-Newey minimum[c]	4.078 (0.396)	12.833 (0.112)	5.070 (0.280)
Uncensored observations	403	174	229

[a]Coefficients (Standard error)
[b]Instruments are : access to information, transport means, interlocked relation, distance to town, group,
[c]P-value in parentheses
Note: *** significant at 1% level, ** significant at 5% level; * significant at 10% level, + significant at 15% level.

Results from IvTobit bring out the effect of the expected price on collection. The Wald test of exogeneity is significant implying that the expected price is indeed an endogenous variable. The test of the validity of the instruments with the Amemiya-Lee-Newey minimum chi-square statistic shows that the instruments seem not to have a direct effect on the dependent variable and hence are valid (perhaps weakly valid in SPZ). The effect of the expected price is positive, confirming that better prices lead to better production.

Collection of gum is influenced by availability of trees: the area of *Acacia senegal* increases the potential for gum collection but the high long-term rainfall leads to low production because the rainfall would reduce the aridity conditions. Collection in common plots has an unexpected positive influence on the quantity collected which can be attributed to that communal areas are more productive. Yet, competition in common plots reduces the individual quantity (see also chapter 6). A significantly positive effect of the collector's experience on quantity is observed.

There are differences between the gum producing regions captured mainly by village effects. The effect of expected price, area of *Acacia senegal* and rainfall is robust in ES but in SPZ the difference in rainfall between collection areas is not significant. The unexpectedly positive effect of collection in common plots might have come from the SPZ where the area covered *Acacia senegal* is very large; a strong negative effect of collection in communal plots is observed in ES. Increased competition over tree resources (when the number of collectors in the same plot increases) leads to low individual quantities. This effect is probably due to occasional collectors who rush to 'the -freely accessible- communal plots' to collect gum especially when prices increase, thereby reducing the individual quantity as mentioned. This may lead to overexploitation and abuse of gum trees in order to obtain substantial quantities. The collector's experience remains significant either in SPZ or ES.

Choice of gum sale place

The next question to solve in this study is the choice of the place of gum sales. A conditional logit model is used to analyse the collector's decision to sell gum in the village or in a town market. The analysis was performed for the cases where collection has actually been done, since these are the collectors who need to make a choice of where to sell. Explanatory variables include market specific characteristics, market proportional transaction costs, and individual characteristics. To include the individual variables where no within-case variability is observed, an alternative-specific conditional logit (asclogit) model was used (Table 3.6).

Table 3. 6. Estimates of alternative-specific conditional logit model of sale place choice (village (0) or market (1))[a]

Variable	Model 1[b]			Model2[c]		
	Senegal	SPZ	ES	Senegal	SPZ	ES
Sale price (CFA)	-0.000	0.010***	-0.000+	-0.000	0.011***	-0.000
	(0.000)	(0.003)	(0.000)	(0.000)	(0.003)	(0.000)
Number of potential buyers (person)	-0.153***	-0.151**	-0.092	-0.059+	-0.107+	0.162+
	(0.047)	(0.069)	(0.084)	(0.054)	(0.077)	(0.123)
Number of sellers (person)	-0.023**	-0.007	-0.076***	0.008	0.013	-0.030+
	(0.010)	(0.019)	(0.017)	(0.015)	(0.024)	(0.024)
Transport cost per unit (CFA/kg)	-0.020*	0.023	-0.046***	-0.010+	-0.030+	-0.038*
	(0.011)	(0.020)	(0.020)	(0.011)	(0.022)	(0.020)
Time to transact (minute/kg)	0.045**	0.047**	0.046	0.045**	0.052**	0.013
	(0.018)	(0.023)	(0.040)	(0.019)	(0.024)	(0.043)
Frequency of sale (1: more than one time transaction)	0.707***	1.138***	0.097	0.745***	1.097***	0.193
	(0.118)	(0.200)	(0.184)	(0.122)	(0.204)	(0.193)
Household size (person)				-0.002	0.062+	0.003
				(0.017)	(0.040)	(0.022)
Age (years)				-0.014*	-0.030*	-0.018+
				(0.011)	(0.017)	(0.018)
Constant				-0.178	0.280**	-0.648
				(0.571)	(0.844)	(0.988)
Log likelihood	-224.220	-88.645	-107.926	-217.799	-85.510	-102.145
Pseudo R-square[d]	0.193	0.261	0.317	0.107	0.282	0.050
LR Chi-square	107.46***	62.54***	100.22***			
Wald Chi-square				45.70***	42.27***	9.47+
Number of observations	802	346	456	802	346	456

[a]Odd ratio (Standard Errors)

[b]Model 1 shows clogit results with choice-specific variables and proportional transaction costs variables specific to the choice.

[c]Model 2 shows asclogit results with choice-specific and individual-specific variables where sale place is the alternative variable including two alternatives (village or market). Village choice is the base alternative.

[d]R-square is manually computed for asclogit model: Pseudo-R-square =1-Log likelihood Full model/ Log likelihood Intercept-only Model

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

Model 1 includes the choice-specific variables directly related to market outlet and proportional transaction costs. We notice first that holding other variables constant, the effect of the number of buyers on choice of market outlet is unexpected: an increase in the number of buyers can normally lead to increase in competition and consequently increase in demand for gum arabic and prices that are attractive to collectors. However, the negative effects suggests that collectors tend to avoid larger markets. It also points to the reliance of collectors to a 'preferred' regular buyer. This explanation may be more relevant in the interlocked context or when prices offered by different traders are not different. Secondly, the increase in the number of sellers decreases the likelihood of selling in a market place because of competition. This competition would give to buyers additional power to 'dictate' the price especially because these collectors have individually low bargaining power. Thirdly, an increase in the transport cost per unit of product is associated with a decrease in the likelihood of selling in the market but an increase in transaction time per unit of gum is associated with an increase the likelihood of selling in the market. An increase in the frequency of transaction would increase the likelihood of selling in the market. This would indicate that the physical transport cost is particularly constraining, but time is not. Hence, spending time is not regarded as inefficient but rather as an investment in a good relationship with the buyer.

A focus on the regions shows that in SPZ, an increase in the price in the village or market leads to an increase in the probability of selling in that particular place while an increase in the number of buyers decreases the likelihood of selling in the village or market, holding other variables constant. Also, an increase in the time to transact is associated with an increase the likelihood of selling in that place. Furthermore, an increase in frequency of transactions increases the likelihood of selling in that place. In ES however, an increase in price, number of buyers, and number of sellers in the village or market, holding other variables constant, leads to a decrease in the probability of choosing to sell either in the

village or market. Moreover, an increase in transport cost per unit is associated with a decrease in the likelihood of selling in the village or market.

Model 2 includes the individual-specific variables in addition to the choice-specific variables. With respect to choice-specific variables, the above discussed results of Model 1 are robust for most variables. Individual-specific factors are also important in influencing the choice of selling gum in the village or transporting it to a town market. For the pooled sample of collectors in Senegal, relative to the probability of choosing to sell in the village (base alternative), the negative coefficient of the age variable shows that markets seem to attract younger collectors. Specific to SPZ, we notice that the probability of selling in the market increases with household size. Collectors with larger families may go to the market to sell gum and on the way back home bring marketable items needed by the household. Similar to the pooled sample, in SPZ, age decreases the probability of selling in the market. Specific to ES, age is also significant and decreases the likelihood of selling in the market.

The Wald chi-square test of whether all regressors are jointly significant is only weakly significant for Model 2 in ES. This implies that caution is to be taken in interpreting the results which are not significant.

3.4 Discussion and conclusion

The above findings confirm several theoretical propositions and previous empirical findings. First, they confirm that the collector tries to maximize his net returns by outweighing the production and market decisions. Hence, improving the net returns by way of higher prices and related incentives by reducing costs can contribute to an improvement of collection. These returns are assessed from the expected price in relation to the distance to the town, being in interlocked relations and the extent of fixed transaction costs. The interlocked relations imply that collection is intended to make payments to the debt contracted by a collector and hence a choice of market and trading partner is made prior to the collection.

Fixed transaction costs are also important in the decision process; if they are very high, they might make the collector decide not collect the gum (Goetz, 1992; Holloway et al., 2001). The possession of transport means, the access to information and participation in groups or associations for marketing may help in reducing such transaction costs (Poulton et al., 2006, Jagwe et al., 2010). These groups/associations attract the old collectors, with small households, or who have expectations that the group/association will provide easy access to the tree resources.

Secondly, collection is in line with production function stipulations: gum collection can increase through the expansion of area *Acacia senegal* area especially where rainfall levels are not very high; Elrayah et al. (2012) confirm that while good rains are a signal of good production, continuously high rainfall is bad for production. Collection can also be increased through the use of more inputs (labour and its experience) and the expansion of the 'farm' size (here the area covered by Acacia trees). However since this area is exploited in forests managed in a communal setting, accessibility to such trees for gum collection should be secured, implying that property rights need to be well defined and enforced as the current governance system does not successfully achieve the exclusion of occasional collectors. This is because the non-exclusion allows competition over forests that lead to the decline in individual collections with potential to overuse and abuse tree resources which may lead to a tragedy of commons as described by Hardin (1968) or Oates (1999). The main reason for such competition is the price incentives offered indiscriminately to the professional and occasional gum collectors.

Thirdly, collectors sell in the village because the differences between village and market price are not large enough to allow collectors to evaluate benefits of going to the market unless other activities can be combined with travelling to the market such as acquiring the products that a household needs. While the price is generally a motivating factor to sell in

the market, the constraining factors include the competition with other collectors who sell gum and maintenance for a particular trader who buy gum. The relationship with a trading partner is maintained most probably because there are no (large) differences in prices paid by different traders on the market.

Fourthly, proportional transaction costs that vary with the quantity to sell remain influential in the decision of where to sell (Vakis et al., 2003). On the one hand, the transport cost is associated with a decline in the probability to sell at distant markets; here, the state of the rural roads infrastructure is to be looked at, as these roads are impassable. Hence, given the problem of transport costs, collectors who have to sell larger quantities would rather stay in the village instead of going to the market (Fafchamps and Hill, 2005). On the other hand, the time to transact a unit of the product was not a deterring factor in selling. Here the social, linguistic and cultural elements are at play rather than the urge to conclude a transaction. The frequency of transactions increases the likelihood of selling with the advantage that this frequency reduces transaction costs involved in the search for a buyer mainly through established relationships. Such relationships also increase reputation and are a basis for building trust (Fafchamps and Gabre-Madhin, 2006).

Finally, the aged collectors prefer to stay in the village. Going to the market seems more attractive to the collectors with large households who would then combine gum selling with acquiring items of necessity to their household needs.

All in all, the results suggest that there is a link between collection and marketing of gum, and by extension NTFPs. Through an evaluation of the net returns: a decision is made about collection and consequently of an efficient market where the collected gum can be profitably sold. In other words, collection can be restricted by market failures. Given that the Acacia trees are available in open access areas and that the markets are not specialized in gum trading, it means that unless the collector has already closed a deal with a buyer beforehand,

he decides to collect, goes to the forest and takes gum depending on his possibilities to put in labour time and cover fixed transaction costs. He then decides on which market to which he sells this gum given the amount he has collected in consideration of proportional transaction costs and household characteristics. This is also because the market of gum is not a specialised market, but one that is used for exchanges of other goods. The analysis also goes in line with predictions of our theoretical model, that costs incurred in finding a good market can be regarded as an investment, whereby the collector may continue to transact with the same trading partner (and hence in the same market). Yet, a revision of the choices may be done at some point depending on the quantity (e.g., if the quantity collected is smaller or larger than expected) and other related proportional costs.

Behaviour and performance of traders in the gum arabic supply chain in Senegal: investigating oligopsonistic myths.

Abstract

Farmers face monopsonist/oligopsonist structures in agricultural or forest products markets because of the limited choice of traders/buyers. As a consequence, these farmers and traders alike, in successive transactions along the supply chain, may get lower prices in selling their products. This leads to a problem of double (or even multiple) marginalisation. We investigate oligopsonist tendencies in the trade of gum arabic, a non-timber forest product which is widely used as an additive in food and non-food industries. We compute traders' shares and a corresponding Herfindahl index in primary, transport and wholesale markets of gum arabic in Senegal to analyse the market concentration; through a gllamm procedure we analyse determinants of these market shares and finally by a weighted least square regression, we analyse determinants of marketing margins of individual traders. The computed Herfindahl index was found too low to have any influence on margins and hence oligopsonist powers could not be confirmed. Instead traders' margins depend on costs, risk and uncertainty that they face. Consequently, traders were not found exploitative; their power is derived from access to capital and market characteristics.

Key words: oligopsony, double marginalisation, Herfindahl index, market accession, market exit, risk, marketing margins.

4.1 Introduction

Markets of agricultural or forest products are often imperfect, especially in developing countries. Towards the consumer end of the supply chain, monopolies or oligopolies are found with many consumers buying from a limited number of retailers. On the other side of the chain, farmers often face monopsonies or oligopsonies because they have a limited choice of traders to whom they can sell. Furthermore, within the supply chain, the number of buyers

at different intermediary levels, from producers to the processing and/or export level, is successively often smaller than the number of sellers. This might imply imperfect competitive market structures with successive oligopsonist tendencies. Due to these successive oligopsonies, buyers may offer lower prices compared to what they would pay if they were in a competitive market, because they also face lower prices in the markets where they sell. As a consequence, the traded volumes are smaller than if the market was perfectly competitive. Furthermore, the market power with successive oligopsonies applied at each level of the supply chain results in a fall in the prices consecutively paid and quantities consecutively traded along the chain. This problem was first described by Spengler (1950) and has become known as 'double marginalisation' in reference to a simultaneous exercise of market power by trading agents against each other. Arguably, double marginalisation does not only determine the price levels in the chain and the volume marketed, but it also affects marketing margins (Spengler, 1950; Lantz, 2009).

The specific role of traders and intermediaries in agricultural markets in developing countries has been subject of many studies in context of their different roles and functions: as intermediaries in searching for a trading partner (e.g., Gabre-Madhin, 2001); as brokers in improving market efficiency (e.g., Gabre-Madhin, 2001); or as risk bearers in exploring or creating market exchange opportunities (e.g., Rubinstein and Wolinsky, 1987; Gadde and Snehota, 2001). However, claims were often made that these traders exploit farmers by capturing excessive 'monopsonist rents' (McMillan et al., 2002; Fafchamps and Gabre-Madhin, 2006; Fafchamps and Hill, 2008) or by colluding (Batt, 2004). Yet, empirical studies such as Batt et al. (2009) or Mose (2007) fail to substantiate such exploitation. In the presence of competition among traders in the maize market in Kenya studied by Mose (2007), no evidence of such exploitation was found.

Fafchamps and Hill (2008) explained that the perception of farmers' exploitation by traders is associated with traders taking advantage of the farmers' low bargaining power and their ignorance on price movements but also with high transport and transaction costs in marketing that these traders face. Lele (1981) explained that these marketing costs result from the long chain of intermediaries from producer to consumer. Some large traders can handle a large share of marketed quantities and surpluses, yet rural traders are often found to work on low margins and earn a meagre income; in fact they are 'just rational and acting under constrained efficiency' (Fafchamps et al., 2003). These small rural traders transact small quantities because of limited access to working capital, limited storage facilities, and high marketing and transaction costs due to extensive travelling on poor roads and inadequate transport infrastructure and services in rural areas (World Bank, 2007)

Poor infrastructure not only increases costs of transportation; it also causes delays in transport and consequently decreases profitability (Schroeter and Azzam, 1991; Fafchamps and Gabre-Madhin, 2001; Shackleton and Shackleton, 2004; Eskola, 2006). Price uncertainty, inconsistent government policies and continued suspicion of trader activity are also found to seriously constrain trade (Schroeter and Azzam, 1991). These constraints not only increase marketing costs, but also determine the environment in which traders operate. This environment in turn influences traders' behaviour including the distribution of market power and profits or margins earned in the market (Raper et al., 2000; Myers et al., 2010).

Despite the importance given to marketing costs and the distribution of market power, both issues have seldom been investigated in the context of oligopsonies and double marginalisation problem. In this chapter we address this gap by studying the case of the performance of traders in the supply chain of gum arabic in Senegal. We investigate the gum market structure and assess its impacts on market outcomes (marketing margins).

Different categories of intermediaries in the Senegalese supply chain of gum arabic and *in extenso* of many raw agricultural and forestry products can be distinguished, namely: (a) a primary category of village traders and mobile traders; (b) an intermediate category of transporters; and (c) a high category of wholesalers, exporters and processors (Figure 2.5). A successive oligopsonistic market structure in the gum arabic chain is observed as local traders purchase gum from many producers but they sell this gum to fewer transporters, whose main function is to move the gum. They in turn sell to fewer wholesalers; and in this high category, the number of local processors and exporters is very limited. We focus our analysis on those primary traders who move between producing villages or weekly markets to buy gum from the collectors, on transporters who move to rural markets in production regions to buy gum from primary traders, and on wholesalers who are established in cities neighbouring the production zones. We describe their role and analyse how the market structures in which they operate influence their performance in the gum business. We specifically investigate whether the variations in the marketing margins are indeed a result of market power as predicted by the double marginalisation. We base this analysis on data collected from the Sylvopastoral and Eastern regions of Senegal from 124 traders who are village, mobile, transporters and wholesale traders.

In the next section we develop a theoretical framework to analyse oligopsonies and to explain the theoretical consequences of the double marginalisation problem. Next the structure of the supply chain of gum arabic in Senegal is explored. This is followed by a methodology and a results section. Finally we discuss these results, and give conclusions.

4.2 Oligopsony markets

As mentioned in the introduction, the agricultural marketing system in most developing countries is characterised by oligopolistic and oligopsonistic structures. On the side of outputs markets, oligopolistic systems are observed where there are relatively few distributors and

numerous consumers (Mendoza and Rosegrant, 1995). Markets of raw agricultural and forest products mainly exhibit oligopsonistic features as there are numerous farmers or collectors, and relatively few traders. Along supply chains of raw products, successive intermediaries function in similar oligopsonies that are associated with the presence of non-competitive buyers at the different levels of the market namely primary and intermediate traders, wholesalers, or processors (Lele, 1981).

Generally in oligopsonistic markets, numerous sellers compete to sell their product to a small number of (often larger and more powerful) buyers (Jehle and Reny, 2000). The most important characteristics of oligopsonies are that: (1) these markets are dominated by a small number of buyers; (2) sellers face few alternatives to sell their goods and if other alternative buyers exist, these tend to be less desirable for instance because markets are inaccessible; and (3) the market shows significant barriers to entry that enable buyers to attain and retain market control (Rogers and Sexton, 1994; Bergman and Brännlund, 1995). Barriers to market entry can be natural, formal or informal. Menzie and Prentice (1987) explain that natural barriers include 'natural' or geographic barriers such as being remote or landlocked. Formal trade barriers are defined as any direct action that restricts trade such as a government policy or regulation (Ackah and Morrissey, 2005), and may include patents, taxes, quantitative restrictions, and quality requirements (Menzie and Prentice, 1987). Informal trade barriers impact on trade indirectly. These include individual constraints such as difficult access to credit, lack of capital to expand the business or to engage in storing the products, lack of or limited business skills/knowledge, and problems due to the institutional framework such as long supply chains or lack of established rules of transaction. Other informal barriers include social, linguistic or cultural differences which have an effect on negotiation (Kherallah et al., 2000; Eskola, 2006).

Oligopsonistic market structures have received relatively little attention in agricultural economics literature. Early in the 20th century, economists started to recognize the imbalance of power between farmers and the system of sale for their produce. Cooperation for joint performance (cooperatives, associations) was considered as a way to correct these imbalances (Nourse, 1922). The Structure-Conduct-Performance approach was occasionally used to analyse oligopoly power and its impacts on consumers in the context of industrial organisation studies; yet, it is only the 'New Empirical Industrial Organization' (NEIO) theory that investigated the relevance of traders' oligopsony power over farmers in inputs markets (Myers et al., 2010). A few studies that focused on oligopsonies laid emphasis on testing, measuring or determining this oligopsony power in different industries and markets (e.g., Ukrainian milk processing industry (Perekhozhuk et al., 2009), U.S. Paper Industry (Mei and Sun, 2008), and UK Salmon markets (Fofana and Shabbar, 2008)). Other studies focused on finding measures or strategies for mitigating this oligopsony power, e.g., theoretically through vertical integration (Loertscher and Reisinger, 2009) or empirically through Fair Trade in the coffee market (Piyapromdee et al, 2008). Some authors analysed the price determination in oligopsonic markets while others focussed on issues of double marginalisation as a consequence of repeated oligopsonies in the chain. We take a closer look at the literature on both issues in the next sections.

Studies by Just and Chern (1980), Sexton (1990), Chen and Lent (1992), Rogers and Sexton (1994), and Myers et al. (2010) provide guidelines on modelling oligopsony relationships between firms and industries. Firms operating within oligopsonies exhibit strategic behaviour as each firm has to be aware of the actions of the other market participants. When firms decide to cooperate, collusion takes place within the industry (e.g., explicitly through cartels) or price leadership occurs when one firm is followed by other firms in the industry.

Profits for an oligopsonist depend not only on demand and supply but also on the behaviour of competing traders. The more the competitors buy, the lower the market price will be. This is due to a 'payoff interdependency' as explained by Church and Ware (1999). Since traders operate in a strategic context, to determine the profit-maximizing quantity, each trader has to figure out how much his competitor is going to buy and sell while recognizing that the competitor is also going through the same thinking process. Each buyer knows that if he can unilaterally increase his market share by acquiring more products, his profits will increase. However, if all firms exercise their power and compete aggressively for more market share, even if they are fewer on the market, they will all be worse off: the resulting low prices will lower both aggregate and individual profits.

Successive oligopsonies in supply chain: the double marginalisation problem

The general double marginalisation problem in supply chains occurs when two (or more) independent firms have large market power and exercise this power to set up prices at mark ups different than MC: monopolies' prices are above MC and monopsonies' prices are below MC; these deviations yield deadweight losses. With successive market imperfections, actors reduce their combined profit by simultaneously exercising their market power and as such no stable equilibrium is reached in the market (Lantz, 2009). In the next paragraphs the problem of double marginalisation is illustrated by taking the case of successive monopsonies instead of oligopsonies to facilitate graphical clarity.

Consider the case of a monopsony and three successive stages of marketing: (1) the acquisition of the product by a trader from farmers in a particular village; (2) a trader supplies the product from the village to a wholesaler; and (3) a wholesaler supplies to an exporter or a processor who aims at maximizing his profits in the transformation of the raw product and there is no vertical integration. Figure 4.1 illustrates the analysis of double marginalisation

with successive monopsonies[3]; this model is not tested in the paper, but it is important to show the effects of the characteristics of market power. Let P_V, P_w, and P_e, represent the prices offered by a village trader to farmers, a wholesaler to a trader and an exporter to wholesaler respectively in a supply chain. S_f and S_v are the farm and trader supply curves, respectively. MC_v and MC_w are the trader and wholesaler's marginal cost curves, respectively, derived from total cost functions. MRv and MRw are the trader and wholesaler's marginal revenue curves. Because a monopsonist is a price maker with extensive market control, he buys the quantity that equates marginal cost and marginal revenue and he pays a lower price for each unit of the product.

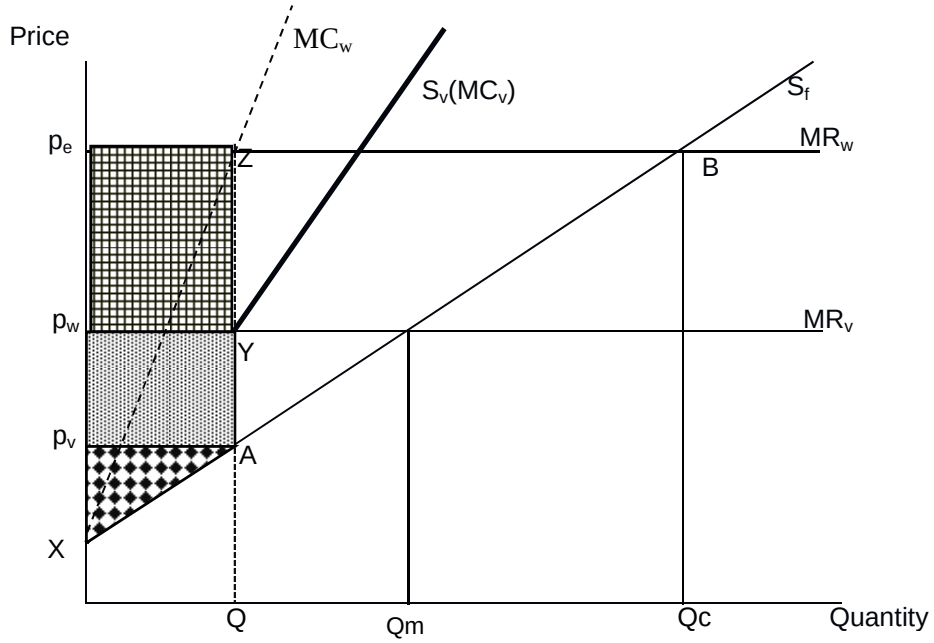

Figure 4. 1. The problem of double marginalisation for successive monopsonies

Q is the quantity bought by a monopsonistic trader from farmers (in the village) at price p_v. The village trader supplies to the wholesaler. This wholesaler is also a monopsonist; hence he pays a price P_w that is lower than the competitive price. The exporter pays P_e and the quantity supplied by a wholesaler is Q.

[3] Figure 4.1 of successive monopsonies relaxes the assumptions of oligopsony for the purpose of clarity. These assumptions relate to the MR curves, and the fact that here the price determination depends only on MR/MC of the single monopsonist buyer and not on based on the actions of the other buyers.

The farmer's surplus is p_vAX, the village trader's surplus is p_vAYP_w. and the wholesaler' s surplus is P_wYZP_e. Hence with successive monopsonies, the aggregate surplus earned along the chain is $XAZP_e$ which is obtained from trading Q quantity of the product.

If the respective traders along the chain were operating in perfectly competitive conditions, the quantity purchased and price to the producer would be greater than in the presence of monopsonies. For instance at the export price P_e, a farmer in a competitive setting could supply Q_c and the surplus throughout the chain would be XBP_e. This competitive surplus is greater than the aggregate monopsonists' surplus.

As the number of imperfect marketing stages increases, the effect of such imperfections on the farmer(price) becomes even more pronounced because each trader in each stage aims at earning a monopsonistic profit (McMillan et al., 2002).

In successive oligopsonies, the impact of double marginalisation in depressing prices, quantity traded and overall surplus in the chain will depend on market concentration and the type of interaction allowed between traders.

The generally proposed solution to the double marginalisation problem is vertical integration which should lead to higher chain profits (Spengler, 1950, Gaudet and Van Long, 1995). Vertical integration eliminates some of the monopoly (monopsony) mark-ups, leading to a lower sale (higher buying) price and an increase in welfare (West, 2000). From a New Institutional Economics perspective, vertical integration may also act positively on profits through minimization of transaction costs.

While surpluses for traders have been explained above by market power in relation to the prices and quantities in transaction, it is important to consider that these surpluses may also depend on the determinants of the marginal costs which are associated with functions performed by these traders. These are outlined in the next section.

Functions and costs of trading

The role of a trader is to transport, grade, bring to market and sell products to consumers (Eaton et al. 2007). Kotler (1997) listed nine market functions: (1) information collection and dissemination; (2) development and dissemination of persuasive communications about offers; (3) negotiation attempts to reach final agreement on price and other items of the offers; (4) ordering backward communication of intentions to buy; (5) financing acquisition and allocation of funds required to finance the carrying of inventory; (6) risk taking in connection with carrying out channel work; (7) successive storage, processing and movement of physical products; (8) payment of bills; and (9) actual transfers of title of goods. All these marketing functions are associated with marketing costs and transaction costs including the cost of searching for an exchange partner (Gabre-Madhin, 1999); the cost of acquiring information specially in the context of information asymmetries (Ellis, 1988; Hobbs, 1996; Upton, 1996); and negotiation costs and costs for concluding and enforcing a contract (Hobbs, 1996).

As mentioned in the introduction, marketing costs are especially high in developing countries due poor infrastructure and inefficient transport system, inadequate storage capacity, lack of reliable market information or modern communication facilities, and significant variations in product form, variety and quality (Rogers and Sexton, 1994; Harris-White, 1997; Batt, 2004). These factors also make trade in developing countries very risky. In the markets of non-timber forest products such as gum arabic, costs are even higher because producers are often dispersed over large areas and markets are located in marginalized areas characterized by poorly developed transport and communication infrastructure.

Social capital and the use of intermediaries may reduce transaction costs and risk. According to Fafchamps and Minten (2001), social capital through kinship or networks may help economize on transactions costs by speeding up the search for trading partners,

providing insurance in order to enforce contracts and facilitating the circulation of information (Fafchamps and Minten, 2001; Le Goulven, 2001).

Finally, it should be noted that in addition to marketing functions and costs, other factors influence marketing margins. Wohlgenant (2001) summarized several studies and identified these factors as technical and structural changes, cooperative behaviour, government programs, product quality and seasonality.

Structure of gum arabic supply chain in Senegal

Similar to agricultural markets in Africa studied by Fafchamps (e.g., Fafchamps and Minten, 1998, 2000; Fafchamps et al., 2003; Fafchamps and Gabre-Madhin, 2006), markets for raw gum arabic are characterized by a large number of gum collectors and relatively few traders and companies as described in Figure 2.5.

Table 4.1. summarizes the features of gum trade for different categories of traders in relation to the supply of gum arabic (i.e., factors that influence the supply of gum on the market), demand for gum arabic(i.e., factors that influence the supply of gum on the market), transaction costs (i.e., factors that determine the extent of transaction costs in markets of gum arabic), risks and uncertainty(i.e., factors that influence the magnitude of risk or uncertainty in marketing gum arabic), and quality requirements (i.e., requirements for quality improvement and maintenance).

Table 4. 1. Features and determinants of gum arabic trade

Determinants of trade	Primary traders	Transporters	Wholesalers	Processors and exporters
Supply of gum	-Production potential -Labour time and opportunity costs -Price offered to gum collectors -Other incentives to collectors to supply gum -Interlocked contracts	-Number of markets and seller -Price offered to primary traders	-Quantities gathered by transporters -Price offered to gum transporters	-Quantities gathered in the production zone -Price offered to wholesalers
Demand of gum	-Price offered by transporters -Buyers' access to working capital, credit, marketing costs	-Price offered by wholesalers -Buyers' access to working capital, credit, marketing costs	-Price offered by exporters and processors -Buyers' access to working capital, credit, marketing costs	-International prices -Own capital, possibility to access credit, marketing and shipping costs -Contracts
Transaction costs	-Production widely dispersed -Opportunistic behaviour	-Road connection and means of transport -Dispersed markets -Opportunistic behaviour	-Loading and unloading sacks, quality monitoring, and payment of road fees -Opportunistic behaviour	Loading and unloading sacks, quality monitoring, and payment of road fees
Risk and uncertainty	-Contract and market -Production failure -Competition over supply -Price uncertainty	-Loading, discharge capacity and delays -Contract and market -Competition over supply -Price uncertainty	-Loading, discharge capacity and delays -Contract enforcement	-Loading, discharge capacity and delays -Contract enforcement
Quality requirements			Sorting and grading has to be done	Investment in machinery for grading

4.3 Methodology

As explained above, the behaviour and performance of a trader in a supply chain structured as successive oligopsony are influenced by his action and his strategy towards his competitors. The current section details the theoretical framework which identifies the role of market power to the analysis of oligopsonistic behaviour. Empirical specifications are also presented.

Theoretical framework

Gum collectors are assumed to be homogeneous and distributed uniformly. Traders are homogeneous and price takers in their selling markets. The final customer in the market chain is considered to be the exporter of raw gum or a processor who uses raw gum to manufacture various products; however the processing or exporting levels are outside the scope of the current study.

Let us assume that the market for gum arabic is composed of n traders (i.e., the buyers) facing numerous sellers (i.e., collectors or traders at successive levels in the chain). The trader maximizes profits at:

$$\pi_i = (p_s - p_b)q_i - c(q_i) \quad (1)$$

where π_i is profit of trader i, $p_s$and p_b are his selling and buying prices, q_i is the quantity traded and $c(q_i)$ the cost function of trading this quantity, with $c'(q) > 0$. Typically, p_b is an endogenous variable for a trader in an oligopsonistic position. The value of $p_b$depends on his activities, but also on the quantities bought by other traders so that $p_b = f(Q)$ and $Q = \sum q_i$. Maximization gives as first-order condition:

$$c'(q_i) = (p_s - p_b) - q_i \frac{\partial p_b}{\partial q_i} \quad (2)$$

If the trader wants to buy a larger quantity, he offers a higher price, hence the last term is positive, making marginal cost somewhat lower than the gross margin. Lower $c'(q)$ implies lower values of q_i, hence the trader buys smaller quantities than he would have done if p_b was not responsive to his actions.

As it is, the effect of q_i on p_b can be written as $\frac{\partial p_b}{\partial Q}.\frac{Q}{p_b}.\frac{p_b}{Q}.\frac{\partial Q}{\partial q_i}$. The first two factors are the inverse of the supply elasticity ε. The last factor shows how total quantity responds to a unit change in *i's* purchases. Given that Q= $\sum q_i$, that factor is :

$$\frac{\partial Q}{\partial q_i} = 1 + \sum_{j \neq i} \frac{\partial q_j}{\partial q_i} \equiv 1 + \beta \quad (3)$$

For simplicity we assume that β, a measure for the degree of collusion, is constant over all i, By replacing the elasticity and equation (3) into the formula for *c'(q_i),* this then becomes:

$$c'(q_i) = p_s - p_b - p_b \frac{1+\beta}{\varepsilon} \frac{q_i}{Q} \quad (4)$$

Following Chen and Lent (1992) we can multiply both sides by $\frac{q_i}{Q}$ and sum over all I and by assuming that the marginal costs are insensitive to market shares, the result for an average trader can be written as:

$$c'(q) = p_s - p_b - p_b \frac{1+\beta}{\varepsilon} \sum \left(\frac{q_i}{Q}\right)^2 \quad (5)$$

or

$$c'(q) = p_s - p_b - p_b \frac{1+\beta}{\varepsilon} \mathrm{H} \quad (6)$$

where H is the Herfindahl index of market power. It is a measure of the relative average size of traders in relation to the market and an indicator of the amount of competition among them (Chen and Lent, 1992). If $H = 1/N$, there is perfect competition or all traders are of equal size and if $H = 1$, the market behaves as a pure monopsony. Increases in the Herfindahl index indicate a decrease in competition while reductions in the Herfindahl index indicate an increase in competition. Values of H between $1 / N$ and 1 correspond to different degrees of oligopsony. Equation (6) shows that the higher is H (i.e., the larger and more unequal the market shares), and the higher the level of collusion (β), the lower will be $c'(q)$ and therefore q itself. By implication, Q will be lower too, and less will be bought, thus depressing the buying prices, while enlarging the gross margins at the trader's level.

Empirical specifications

The empirical application of the profit maximisation model in oligopsony markets of gum arabic is made in reference to equations (1) and (6); where we explore the magnitude of market power and the margins and explain determinants of market power (in terms of the share of traders in market) and marketing margins. First, we compute market shares of traders based on the transaction quantity of each trader in proportion to the total size of transactions in that market; and on the basis of these market shares, a Herfindahl index of power in each market is derived. We then analyse on the individual level the factors that influence the traders' market share and derive an interpretation for market accession. Secondly, we compute gross margins per unit of transaction based on the buying and selling prices and then net margins subtracting the fixed and variable costs involved in buying and selling. Finally, at the market level, we analyse the factors that influence the marketing margins and derive an interpretation for market exit.

(1) Computing market share and deriving the Herfindahl index

The Herfindahl index (H) is a measure of market power, and it involves the calculation of the market share of each trader as a ratio of the total quantity of his transactions on the total quantity of transactions conducted in each market.

Since data on the total quantities corresponding to transactions in primary, transporting and wholesale markets were not directly available [4], the total size of each market was estimated using one of the different approaches described below: (a) in case all traders operating in a market were interviewed and each trader indicated the total quantity of his transactions in the market, the sum of quantities of all traders was obtained (e.g., primary markets of Barkédji, Labgar, Séno Youpé); (b) in case all traders in a primary market could not be interviewed, total quantities supplied by producers were calculated based on the

[4] Secondary data is scarce and that it was not possible to interview all traders in all markets due to their absence or reluctance to accept interviews.

average number of producers who sell in a particular market and the average quantity supplied by producers in that market; (c) the average annual transactions in some markets were available from secondary sources (CSE (2006) and EXPERNA (2008) in the period 2011-2004 and 2005-2006 in the SPZ and ES respectively. Such averages served as an estimate of the current market size assuming that transactions followed similar trends over time (e.g., Linguère, Kamb); (d) in transporting markets, the aggregation of quantities from primary markets is computed; and (e) in wholesale markets, the weighted average production of the last five years (COMTRADE, 2011) served as an estimate of the current exports. Weights in the wholesale markets of the SPZ and ES were derived as 55 and 5 per cent of the exports from SPZ and ES respectively (the remaining 40 per cent exports are from the Northern region (DEFCCS, 2005; Diop 2005)).

A trader‘s share is computed as the proportion of his total transaction quantities over the total market size:

$\text{Share}_i = q_i/Q$ such that $\sum \frac{q_i}{Q} = 1$ (7)

In the second step, the Herfindahl index is calculated by taking into account the number of traders and variance between their shares:

$$H = \frac{1}{N} + NV \quad (8)$$

where N is the number of traders in the market and V is the statistical variance of traders' shares defined as:

$$V = \frac{\sum_{i=1}^{n}(q_i - 1/N)^2}{N} \quad (9)$$

If all traders have equal shares, then V is zero and H equals $1/N$. If the number of firms in the market is held constant, a higher share dispersion will result in a higher index value. As such computed, the value of the Herfindahl ranges from $1/N$ to 1 where a very low index implies competition while an index close to 1 implies high concentration (refer to equation (6)).

A normalised Herfindahl index is computed so that it ranges between 0 and 1:

$$H^* = \frac{H-1/N}{1-1/N} \quad (10)$$

When $H = 1$, $H^* = 1$, which is the case of pure monopsony. If traders have equal shares, $H = 1/N$ and $H^* = 0$ (there is no dispersion meaning that $V = 0$), which is the case of perfect competition.

There are other measures of market power at the market level including the four-firm concentration ratio[5]. Unlike this concentration ratio, the Herfindahl index reflects both the distribution of the market shares of the top four firms and the composition of the market outside the top four firms. It also gives proportionately greater weight to the market shares of the larger firms, in accordance with their relative importance in competitive interactions (Kelly, 1981).

(2) Computing margins

Two types of unit margins are computed as follows:

Gross margin = $p_s - p_b$ (11)

Net margin = Gross margin – $c(q)$ (12)

With:

- Selling price (p_s): the price at which the trader (a primary trader, transporter or wholesaler) sells the gum to a 'superior' trader (a transporter, wholesaler or exporter respectively). In the sale market, the trader is considered to be a price-taker, thereby having no influence on the determination of this price;
- Buying price (p_b): the price at which the buyer (primary trader, transporter or wholesaler) obtains gum either from gum collectors in the case of primary traders and subsequently in the chain from an 'inferior' trader (primary trader or transporter).

Marketing costs ($c(q)$) include:

[5] The Lerner index is another measure of power at the firm level. It measures the extent to which a given firm's buying prices exceed marginal costs (Rogers and Sexton, 1994).

- Transport cost: is a combination of distance and transport mode. Primary traders often use horse or donkey carts in travelling to villages or hire public transport in travelling to town market. Transporters or wholesalers who travel to rural markets use trucks. The transport function reflects a fixed cost that varies only with distance and a proportional cost that varies with the quantity to transport (refer to chapter 4);
- Storage cost: while building up the volumes, hoarding stocks in order to get a good price or waiting for a buyer, traders will incur a storage cost. This the actual or imputed cost for hiring a room in which to store gum for the duration of gum harvesting season;
- Cleaning and sorting cost: in order to improve its value, traders may clean gum by removing impurities and mixtures, and grade gum based on visible qualities of gum including the size of nodules and their colour;
- Hired labour cost: depends on the average daily wages, the number of days that a trader hires labourers and the number of labourers hired in the season;
- Other costs: mainly communication and road fees as given by traders.

Data

A survey of traders involved in gum arabic marketing was conducted in Senegal in the two major gum producing areas namely the Sylvopastoral Zone and Eastern regions between February and May 2009. The sample of traders was designed to be representative of all the traders involved in the gum arabic supply chain in these two regions of study where gum arabic is actually produced and marketed. Traders interviewed in each region comprised of primary traders (village and mobile traders), transporters and wholesalers. These traders were interviewed using a questionnaire which pertained to individual characteristics of the traders, market characteristics, and marketing elements. Additional informal interviews were held with exporters and processors.

In total, a random sample of 124 traders were formally interviewed; 90 in SPZ and 34 in ES. The distribution of traders reflects the interest in gum production and trade in SPZ. In the past, traders limited their procurement activities to SPZ with the aim of minimising transport costs thereby maximizing their profits; production and trade in the more remote ES was low (AGC, 2007).

Secondary data sources were also used. These include the Atlas published by the Ministry of Environment (CSE, 2006) on the markets statistics in SPZ and the EXPERNA report on production statistics in ES (EXPERNA, 2008).

(1) Explaining individual shares of traders in a market

The determinants of the market share of a trader are analysed. We distinguish trader and market characteristics. Human capital, social capital, and wealth are variables that have been recurrent in the study of various aspects of trading (e.g., Fafchamps and Minten, 1998, 2001); however, market factors were not previously given attention.

(a) Variables associated with trader characteristics are:

- Education: this is a dummy that takes a value of 1 if the trader has received some form of education whether in the Coranic or formal schools or 0 otherwise. The educated traders might have knowledge in running their business and thereby earn high margins;
- Trader's experience: this is the number of years that the trader has spent in the gum business. The more experienced traders can take advantage of their knowledge and business skills to have high shares in the market;
- Wealth: this wealth substitutes the accessibility to capital because formal institutions that would supply credit are quasi-inexistent in the rural areas. Two variables proxy the trader's wealth: (1) the value of livestock owned by the trader and (2) the number of houses that the trader possesses. These proxies are exogenous to market share because they are based on

historical decisions and not causally related to the trade of gum. The higher the wealth, the higher the possibility to have funds and therefore the higher would be the market share;

- Number of family relatives involved in gum business: this number indicates the range of trader's network. Such network facilitates the access to information regarding the supply and demand markets;

- Number of language spoken: this indicates the ease of communication which facilitates transactions especially in a multilingual society like in Senegal. The more languages spoken by a particular trader, the higher would be his market share;

- Possession of a telephone: this is a dummy variable that takes the value of 1 if a trader possesses a (mobile) telephone or 0 otherwise. The possession of a telephone facilitates communication in terms of accessing information on markets, prices and transactions. Hence if a trader has a telephone, he might have a higher share of the market than a trader who does not have the telephone; and,

- Area of operation: rural markets in Senegal held on different days in the week, hence the area of operation is represented by the number of markets (and villages) in which traders could have their supplies. The area of operation is exogenous to market share; a large market share does not mean that a trader operates in several market. Instead, the larger is the area, the larger may be the quantity of trader's transactions.

(b) Variables associated with market characteristics are:

- Market size: this is the total of the quantities transacted in that market. This size is expected to have a positive effect on the market share;

- Number of buyers: this is the number of all traders who operate in a particular market. This number is expected to have a decreasing effect on the market share as it implies competition over the transactions;

- Distance of the market or village from the nearest town: this is the distance in kilometres from the town to the market or village. The longer the distance, the lower would be the buying price;
- Distance from Dakar: this is the distance in kilometres from Dakar to the buying place. The longer the distance, the lower would be the buying price because of the higher costs for a buyer to transport to Dakar;
- The existence of storage in the market: this is a dummy variable that takes a value of 1 if storage is available in the market or 0 otherwise. This variable indicates that in the market where storage is provided, traders might take advantage of storage in terms of building-up volumes or waiting for buyers thereby increasing their market share.

Due to the presence of explanatory variables at two levels namely the low level of traders and the high level of market, the generalized linear latent and mixed models (gllamm) procedure is used instead of a standard regression. This gllamm procedure takes into account the hierarchical structure of the data by explicitly allowing a random effect of the higher level at the market and thereby correcting for the independence of observation. This is because traders of a certain category who are drawn from a market would be more homogeneous than if traders were randomly sampled from a larger population (see Rabe-Hesketh et al. (2004) for details on gllamm).

(2) Explaining marketing margins

We test the correlation between marketing margins and market power and investigate determinants of these margins. Following our theoretical model and studies by Wohlgenant (2001) and Fafchamps, et al. (2003), the following determinants of marketing margins are included:

- Marketing costs ($c(q)$) include all the costs spent by trader in selling gum. As mentioned above, these include the transport, storage, cleaning and sorting, labour, and other costs.

These costs were computed per kg of gum arabic sold. The costs have a decreasing marginal effect on the margins and hence are expressed as a quadratic form.

- Distance to sell: this is the physical distance in kilometres from the trader's business (base) to the selling market. Margins are expected to increase with distance.
- Price uncertainty: this was calculated as the deviation of the price received by the trader from the mean sale price in each market in the previous season. The higher this deviation and hence the uncertainty, the higher would be the margin retained by the trader.
- Risk: traders in gum arabic face a number of risks that can be idiosyncratic risk or systemic market risk. Idiosyncratic risk affects an individual trader and includes for instance the failure to obtain gum as contractual payment, finding a buyer, or delays; systemic market risk affects almost all traders in the market in a similar way and includes for instance production failure, competition over supplies, or unpredictable price variations. The individual and market risk are each indicated by a dummy that takes a value of 1 if a trader has indicated in the interviews concern for any component of this risk or 0 otherwise[6].

Due to the heteroskedasticity of the total costs variable with respect to marketing margins, the weighted least square estimation is used instead of standard regression. Greene (2008) defines the weighted least square estimator as:

$$\hat{\beta} = \sum_{i=1}^{n} w_i \boldsymbol{x}_i y_i \Big/ \sum_{i=1}^{n} w_i \boldsymbol{x}_i \boldsymbol{x}'_i \qquad (13)$$

Where the weight $w_i = 1/\sigma_i^2$. Here, observations with smaller variances receive a larger weight in the computations of the sums and therefore have greater influence in the estimates obtained. Analytical weights were used by estimating a regression based on $1/\sigma_i^2$ because the variance is not constant.

[6] Due to the difficulty of quantifying risk, we relied on an indication of perception of risk related to the gum trading.

Having explained the variables included in the study, we now present the results of our empirical analysis.

4.4 Results

There are differences in characteristics of market transactions, market power and the exercise of this power towards achieving performance between primary traders, transporters and wholesalers. In this section we first present an overview of characteristics of gum arabic market in terms of traders' transactions and test the concentration of market power. This leads us to analysing determinants of such market power and discussing their potential effect.

Characteristics of the groups of traders

In terms of transactions, an overview of quantities, prices, costs and margins associated with buying and selling gum shows differences between zones and categories of traders (Table 4.2). Because the gum production in the two zones (SPZ and ES) is different, they are reported separately.

Table 4. 2. Descriptive statistics of gum trade components

	All traders			Primary traders			Transporters			Wholesalers			Equality test		
	Senegal (124)	SPZ (90)	ES (34)	Senegal (88)	SPZ (69)	ES (19)	Senegal (29)	SPZ (16)	ES (13)	Senegal (7)	SPZ (5)	ES (2)	Category	Region	Region X category
Quantities (tons)															
Total quantity	5.27 (18.2)	6.52 (21.2)	1.97 (2.7)	1.49 (1.9)	1.71 (2.0)	0.68 (0.9)	5.00 (7.5)	6.73 (9.8)	2.89 (1.8)	53.93 (59.5)	72.20 (61.9)	8.25 (8.1)	27.3***	35.9**	17.9***
Quantity per transaction	1.15 (5.9)	1.42 (6.9)	0.43 (0.5)	0.14 (0.2)	0.13 (0.2)	0.17 (0.3)	0.83 (1.3)	0.98 (1.7)	0.63 (0.5)	15.14 (21.6)	20.57 (23.9)	1.58 (1.1)	15.8***	20.8***	12.2***
Prices (CFA/kg)															
Buying price	568.95 (206.5)	453.89 (67.4)	873.53 (122.6)	511.70 (175.2)	427.25 (50.6)	818.42 (109.6)	705.86 (198.9)	535.63 (27.6)	915.38 (71.8)	721.43 (281.1)	560.00 (41.8)	1125.0 (106.1)	47.8***	482.2***	5.3***
Selling price	670.29 (222.4)	549.07 (71.5)	991.18 (156.4)	611.45 (176.9)	526.93 (58.6)	918.42 (107.0)	794.83 (235.0)	596.88 (12.5)	1038.4 (110.2)	894.04 (344.4)	701.66 (90.2)	1375.0 (176.8)	55.2***	453.1***	9.7***
Marketing costs (CFA/kg)															
Transport cost to buy	10.61 (28.5)	13.56 (32.7)	2.79 (6.5)	6.72 (16.0)	7.38 (17.5)	4.31 (8.3)	24.47 (50.0)	43.54 (61.6)	1.00 (2.4)	2.11 (2.8)	2.95 (2.9)	0.00 (0.0)	4.3**	3.9**	5.8***
Transport cost to sell	14.91 (20.4)	16.13 (21.2)	11.67 (18.3)	16.29 (23.3)	17.03 (23.6)	13.62 (22.5)	10.04 (8.5)	13.59 (10.2)	5.66 (0.4)	17.63 (14.4)	11.83 (5.2)	32.15 (23.3)	1.22	0.21	1.14
Storage cost	2.32 (5.7)	2.29 (2.4)	2.39 (2.1)	2.05 (6.3)	2.08 (7.1)	1.91 (2.1)	1.88 (2.4)	1.07 (2.4)	2.88 (2.2)	7.5 (5.8)	9.00 (6.3)	3.75 (1.8)	1.6+	0.4	1.0
Sort cost	1.69 (2.7)	1.13 (2.4)	3.18 (3.0)	1.57 (2.6)	1.04 (2.3)	3.47 (3.0)	2.07 (2.9)	1.13 (2.4)	3.23 (3.1)	1.71 (2.9)	2.40 (3.3)	0.00 (0.0)	0.4	0.8	2.3*
Hired labour cost	18.94 (30.6)	16.87 (26.1)	24.43 (40.3)	17.77 (28.5)	19.27 (28.7)	12.33 (27.8)	21.05 (36.6)	9.04 (12.3)	35.84 (50.1)	24.88 (33.2)	8.77 (6.9)	65.14 (43.6)	1.6	7.2***	5.2***

Other expenses	8.07	8.12	7.93	8.23	8.25	8.17	6.41	5.69	7.30	12.83	14.07	9.74	0.7	0.1	0.2
	(10.6)	(9.3)	(13.5)	(11.2)	(9.7)	(15.8)	(8.6)	(6.8)	(10.6)	(9.6)	(9.6)	(12.2)			
Margins (CFA/kg)															
Gross margin	101.34	95.18	117.65	99.75	99.68	100.00	88.97	61.25	123.08	172.61	141.66	250.00	8.5***	10.2***	4.6**
	(60.8)	(58.4)	(65.0)	(53.1)	(56.2)	(40.8)	(60.5)	(28.5)	(72.5)	(105.9)	(106.7)	(70.7)			
Net margin	55.42	50.64	68.06	53.84	52.00	60.50	47.51	30.73	68.16	108.06	95.60	139.24	3.8**	3.0*	0.8
	(55.5)	(53.1)	(60.5)	(50.7)	(52.8)	(43.0)	(53.2)	(32.9)	(66.5)	(95.6)	(85.3)	(151.6)			

Note: Mean values are given and their corresponding standard deviations are indicated in parentheses Equality test is the ANOVA.
Significance: *** for 1%; ** for 5%, * for 10%, + for 15%

The different categories of traders are significantly different in characteristics of their transactions including quantities, prices and costs. Traders of gum arabic in the Sylvopastoral zone (SPZ) are significantly different from traders in Eastern Senegal (ES) in quantities (the total quantity and the average quantity per each transaction are higher in SPZ than in ES); buying and selling prices (gum traders in SPZ buy and in turn sell gum at lower prices than traders in ES; and price variations un ES are larger compared to SPZ which could also be due to the fewer number of traders interviewed in ES); unit transport cost to buying within regions (traders in SPZ have a higher cost of transportation per unit to the buying villages and markets than traders in ES); labour cost per unit (traders in SPZ have a lower labour cost per unit than traders in ES); and margins (traders in SPZ have lower gross and net margins than traders in ES).

The above differences across the zones can be explained by the differences in the magnitude of gum collection activities and the nature of gum businesses. Collection of gum has been done in the Sylvopastoral zone for several centuries (Webb, 1985). This zone is easily accessible from Dakar, its main town Linguère is about 260 kilometres from Dakar with a well-built off-season road infrastructure. The cities situated along the road from Linguère to Dakar are also important transaction points for gum trade such as Dahra and Touba where most wholesalers and some exporters are found.

Collection of gum is a recent activity in Eastern Senegal, undertaken following the raised awareness that the region has enormous potential in terms of the presence and productivity of *Acacia senegal* trees (DEFCCS, 2005). However, collection is still done at a very small scale and small quantities are obtained by harvesters. Furthermore, the region is landlocked, situated at about 600 kilometres from Dakar and without proper road infrastructure[7]. Apart from EXPERNA (an association of gum collectors), the other large

[7] The road stretching from the city of Kaolack to Tambacounda (280 kilometres) was only constructed in 2008-2009.

traders operating in ES are found in markets in Bakel and Goudiry. These traders transact with large wholesalers found in the region or in Kaolack.

The presence of EXPERNA seems to lead to higher prices in the region compared to the Sylvopastoral zone because the association bargains better conditions directly with exporters or foreign companies. Traders are forced to match the EXPERNA prices whereas the lack of organisation in SPZ leaves collectors dependent on traders in terms of prices.

Significant differences are also observed within categories of traders across regions with respect to the quantities traded, prices, costs and margins. Figure 4.3 compares prices, costs and margins for the different categories of traders in the gum production zones.

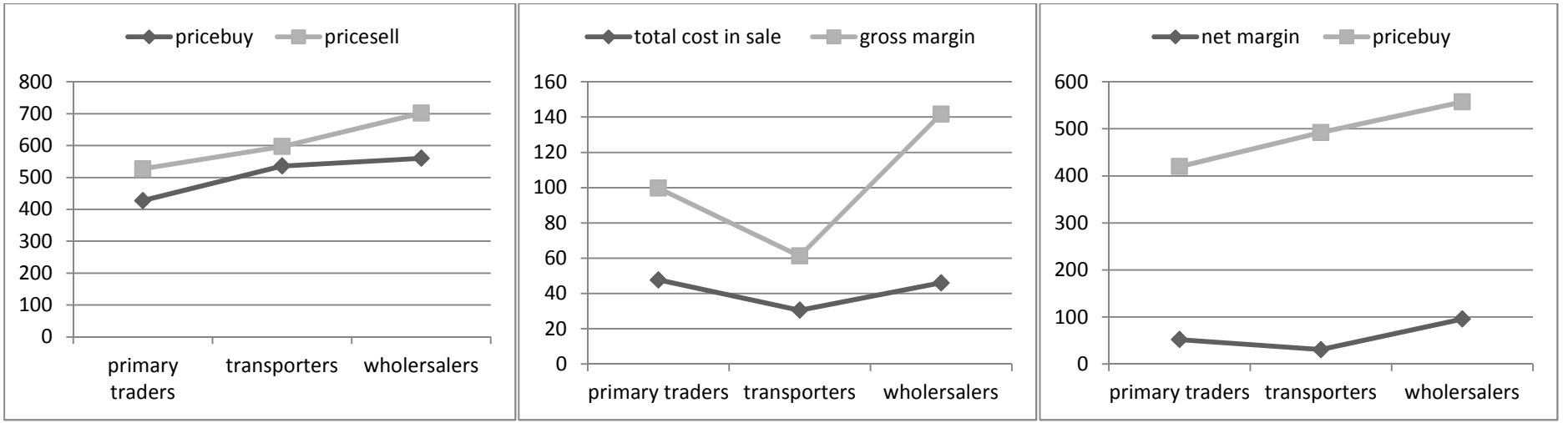

Figure 4. 2a. Prices, costs and margins per categories of traders in the Sylvopastoral Zone

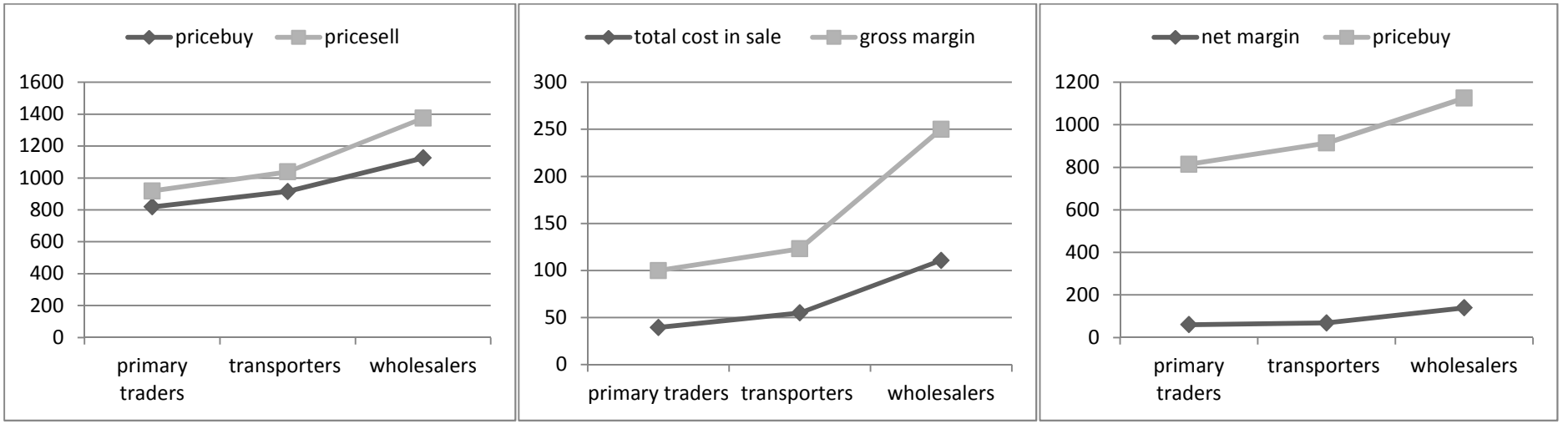

Figure 4. 2b. Prices, costs and margins per categories of traders in Eastern Senegal

In SPZ, the buy and sell prices (p_b and p_s) increase from one category of trader to another. Moreover, transporters buy at the selling price of primary traders; but on average, wholesalers can buy at a price slightly lower than the selling price of transporters. As the quantity increases, the gross margin ($p_s - p_b$) would normally increase and the costs reduce because of economies of scale. The gross margins are lowest for transporters, but so are also their total costs. This enables them to earn a sufficient a margin that is proportionate to the value added. Wholesalers, who have total costs that are almost the same as those of primary traders, have the largest margins.

A comparison of the net margins and the buying price (p_b) shows that on average p_b shifts upward along the different categories of traders and the net margins also increase except for transporters whose net margin is lower.

In Eastern Senegal, the buying and selling prices vary in the same direction from one category of trader to another, and wholesalers can buy at a price slightly higher than the average selling price of transporters. We observe that the total costs and gross margins also increase consecutively for the different categories of traders. However the gross margins are largest for wholesalers. A comparison between the buying price and net margins shows that on average, the real buying price and net margins increase throughout for different categories of traders.

On the market share and Herfindahl index

According to theory, it is expected that traders who operate in oligopsonistic markets acquire gum arabic at a price below the competitive market price. To investigate the presence of oligopsonistic tendencies, market shares for individual traders and the Herfindahl index (H) were calculated following equations (7) to (10) (Table 4.3 and disaggregated results for markets in Table 4A.1 in appendix).

Table 4. 3. Average individual shares and normalised Herfindahl indices in gum markets[a]

	Number of markets	Number of traders	Mean individual share (percentage)	Normalised Herfindahl index
All traders				
All markets	30	124	14.3(12.05)	0.130 (0.12)
Primary traders	21	88	13.2 (11.31)	0.127 (0.14)
Transporters	7	29	16.4 (12.18)	0.135 (0.09)
Wholesalers	2	7	25.0 (19.37)	0.148 (0.00)
Sylvopastoral Zone				
All markets	21	90	13.3 (11.02)	0.132 (0.14)
Primary traders	15	69	12.0 (9.88)	0.129 (0.15)
Transporters	5	16	18.1 (13.35)	0.139 (0.11)
Wholesalers	1	5	20.1 (17.20)	0.148
Eastern Senegal				
All markets	9	34	17.3 (14.42)	0.125 (0.08)
Primary traders	6	19	17.6 (14.83)	0.121 (0.10)
Transporters	2	13	13.3 (9.39)	0.125 (0.03)
Wholesalers	1	2	33.3 (23.57)	0.148

[a] Mean values are given and their corresponding standard deviations are indicated in parentheses.

The shares of individual traders and Herfindahl index of market power vary between markets; while some markets display competitive tendencies, other markets display (strong) oligopsonistic features.

A comparison between the Sylvopastoral zone and Eastern Senegal shows that the average market share of traders in the SPZ is lower than that of traders in ES. Furthermore, the average individual shares of traders are lower in SPZ than in ES except for transporters. The average Herfindahl index of markets in the SPZ is higher than that of markets in ES because this normalised index adjusts for the number of traders which is smaller in ES than in SPZ. Furthermore, the average Herfindahl indices in primary traders' and transporters' markets are higher in SPZ than in ES, while the average Herfindahl index of wholesalers is the same in both regions. As on average the indices are low, we observe the presence of competition or at the most, moderate concentration. In both regions, the Herfindahl index

increases as trading of gum moves along the supply chain: it is lowest in primary markets and highest in wholesale market. This situation is realistic because the move along the chain is associated with fewer and fewer buyers, with relatively ‘stronger’ (oligopsony) power.

In sum, the computations of market power revealed that on average there are no or at the most low oligopsonist tendencies. Yet, it remains important to investigate factors that might influence this market power through the distribution of individual shares of traders.

Individual shares of trader in a market

Market shares express the relative size of the trader’s transactions; these shares vary in accordance to several factors including the market size and the number of buyers. However, the question arises as to why there are wide differences in the computed shares, implying that besides the market size and the number of buyers there are other factors at play. These factors are grouped into trader characteristics and market characteristics (Tables 4.4 and 4.5).

Table 4. 4. Descriptive statistics of trader characteristics influencing market share[a]

	All traders			Primary traders			Transporters			Wholesalers			Equality test[b]		
	Senegal (124)	SPZ (90)	ES (34)	Senegal (88)	SPZ (69)	ES (19)	Senegal (29)	SPZ (16)	ES (13)	Senegal (7)	SPZ (5)	ES (2)	Trader	Region	Region X category
Education (1: formal education)	0.68 (0.04)	0.61 (0.05)	0.85 (0.06)	0.69 (0.05)	0.61 (0.06)	1 (0.00)	0.62 (0.09)	0.63 (0.12)	0.62 (0.14)	0.71 (0.18)	0.60 (0.24)	1 (0.00)	0.6	6.6***	12.1**
Experience in gum business years)	13.0 (9.15)	16.0 (8.63)	4.9 (4.45)	13.2 (9.37)	15.8 (8.88)	3.7 (2.56)	15.0 (1.29)	16.7 (7.44)	6.7 (6.26)	13.4 (10.06)	16.6 (10.38)	5.5 (0.71)	0.6	19.9***	0.2
Wealth (‘000000 CFA livestock value)	5.1 (4.70)	5.4 (4.42)	4.3 (5.37)	4.5 (4.11)	4.6 (3.84)	2.2 (5.06)	5.9 (5.52)	6.8 (4.89)	4.7 (6.24)	9.0 (6.33)	12.0 (4.44)	1.5 (2.18)	1.3+	8.9***	3.5**
Number of houses	1 (0.59)	1 (0.63)	1 (0.50)	1 (0.47)	1 (0.47)	1 (0.45)	2 (0.74)	2 (0.75)	1 (0.60)	2 (0.90)	2 (0.84)	1 (0.00)	3.5**	11.2	6.0***
Family relatives in gum business (persons)	1 (1.06)	1 (1.08)	0 (0.29)	1 (1.13)	1 (1.12)	0 (0.23)	1 (0.86)	1 (0.97)	0 (0.38)	1 (0.53)	1 (0.45)	0 (0.00)	0.4	10.9***	0.7
Languages spoken (language)	2 (0.75)	1 (1.08)	2 (0.63)	2 (0.72)	2 (0.73)	2 (0.71)	2 (0.67)	2 (0.77)	2 (0.48)	3 (0.90)	3 (1.09)	3 (0.00)	4.5**	0.1	0.6
Possession of telephone (1: owns a phone)	0.65 (0.04)	0.66 (0.05)	0.62 (0.08)	0.64 (0.05)	0.61 (0.06)	0.74 (0.10)	0.59 (0.09)	0.75 (0.11)	0.38 (0.14)	1 (0.00)	1 (0.00)	1 (0.00)	4.3*	0.2	9.6*
Operation area (markets)	3 (1.93)	3 (1.97)	2 (1.77)	2 (1.61)	3 (1.64)	2 (1.49)	3 (2.18)	3 (2.30)	2 (2.11)	1 (1.29)	1 (1.74)	1 (0.00)	4.3**	0.6+	0.4

[a] Mean values are given and their corresponding standard deviations or standard errors are indicated in parentheses respectively for continuous variables or categorical variables.

[b] Equality test refers to two-way ANOVA test for continuous variables or Chi-square test for categorical variables.

Significance: *** for 1%; ** for 5%, * for 10%, + for 15%.

Table 4. 5. Descriptive statistics of market characteristics influencing market share[a]

	All markets			Primary			Transporting			Wholesale			Equality test[b]		
	Senegal (30)	SPZ (21)	ES (9)	Senegal (21)	SPZ (15)	ES (6)	Senegal (7)	SPZ (5)	ES (2)	Senegal (2)	SPZ (1)	ES (1)	Trader Category	Region	Region X category
Market size (ton)	34.0 (68.54)	42.5 (78.70)	11.5 (9.53)	16.8 (11.29)	20.4 (10.02)	3.6 (1.13)	30.2 (17.90)	38.5 (40.88)	20 (0.00)	266.3 (160.05)	360.0	32.0	778.2***	1283.8***	570.7***
Buyers (persons)	7 (2.15)	7 (2.09)	7 (2.34)	8 (2.13)	8 (1.90)	7 (2.85)	6 (1.86)	6 (2.50)	7 (0.00)	4 (0.98)	5	3	8.3***	0.6	1.2
Distance to nearest town (km)	54.1 (50.93)	63.3 (51.25)	29.8 (41.80)	64.7 (54.74)	73.6 (52.89)	32.4 (50.14)	33.0 (25.24)	38.4 (20.47)	26.3 (29.58)	8.1 (21.54)	0	285	3.2**	0.3+	2.1+
Distance to Dakar (km)	420.9 (130.45)	351.3 (62.09)	605.5 (68.60)	413.5 (119.57)	360.9 (64.87)	604.8 (62.77)	461.7 (149.57)	338.4 (20.47)	613.5 (80.43)	345.7 (147.41)	260	560.0	3.7**	197.2***	1.0
Storage (1: available)	0.38 (0.04)	0.40 (0.05)	0.32 (0.08)	0.41 (0.05)	0.38 (0.06)	0.53 (0.12)	0.17 (0.07)	0.31 (0.12)	0.00 (0.00)	0.86 (0.14)	1	0.50	12.4***	0.6	18.3***

[a] Mean values are given and their corresponding standard deviations or standard errors are indicated in parentheses respectively for continuous variables or categorical variables.

[b] Equality test refers to two-way ANOVA test for continuous variables or Chi-square test for categorical variables.

Significance: *** for 1%; ** for 5%, * for 10%, + for 15%.

On average the proportion of traders who are educated is smaller in SPZ than in ES; not surprisingly traders in SPZ have longer experience in gum business than traders in ES; in terms of livestock values, traders in SPZ are wealthier than traders in ES; traders in SPZ have more relatives involved in gum business than traders in ES; and the area of operation of traders in the SPZ is larger than in ES.

There are also significant differences in characteristics of traders across different market type. For instance, in terms of livestock ownership value, primary traders are less wealthy especially compared to wholesalers. Primary traders have less relatives involved in the business; wholesalers speak on average 2 languages; the proportion of traders who own a telephone is smallest for transporters; and primary traders operate in most markets. Nevertheless, there are significant differences within categories of traders across regions with respect to education, wealth, house ownership and possession of telephone.

Furthermore, there are significant differences in market characteristics across the zones. Markets in the SPZ are larger as the average quantity transacted is higher than in ES; markets in the SPZ are nearer to Dakar than in ES; and markets in the SPZ are further from towns than in ES. There are also significant differences across market categories. For instance, primary markets are smallest and wholesale markets are largest in size; buyers are most numerous in primary markets and least numerous in wholesale markets; primary markets are located furthest from the town and wholesale markets are located nearest to town; and transporters buy in markets that are located furthest from Dakar. Furthermore, the lowest proportion of transporting markets have adequate storage. Market categories across regions differ with respect to market size, distance to nearest town and availability of adequate storage.

The influence of trader and market characteristics on the trader's individual share in the market are shown in table 4.6.

Table 4. 6. Gllamm results for traders' market shares (percentage)[a]

	All traders			Primary traders			Transporters		
	Senegal	SPZ	ES	Senegal	SPZ	ES	Senegal	SPZ	ES
Education (1: formal education)	3.033+	2.6481+	0.340	3.605+	3.844*	0.038	-2.005	16.391**	8.485***
	(2.301)	(2.398)	(6.273)	(2.455)	(2.015)	(0.505)	(3.922)	(8.235)	(1.846)
Experience in gum business (years)	0.195**	0.154*	0.319	0.290***	0.263**	1.420***	0.341+	0.995**	0.333***
	(0.107)	(0.116)	(0.261)	(0.107)	(0.100)	(0.411)	(0.228)	(0.444)	(0.121)
Wealth (log livestock value)	1.117+	0.198	3.387*	2.310**	1.611*	7.358**	-0.643	0.350	1.882**
	(0.954)	(1.032)	(1.931)	(0.973)	(0.865)	(3.151)	(1.860)	(3.083)	(0.975)
Number of houses (houses)	1.259	3.415*	-1.710	3.762+	3.626+	3.283	4.434+	8.762*	3.646**
	(1.954)	(2.167)	(4.598)	(2.484)	(2.322)	(6.356)	(3.006)	(4.485)	(1.964)
Family relatives in gum business (persons)	0.198	0.325	0.728	1.315*	1.270+	2.304*	-2.900	6.112+	2.825
	(1.222)	(1.080)	(6.931)	(1.063)	(0.881)	(12.978)	(2.771)	(3.912)	(2.433)
Languages spoken (language)	5.475***	5.478***	6.445+	7.154***	7.075***	-4.635	0.237	2.450	13.277***
	(1.500)	(1.520)	(4.634)	(1.516)	(1.322)	(6.868)	(2.979)	(3.939)	(3.216)
Possession of a telephone (1: owns a phone)	6.321***	4.714**	10.465*	4.444**	4.621**	8.987***	10.397***	6.891*	3.034+
	(2.014)	(2.117)	(5.732)	(2.050)	(1.783)	(9.526)	(3.228)	(4.277)	(2.760)
Area of operation (markets)	0.070	0.104+	1.709+	1.112**	1.405***	0.316	0.222	-0.871	0.235
	(0.502)	(0.514)	(1.663)	(0.503)	(0.335)	(2.103)	(0.754)	(2.001)	(0.913)
Market size (ton)	-0.023	-0.021	0.158	0.313**	0.278+	5.685*	0.143+	0.138+	-0.025
	(0.017)	(0.017)	(0.284)	(0.133)	(0.117)	(3.274)	(0.121)	(0.138)	(0.402)
Buyers (persons)	-0.980**	-0.762+	-0.101	-1.261**	-1.298**	-0.936	-1.117*	-0.340	-0.004
	(0.479)	(0.535)	(1.488)	(0.504)	(0.539)	(1.701)	(1.158)	(1.484)	(0.867)
Distance to nearest town (km)	0.049*	0.033	0.171*	0.093***	0.059	0.429*	0.232**	0.382	0.002
	(0.029)	(0.081)	(0.081)	(0.034)	(0.069)	(0. 980)	(0.103)	(1.327)	(0.343)
Distance to Dakar (km)	-0.048**	-0.045	-0.011	-0.071***	-0.047	0.158*	0.155***	0.002	0.030
	(0.022)	(0.067)	(0.049)	(0.026)	(0.055)	(0.092)	(0.055)	(0.613)	(2.621)

Storage (1:available storage)	5.529*	2.266*	8.877*	1.876	3.327+	14.959**	0.205	6.056	5.924***
	(2.355)	(2.725)	(4.302)	(2.631)	(2.590)	(6.151)	(3.798)	(6.498)	(2.070)
Zone (1:ES)	18.390***			28.266***			-34.015**		
	(6.914)			(9.172)			(14.834)		
Constant	-4.206	12.824	-56.530	-8.296	-3.065	-235.580	-56.018*	-44.812	65.900
	(16.618)	(24.333)	(56.203)	(17.141)	(20.116)	(50.545)	(33.858)	(18.398)	(16.726)
F	3.39***	2.53***	1.80+	4.68***	3.84***	1.54+	1.47*	0.83+	2.18+
Adjusted R-squared	0.202	0.171	0.225	0.355	0.334	0.248	0.179	0.138	0.470
Number of traders	124	90	34	88	69	19	29	16	13
Number of markets	30	21	9	21	15	6	7	5	2
Variance at traders' level	108.708	90.573	103.349	78.789	50.862	82.586	55.660	56.803	5.309
	(13.809)	(13.502)	(25.071)	(11.879)	(8.659)	(26.795)	(14.619)	(20.058)	(2.082)
Variance at market level	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.0001)	(0.000)	(0.0001)	(0.0001)	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)

[a] Standard errors are in parentheses.
Significance: *** for 1%; ** for 5%, * for 10%, + for 15%

The results show a large variance at the traders' level but a close to zero variance at the market level. Pooled over all types of traders, the market share of an individual trader is positively influenced in a significant way by education, experience in gum business, wealth in livestock value, knowledge of languages and possession of a telephone that is used to gather market information; these possibly refer to communication and negotiation skills. A large number of buyers operating in a market has a negative effect on the individual market share. Traders' individual market shares evolve with increased physical distance of the market from the town, and better availability of storage facilities. But the longer the physical distance of the market from Dakar, the smaller is the trader's individual market share; this would be the effect of primary markets in SPZ. Furthermore, the regional dummy indicates that individual market shares in Eastern Senegal are larger than shares in the SPZ.

Specifically for traders in SPZ, the individual market share is positively influenced by education, experience in gum business, his wealth in number of houses possessed, knowledge of languages, possession of a telephone that is used to gather the market information, and area of operation. The lower the number of buyers who operate in a market and the better the availability of storage facilities in a market, the larger would be the trader's individual market share. Specifically for traders in ES, the individual market share is positively influenced by wealth in value of livestock owned, knowledge of languages and possession of a telephone that is used to gather the market information, and the area of operation. The longer the distance to the nearest town, the larger would be the trader's individual market share.

Variables that have a positive influence on the market share of an individual traders in primary markets are education, experience in gum business, and access to funds as represented by the wealth in livestock value owned and house possessed, family network in business, knowledge of languages, possession of a telephone, area of operation, size of the market and distance to nearest town. The variables that have a negative influence are the

number of buyers who operate in a market and distance of the market from Dakar. Furthermore, the regional dummy indicates that individual market shares in ES are larger than shares in the SPZ in primary markets. Within these primary markets, the influential determinants may differ in the SPZ than ES.

Variables that have a positive influence on the market share of an individual traders in transport markets are experience in gum business, access to funds as represented by the houses possessed, knowledge of languages, possession of a telephone that is used to gather the market information, the size of the market, distance to nearest town, distance to Dakar and availability of storage. The number of buyers who operate in a market has a negative influence on the market share. Furthermore, the regional dummy indicates that individual market shares in ES are smaller than shares in the SPZ in transport markets. Also within these transport markets, the influential determinants differ between the SPZ and ES.

The significant influence of variables vary within markets or zones, and even if data set was not large enough to elicit the determinants of wholesalers' market shares, the results above enable us to substantiate that all in all there is positive influence of education and business experience of the trader (these factors can be designated as human capital); access to funds represented by ownership of livestock or houses (financial capital); the network of relatives who are also involved in gum business (social capital); information accessibility represented by the number of languages spoken and telephone ownership (communication capital); and area of operation (physical capital). Market characteristics such as market size and availability of storage have a positive impact on the individual market shares whereas competition over transactions indicated by the number of buyers reduces the market share. If the market is physically located far away from town, it might attract only a few buyers and hence lead to large individual shares in the market. Primary traders who are located nearer to Dakar have larger individual market shares. Transporters who are located further away from

Dakar have larger individual market shares. The latter can be explained by the function of transporters.

Interpretation on the accession to gum arabic markets

The relatively low levels of concentration of market power observed in gum arabic markets might be an indication of free entry in these markets. However, in some markets high entry requirements are set implying that there may be barriers restricting market accession and expansion within the market or expansion of the area of operation. Such barriers determine not only the structure of the market but also the performance of the market actors. Here, we re-interpret determinants of the market share distribution in terms of factors influencing market accession bearing in mind that the importance of such factors varies along stages of the gum supply chain.

Market accession may be influenced by access to capital: (1) human capital: while education might be or not always be important in starting a gum business, at least some experience in general business is a prerequisite as an indication of the skills to transact in gum markets; (2) financial capital: with difficulties to access credit especially in rural areas, the backup of own (old) capital is needed to start or expand the business; (3) social capital: most gum business are families directly or indirectly supported by a system of networks of family relatives. These networks serve not only the purpose of information provider but can also act as transaction partners; (4) communication capital: information systems play an important role in determinant market shares. Such information systems pertain to the markets, prices and gum-transaction related conditions. and (5) physical capital. Other influences of market accession may include geographical barriers reflected by distances to towns or Dakar. These barriers imply that there are high transport costs which are intensified by missing roads or the generally bad conditions of rural roads. As the gum producers are dispersed, extending the area of operation may be very difficult for a trader. Furthermore, legal requirements must be

fulfilled in order to start and register the business in terms of start-up capital and further fiscal duties (AEPC, 2007). These requirements may be difficult to achieve for individuals and even companies.

Marketing margins

Computations of the market power revealed no or at the most low oligopsonist tendencies. This would imply that little evidence is found for oligopsonistic margins while determining their buying prices. We explored, at the market level, whether the margins observed are associated with market power and found no correlation between the margins and market power.

The net margins as proportions of selling price are 17.3, 9.6 and 18.5 per cent in primary, transporting and wholesale markets respectively. The above margins were compared to margins earned in other markets for agricultural inputs or products, or for non-timber forest products. For instance, in the yellow maize market of Mozambique, Zucula and Massinga (1993) found that net margins ranged from 8.3 to 19 per cent of the total price for the retailers; in the fertilizer market in Uganda, Omamo (2003) found that retail margins ranged from 5 (in Bukedea) to 28 per cent (in Kabale); in the market of non-timber forests in Cameroon, Ndoye et al. (1998) found that the marketing margins obtained by traders varied between 16 per cent for African pear (*Dacryodes edulis*) and 30 per cent for wild mangoes (*Irvingia spp.)* of the value of sales; in the market of frankincense in Tigray, Kassa et al. (2011) found that the wholesalers earned marketing margins of 41.1 per cent and 31.4 per cent in 2007 and 2010 respectively. This comparison implies that the margins earned by traders in the gum arabic sector are not as excessive as in the comparison cases, and these traders might hence not just be labelled as exploitative.

Even if the exercise of market power by buyers could not be confirmed, the question remains as to why these margins are large, at least in some markets, even larger in comparison

to the costs involved in trade. The reason might be that these margins depend on the supply conditions prevailing in the market but also on the need to cover for the uncertainty associated with volatility in the gum price or quality variations and the risk involved in trade either at the individual or market level. We investigate the influence of such sale costs, price uncertainty and risk on the gross margins. Table 4.7 presents these factors' descriptive statistics. A Breusch-Pagan test for heteroskedasticity rejected the null hypothesis of constant variance ($\chi^2(1)$ = 15.13***); the weighted least square regression is used to correct for this heteroskedasticity, analytical weights are used with the total cost as the weight variable (the weight is equal to inverse of squared total costs). Table 4.8 presents the regression results for determining the gross margins.

Table 4. 7. Descriptive statistics of trade characteristics influencing gross margins[a]

	All traders			Primary traders			Transporters			Wholesalers			Equality test[c]		
	Senegal (124)	SPZ (90)	ES (34)	Senegal (88)	SPZ (69)	ES (19)	Senegal (29)	SPZ (16)	ES (13)	Senegal (7)	SPZ (5)	ES (2)	Category	Region	Region X
Gross margin (CFA/kg)	101.34 (60.85)	95.18 (58.40)	117.65 (65.00)	99.75 (53.09)	99.68 (56.25)	100.00 (40.82)	88.97 (60.55)	61.25 (28.49)	123.08 (72.50)	172.61 (105.93)	141.66 (106.72)	250.00 (70.71)	8.5***	10.2***	4.6**
Total marketing costs (CFA/kg)	45.62 (39.73)	44.54 (35.86)	49.59 (48.95)	45.91 (37.66)	47.68 (39.17)	39.50 (31.68)	41.46 (43.27)	30.52 (15.30)	54.92 (61.00)	64.55 (50.54)	46.06 (26.44)	110.76 (80.92)	2.2+	4.7**	3.4**
Distance to sell (km)	47.7 (83.36)	43.0 (64.08)	60.0 (120.9)	46.6 (89.54)	33.7 (58.30)	93.3 (151.6)	32.3 (42.29)	52.9 (43.92)	4.5 (15.76)	124.7 (98.85)	132.6 (119.47)	105.0 (21.21)	3.7**	0.1	5.0***
Price uncertainty (CFA/kg)[b]	-13.77 131.45)	-13.77 136.30)	32.69 (119.6)	-13.77 (109.8)	-13.77 (102.4)	50.00 (136.4)	-34.61 (191.7)	-21.87 (243.9)	-34.61 (106.8)	0.00 (89.44)	70.00 (109.54)	0.00 (0.00)	1.2	0.3	3.1
Idiosyncratic risk (1:recognised)	0.56 (0.50)	0.69 (0.46)	0.21 (0.41)	0.59 (0.49)	0.70 (0.46)	0.21 (0.42)	0.41 (0.50)	0.62 (0.50)	0.15 (0.37)	0.71 (0.49)	0.80 (0.45)	0.50 (0.71)	3.5+	23.3***	24.7***
Systemic market risk (1:recognised)	0.52 (0.50)	0.51 (0.50)	0.56 (0.50)	0.46 (0.50)	0.46 (0.50)	0.47 (0.51)	0.76 (0.43)	0.81 (0.40)	0.69 (0.48)	0.29 (0.49)	0.20 (0.45)	0.50 (0.71)	9.2***	0.2	10.1*

[a] Mean values are given and their corresponding standard deviations or standard errors are indicated in parentheses respectively for continuous variables or categorical variables.

[b] Median value is given for the price uncertainty variable because the mean value is 0.

[c] Equality test refers to two-way ANOVA test for continuous variables or Chi-square test for categorical variables.

Significance: *** for 1%; ** for 5%, * for 10%, + for 15%.

Table 4. 8. Weighted least square regression results for traders' gross margins (CFA/kg)[a]

	All traders		Primary traders		Transporters	
	Senegal (124)	SPZ (90)	ES (34)	Senegal (88)	SPZ (69)	Senegal (29)
Total costs	1.060***	1.202***	0.774+	1.112***	1.120***	-0.187
	(0.314)	(0.389)	(0.632)	(0.415)	(0.536)	(2.104)
Total costs squared/200	-0.412*	-0.670*	-0.082	-0.652***	-0.721**	0.559
	(0.327)	(0.451)	(0.558)	(0.595)	(0.815)	(5.495)
Distance to sell (km)	0.109+	0.143**	0.033+	0.037+	0.072+	0.631***
	(0.077)	(0.094)	(0.057)	(0.041)	(0.108)	(0.182)
Price uncertainty (CFA/kg)	0.015	0.036+	-0.024	-0.016	-0.000	0.033+
	(0.036)	(0.041)	(0.132)	(0.056)	(0.071)	(0.039)
Idiosyncratic market risk (1:recognised)	25.733**	18.305+	31.842	33.141**	32.394*	5.395
	(12.950)	(14.240)	(45.628)	(16.378)	(19.356)	(20.025)
Systemic market risk (1:recognised)	27.111**	14.298+	41.841*	30.211**	30.832*	21.760+
	(11.031)	(13.879)	(22.771)	(13.918)	(17.872)	(23.559)
Zone (1:ES)	29.567**			18.845+		88.514***
	(13.717)			(13.640)		(25.189)
Constant	18.363*	25.734	49.290*	20.708	16.992	8.058
	(17.592)	(21.323)	(29.459)	(21.950)	(27.566)	(50.681)
F	5.47***	3.00***	3.16***	4.05***	3.54***	3.95***
R-squared	0.315	0.286	0.397	0.307	0.309	0.583

[a]Analytical weights are used. The weight variable is the total costs.

Robust standard errors with corrected heteroskedasticity are in parentheses.

Significance: *** for 1%; ** for 5%, * for 10%, + for 15%

As mentioned above, traders in ES earn a higher gross margin than traders in SPZ; the gross margin is highest for wholesalers. The cost of selling gum is lower in SPZ than in ES, while the concern for individual risk is indicated by a higher proportion of traders in SPZ than in ES, and the concern for market risks is more pronounced among traders in ES.

There are also significant differences in characteristics of trade across different market types. For instance, transporters have the lowest cost of selling gum especially compared to wholesalers; the distance to sell is lowest among transporters and highest among wholesalers; the proportion of traders who indicated concern for individual risk is lowest with transporters and highest with wholesalers; and the proportion of traders who indicated concern for market risk is highest with transporters and lowest with wholesalers. Furthermore, there are significant differences within categories of traders across regions with respect to cost of selling gum, distance to sell, and concerns for individual and market risk.

In general and specifically in SPZ, the gross margin will increase with price uncertainty, distance to sale place and concerns for individual and market risk. The gross margin also increases with the costs however at decreasing rate. In ES, larger margins are typically retained than in SPZ. Specifically in ES, longer distance to sale and higher concerns for individual and market risk significantly increase the need for retaining larger margins.

Gross margins for traders in primary markets and specifically in SPZ are positively influenced by distance to sale, concerns for individual and market risk, and costs. Primary traders in ES retain larger margins; the most influential factor for these traders is market risk.

Gross margins for transporters are positively influenced by the distance to sale, price uncertainty, and concerns for individual risk. These margins are a decreasing function of cost involved in selling. In the SPZ, the significant variables influencing gross margins are price uncertainty, distance to sale, and concerns for individual and market risk. Transporters in ES

retain larger margins; the most influential factors for these traders are the distance to sale, and concerns for market risk.

Influential factors could not be determined for wholesalers. However, the analysis suggests that gum traders retain margins due to high marketing costs, long distances to sale, high price uncertainty, and higher perception of idiosyncratic and systemic market risk. According to the traders during the interviews, marketing costs in the gum arabic are high due poor infrastructure and inefficient transport system, and lack of market information. Trade in markets involves a lot of price uncertainty and high risks especially in terms of regularity of supply that can be associated with production failure, finding a market, and inability or high costs of enforcing contract. These factors make trade in gum arabic not only costly but also very risky and due to risk averseness, traders retain higher margins.

Interpretation on the exit from gum arabic markets

We did not interview traders who withdrew from gum trade. However, the analysis of factors influencing the traders' margins enables us to reflect on potential causes of exit of traders from gum arabic markets. Therefore, we re-interpret the determinants of the gross margins in terms of factors influencing market exit bearing in mind that the importance of such factors varies along stages of the gum supply chain.

Market exit results from the unprofitability of business: for the pooled data, the fixed cost was estimated at 45 CFA per kilogram of gum arabic bought (less than 10 per cent of the buying price); hence it is not excessively high to drive a trader out of business. The infrastructural problem as reflected by the distance and the uncertainty could lay some strain on the trader's profitability; and the importance of risk is certainly noticeable. In the systemic context, supply shortages may be the main causes of exit: if there are recurrent production failures, traders may move out of the gum arabic sector and invest their time and money elsewhere; the low production levels implying large variable costs may cause losses to traders

especially if they cannot negotiate higher selling prices. On an individual level, the risk of contract defaulting is important especially at the primary trading level: a trader who has offered commodities or funds to be reimbursed by the supply of gum in an interlocked system is often deceived by the collector who side-sells his product to another buyer (DEFCCS, 2005). Such repetitive defaults may seriously jeopardize the trader's profitability as he may even need to incur some cost to enforce the contract if at all he wants to stay in business.

4.5 Discussion and conclusions

This study investigates the behaviour and performance of gum traders in the oligopsonistic market for gum arabic in Senegal. Oligopsonic markets are characterised by a small number of buyers who face a relatively larger number of sellers; this is a situation that is often observed in the marketing of raw agricultural or forest products in developing regions and specially in the rural areas where accessibility to the production zones, high transaction costs and various other barriers significantly restrict entry and expansion of traders. Institutions such as associations/cooperatives or contracts which could change the structure of markets in such a way that buyers and sellers get equivalent market power, are often missing in these areas. Oligopoly markets for the supply of consumable products have received attention; however, despite that the oligopsonist situation is commonly observed on the production side, it seemed not to have caught the interest of researchers who at times merely confirmed the common belief that traders are exploitative. Such idea of exploitation is usually associated with the fact that even in markets where traders could act competitively, they would choose to collude or excessively exert their market power in order to bring down the price.

As oligopsonies are observed at the consecutive levels of the supply chain, the tendencies to drive-down the buying price result in lowering the transaction volumes and total margins of the chain. These tendencies hence cause a double/multiple marginalisation problem. Furthermore, a formal profit maximisation model shows that a firm involved in

oligopsony markets is directly linked to the actions of the competitors and suppliers. These principles form the theoretical basis for the current study.

After classifying traders in the gum business into primary traders, transporters and wholesalers, we found that these categories of traders are significantly different in the characteristics of their transactions. A comparison of buying and selling prices, various marketing costs and derived margins show that the wholesalers earn the highest margins along the gum supply chain while the transporters earn the lowest margins. Wholesalers benefit from the wide deviations between the buying and selling price, and hence earn high gross margins. Furthermore, as the wholesalers transact with large quantities, their unit costs remain relative low which lead them to even higher net margins. This cost situation remains a problem to the business of primary traders because even if they can earn large margins, transacting small quantities entails high unit costs which lead them to low net margins and little payment to gum collectors. More specifically, this may explain the slow market development in Eastern Senegal: because of low production capacity in region, the unit cost remains high for all categories of traders specially in terms of labour and transport as the region is also constrained by problems of accessibility and remoteness. Fafchamps and Gabre-Madhin (2006) and Kwoka (1977) also found that the larger traders or firms can earn higher margins. The same conclusion also applies by considering the buying circumstances: primary traders need to get their supplies in visiting dispersed villages with scattered collectors that each sell small quantities, transporters need to visit several markets in the production zones to obtain gum from the primary traders, and wholesalers just generally remain established in their own shops and are supplied by transporters, hence with lower marketing costs and risks.

Investigations of whether the performance of the traders was driven by their relative power in the market started with the calculation of the market shares of traders and the Herfindahl index. Within the markets, there are variations in the shares of individual traders

and between markets there are variations in the values of the Herfindahl index. These values generally increase from primary traders to transporters and wholesalers implying that the upward move along the chain leads to higher market power and stronger oligopsonistic tendencies. We found that the share of a trader in a market is influenced by several factors that can be grouped into the elements of capital: human capital (experience in business and the possibility to communicate); financial capital (possibility to make available funds to be used in trade); physical capital (area of operation); and social capital (a network of relatives involved in business who can act as source of information and knowledge, and possibly as transaction partners). Fafchamps (1996, 1999, 2002, 2006), Fafchamps and Minten (2000) and Fafchamps and Gabre-Madhin (2006) had also found that traders rely extensively on such networks as relationships increase trust by granting and receiving credit, exchanging price information, and economizing on quality inspection thereby reducing transactions costs and increasing trading margins. At market level, its size and the availability of storage increase the trader's individual market share whereas competition over transactions indicated by the number of buyers reduces the market share. While this share can be increased by expansion of trading area, barriers due to capital constraints and the legal framework may be significant. Capital and market factors could also be the main cause of market accession.

Computations of market power showed that there were no or very small oligopsonistic tendencies in the gum arabic market. Market power was not found to influence the margins earned by traders. Rather these margins seem to depend on the supply conditions, marketing costs, perception of price uncertainty and risk. According to Harris-White (1997) or Batt (2004), shortcomings associated with poor infrastructure and inefficient transport system, and lack of market information increase marketing costs. Brorsen et al. (1985), Schroeter and Azzam (1991) and Holt (1993) found that price uncertainty and risk indeed influence the marketing margins. The magnitude of risk could also be the main cause of market exit.

These findings imply that traders in the gum market, while working towards enlarging their supplies do not follow the oligopsonistic tendencies or exercise their power in an exploitative manner. Such exploitation on the seller would constrain supply and profits for the whole chain because the buying price is kept artificially low. Instead, the margins that traders keep are a reflection of the costs, uncertainty and risk that they face while conducting their trade. The study has therefore shown that traders are not necessarily exploitative in terms of using their market power towards producers in the primary markets or other traders in the intermediate or wholesale markets; they may pay a low price because they face risk and uncertainty, and high costs, especially if they are not able to exploit scale economies. In other words, the benefits that they could obtain from gum trading may be limited by poor market access conditions such as poor transportation conditions, lack of infrastructure and market information in addition to individual and market related risks. Our results show interesting similarities on the performance of rural money lenders who act as a source of informal rural credit. While they are often accused of being usurious by charging high interests, their returns can be justified by their methods of screening borrowers and enforcing repayment in the presence of imperfect information (Aleem, 1990; Hoff and Stiglitz, 1995). The study has also served to remind about the important functions of rural traders in general and of the gum traders in particular in regard to the gum sector despite the difficult marketing conditions.

Appendix 4A.

Table 4A.1. Average market share and Herfindahl index per market and category of trader[a]

Market	Primary traders		Transporters		Wholesalers	
	Individual share (percentage)	Herfindahl index	Individual share (percentage)	Herfindahl index	Individual share (percentage)	Herfindahl Index
Sylvo pastoral zone						
Barkédji	10.0 (19.612)	0.590	10.9 (10.461)	0.142		
Dodji	12.5 (6.442)	0.080	25.0 (5.555)	0.018		
GuèyeKadar	16.7 (11.758)	0.166				
Kamb	20.0 (11.566)	0.094				
Linguère	14.3(5.735)	0.039	20.0 (14.789)	0.197		
Labgar	10.0 (10.886)	0.119	20.0 (9.577)	0.058		
Linde	12.5 (8.102)	0.053				
Louguéré Thioly	14.3 (6.552)	0.065				
Nakara	12.5 (6.665)	0.053				
Ndiayène Fouta	11.1 (4.689)	0.021				
Ranérou	11.1 (6.978)	0.062				
Thiel	10.0 (6.632)	0.044				
Vélingara	6.7 (2.801)	0.014	20.0(21.683)	0.281		
Widou	14.3 (10.132)	0.164				
Yaré Lao	16.7 (19.367)	0.372				
Dahra					20.1 (17.200)	0.148
Average SPZ	*12.0 (9.875)*	*0.129(0.155)*	*18.1 (13.355)*	*0.139 (0.107)*	*20.1 (17.200)*	*0.148 ()*
Eastern Senegal						
Bala	16.7 (20.711)	0.258	14.3 (10.814)	0.100		
Brifal	20.0 (1.863)	0.002				
Gabou	14.3 (9.196)	0.092	12.5 (8.622)	0.149		
Goudiry	10.0 (6,9526)	0.048				
Kadiel	33.3 (17.271)	0.119				
Séno Youpé	33.3 (26.305)	0.208				
Tambacounda					33.3 (23.575)	0.148
Average ES	*17.6 (14.827)*	*0.121 (0.096)*	*13.3 (9.389)*	*0.125 (0.035)*	*33.3(23.575)*	*0.148 ()*
Senegal						
Average	*13.2(11.307)*	*0.127 (0.139)*	*16.4 (12.184)*	*0.135 (0.088)*	*25.0 (19.367)*	*0.148 (0.000)*

[a]Standard deviations are in parentheses

Quality of gum arabic in Senegal: linking the laboratory research to the field assessment

Abstract

This chapter links the field assessment of gum quality based on visible attributes of gum to chemical analyses based on invisible attributes of gum with a purpose of finding links in the definition of gum quality by collectors and traders on the one hand and by users on the other hand. We find that good quality as defined by collectors and traders is not always good when measured in the laboratory; however, an opportunity to increase good quality on the field increases the likelihood of obtaining chemically good gum. Furthermore, we investigated determinants of quality supply in terms of two attributes of visual inspection namely the size and cleanliness of gum nodules, the latter is especially the basis for obtaining chemically good gum. Quality is determined by several factors on which the collector has no influence including the selection of tree species, edaphic conditions and climatic factors. However, quality maintenance and improvement can be positively influenced by harvest and post-harvest practices and participation in trainings that sharpen good practices, the behaviour and experience of traders, and price expectations especially if these expectations are related to tree management.

Keywords: ordered logit, gum arabic, quality, marketing

5.1 Introduction

Gum arabic is widely used in food and non-food industries where it functions as an emulsifier, stabilizer, thickener, flavouring or coating agent (Wickens et al., 1995; Nussinovitch, 1997; Verbeken et al., 2003; ITC, 2008). These functions are associated with certain quality requirements fulfilled by gum properties such as absorption, tastelessness, odourlessness, solubility, viscosity and rheological behaviour (Glicksman, 1969). According to Chikamai and Odera (2002), these properties are determined by several factors including

the botanical sources of *Acacia senegal* trees, tapping methods and harvesting period, soil conditions and climatic factors.

Gum arabic, similar to agricultural and other non-timber forest products, possesses both intrinsic and extrinsic quality attributes. According to van Boekel (2005) and Luning and Marcelis (2009), intrinsic quality attributes are physically linked to the product while extrinsic quality attributes do not necessarily have a direct relationship with the product properties but can affect the users' quality perception or the product's acceptance. Extrinsic attributes of forest products include for instance being organically or sustainably collected. As gum arabic is not directly consumed but just an ingredient in processing, the extrinsic quality aspects may be less important in trade; hence, these attributes are not the emphasis of our current study. Rather, we focus on intrinsic physical attributes. These attributes may be visible such as the gum size and fullness or hardness of its nodules, its colour, and cleanliness; or invisible such as the gum's chemical composition. While certain attributes are permanent, others may be changed intentionally (e.g., through post-harvest cleaning) or unintentionally through the product's interaction with the environment (e.g., as the gum matures or dries, it can change colour).

The visible quality attributes are not the only determinant in gum trading, but, they are important for grading the gum in absence of any more sophisticated method. Grading is important because it helps in targeting markets which are undersupplied, in finding market niches suitable to different uses, or in awarding price premiums. These premiums could reflect the costs of all efforts in cleaning, sorting and supplying top quality gum. The sum of gains of graded gum is supposed to be higher than what the collector would be paid for bulk gum. Factors influencing quality attributes need to be well understood if a grading system has to be maintained or improved. These influencing factors are human (such as collectors' harvesting practices and involvement in post-harvest activities); environmental (such as soil

conditions or climate variability which are different from region to region); or market development (such as price premiums, costs, and users' demands).

In this chapter, our aim is to investigate the factors that contribute to the current supply of quality by gum collectors. In the first instance we analyse the relevance of the quality assessment by collectors and primary traders as compared to the users' requirements that are measurable by laboratory tests. It is important to establish a link between the field and laboratory assessment of quality because even if these two sides may talk a different language, they should converge to the same meaning of quality such that collectors may indeed supply what is needed by users and thereby benefit from the maintenance and improvement of such quality. Such a link will also pave ways for small gum producing countries to establish a grading system which is not just based on the distinction of different species (e.g., gum from the *Acacia senegal* is hard, while gum from *Acacia seyal* is flaky) or different varieties within a species (e.g., *Acacia senegal var. senegal* found in Sudan and Senegal vs. *Acacia senegal var. kerensis* found in Kenya), but a distinction of quality grades within a certain variety itself. Second, we empirically analyse determinants of quality attributes namely the size and cleanliness of gum nodules using a dataset constructed through monitoring of quality supplied by collectors throughout the gum collection season of 2009-2010 in 16 markets in the Sylvopastoral Zone and Eastern Region of Senegal. This monitoring followed a training conducted at the beginning of the collection season which aimed at sensitizing collectors on good practices for quality improvement and maintenance.

In the next section we introduce the definition of quality and its relevance, and then specify the aspects of quality of gum arabic. The section is followed by the methodology and subsequently results are presented. In the last section we discuss these results and present conclusions.

5.2 Quality definition and relevance

Quality is generally defined as a measure of excellence. It is a widely used concept that however remains abstract and complex. In production, quality is a state of being free from defects and significant variations, brought about by the strict and consistent adherence to measurable and verifiable standards to achieve uniformity of output that satisfies specific user requirements (Dale et al., 1997). In business, quality of the goods and services refers to the creation of customer satisfaction and is one of the elements that contribute to profitability (Evans and Lindsay, 2005).

Evans and Lindsay (2005) distinguished five perspectives from which quality is considered. These are: (1) judgemental perspective of considering quality as absolute and universally recognisable; (2) product-based perspective with quality as a function of specific measurable variables of the product; (3) user-based perspective that considers the product performance within its intended function or use; (4) value-based perspective that takes into account the relationship between the product usefulness to its price; and (5) manufacturing-based perspective where quality is considered as conformance to manufacturing specifications. The first four perspectives are important for gum arabic.

However, it should be recognised that the meaning of quality is not static but evolves through time and depends on the people involved in the supply chain. For instance, producers might put emphasis on agronomic practices (seeds, disease resistance) while distributors might focus more on storage conditions (shelf-life, little waste); the ultimate aim is that the end-user/consumer is satisfied (Ruben et al., 2007). Variations in quality perspectives imply that from producers to users through traders and distributors, there might different measures and rewards of quality.

Quality has several attributes. On the one hand, in the introduction, a division between intrinsic and extrinsic quality attributes of a certain product was suggested. Van Boekel

(2005), Ruben et al. (2007) and Luning and Marcelis (2009) explain that intrinsic attributes are physically inherent to the product while extrinsic attributes are not directly a physical property of the product. Intrinsic attributes can be noticeable by sensory observation and are the result of physicochemical and other properties of a product. Examples of intrinsic attributes include texture, taste, protein content or microbial condition. Extrinsic attributes can affect the consumer's quality perception or the product's acceptance. Examples of extrinsic attributes include religious rules, organic production, or brand name which can influence the consumers' quality perception or products' acceptance. On the other hand, Fafchamps et al. (2008) suggested that a product's quality is determined by both observable (e.g., colour, size, shape) and non-observable attributes. In their research of non-staple food markets in India, they concluded that observable attributes formed the basis for rewarding producers with a price premium associated with drying, grading, and packaging the crops whereas agricultural practices (irrigation, usage of seeds, or the application of pesticide) did generally not influence the price.

The reward for quality is associated with the fact that even if quality may be seen as an attribute of the product, it has its own cost and price. Tollens and Gilbert (2003) explain that buyers and sellers trade higher or lower quality products depending on the quality premium; in other words, quality is determined by the interaction between the demand for quality and the quality level that producers seek to provide. Hence differences in price are normally associated with quality differences; these differences may even be translated into well-defined grades (Fafchamps et al., 2008).

Quality is not only used to obtain high prices; according to Alexiades and Shanley (2004), producers can choose to supply high quality products in order to access and maintain position in high-value markets. Evans and Lindsay (2005) confirmed that quality is an important source of competitive advantage generating higher returns on investments and

increased market share. However, achieving top quality is not costless because quality needs appropriate technology, which may be simple, but costly in labour and time. Furthermore, especially in context of international trade, compliance with (more strictly enforced) standards and food safety control systems can be difficult to manage or prohibitively expensive in particular for small exporters. The consequence of investing in quality may be the reduced short-run profitability but in the long-run such investments and related improved capacities and awareness lead to improved profitability (Henson and Jaffee, 2006; Belcher and Schreckenberg, 2007).

The positive relation between price and quality is assumed to be the norm implying that if the higher quality is not rewarded by a higher price, there are no incentives to improve quality. However, if the relation between quality and price is not explicit, there may be cases where rising prices result in poor or declining quality of the product. For instance, in the forestry sector, Martinez et al. (2007) found that in the market of Linaloe (*Bursera aloexylon*) used for wood, increased competition led to increased levels of extraction of the linaloe resource even before maturity thereby leading to low wood quality; Neumann and Hirsch (2000) report that in Nepal, when buyers pay according to weight regardless of quality, harvesters of non-timber forest products supply without selecting quality products (quoting Edwards, 1996) or increased competition leads to harvesting of low-quality immature seeds of timur (*zanthoxylum armatum*) because there is a strong incentive to harvest any seeds before a competitor does (quoting Rawal, 1995). The reason for this negative relation between price and quality is associated with the nature of resource tenure especially for forest products. In private and community-managed forests where competition is regulated, the quality is much better whereas in open-access forests where the ‘first come, first serve’ rule operates, insecure tenure over collection areas leads to risk of over-exploitation and inability to manage the quality (Belcher and Schreckenberg, 2007). Furthermore, quality cannot be rewarded due to

low bargaining power of rural producers. Especially of these non-timber forest products, collectors are often at a disadvantage in marketing their produce because they produce small volumes of inconsistent quality. They sell their ungraded products to traders who, if they invest in clean and post-harvest storage, reap the benefits of selling the product in graded categories (Enriquez et al., 2006).

Gum quality has intrinsic and extrinsic quality attributes, of which some are visible. Problems with quality are that gum arabic may sometimes be mixed with other types of gums to increase weight, harvested immaturely to get it off the tree before other collectors, un-cleaned of its impurities, dried or stored improperly, and not graded (Seif el Din and Zarroug 1996; DEFCCS, 2005). Such problems make that quality of gum supplied is neither reliable nor consistent unless the collector or any subsequent buyer takes a deliberate effort to clean and grade it. Variations in quality have also led to design of artificial gum substitutes that have enhanced and reliable properties (Al-Assaf et al., 2007; Aoki, et al., 2007). Therefore, gum producing countries, including Senegal, need to realise that maintaining and improving the quality of the gum is essential in order to retain and expand their market share. Furthermore, there is need for designing price incentives associated with a grading system to increase the offer of good quality gum.

5.3 Aspects of gum arabic quality

Gum arabic has unique properties that make it useful in a wide range of specific food, and non-food industrial applications. Examples of applications in the food industry are shown in table 5.1.

Table 5. 1. Functions of gum arabic in food products

Function	Examples of food applications
Adhesive	Bakery
Crystallization inhibitor	Sugar syrups, pastilles, candies
Clarifying agent	Beer, wine
Coating agent	Candies
Emulsifier	Caramels, toffees, soft drinks
Encapsulating agent	Powdered fixed flavours
Flocculating agent	Wine
Foam stabilizer	Whipped toppings, beer, marshmallow
Gelling agent	Puddings, desserts, mousses
Mold release agent	Gum drops, jelly candies
Protective colloid	Flavour emulsions (e.g., orange, lime, beer, cola)
Stabiliser	Mayonnaise, beer, ice cream, sherbet
Suspending agent	Chocolate milk
Swelling agent	Processed meat
Syneresis inhibitor	Cheese, frozen foods
Thickening agent	Jams, sauces, gravies
Whipping agent	Icings, toppings

Source: Glicksman (1969), Williams and Phillips (2009), Phillips (2012)

Gum arabic is also used in non-food industries for instance in modern pharmacy where it is commonly employed as a demulcent, emulsifier, binder, or for film-forming (Moges, 2004; Khan and Abourashed, 2010). It is also used in partial destruction of many alkaloids such as atropine, hyoscyamine, scopolamine, homatropine, morphine, cocaine, and physostigmine (Khan and Abourashed, 2010). Ali et al. (2009) suggested a possible use of gum arabic in dentistry because it enhances dental remineralisation and has some antimicrobial activity. The recently discovered health benefits of gum arabic include its anti-obesity effects if used as a dietary supplement (Ushida, 2012), and maintenance of uric acid at normal levels in the treatment of gout (Osman et al., 2012).

Other commercial uses of Acacia gum include its utilization in production of inks, pottery pigmentation, water-colours and paints, wax polishes, liquid gum, textiles, and lithography (Barbier, 1992, 2000; Fagg and Allison, 2004; Wickens et al., 1995; Idris and Haddad, 2012).

Depending on the uses of gum arabic that are as diverse as just described above, different quality grades of the gum are needed. Typically the food and pharmaceutical industries require the finest quality whereas the painting industry does not necessarily need the best quality.

Quality grades are assessed by chemical and physical characteristics. Chemical characteristics of gum arabic quality have been defined by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) and adopted or modified by other regulations such as the EU Gum Arabic Specification (E414), the European Pharmacopeia, the United States Food Chemical Codex or the United States Pharmacopeia and the National Formulary (Williams and Phillips, 2009).

The physical characteristics of gum arabic are visible features associated with colour, size and solidity of the gum nodule, and cleanliness from impurities such as tree bark or dirt. Generally ‘good’ gum must be clean, with solid nodules that are orange-brown coloured (Macrae and Merlin, 2002). Sudan, Nigeria and Chad have registered their gum grades on the world markets such that these grades have become internationally known and command different prices (e.g., Sudan’s grades in table 5.2). Small producing countries like Senegal do not have such a known grading system.

Table 5. 2. Sudan classification of gum arabic

Grade	Description	Percentage at sorting
Hand Picked Selected	Cleanest, lightest colour, and whole nodule, Ø >30 mm; most expensive grade	0 to 5
Cleaned amber and sifted	Clean, siftings are removed, pale to dark amber colour, whole or broken nodule, Ø >20 mm	5-10
Cleaned	Standard grade, contains siftings but dust is removed, whole nodule plus fragments, 10 <Ø <20 mm	70
Siftings	Fine particles left after sorting, contains sand, bark and dirt, 2.5<Ø < 10 mm	5
Dust	Very fine particles collected after the cleaning process, Ø< 2.5 mm	5
Red gum	Dark and red particles, only for local use	

Ø - Diameter
Source: Macrae and Merlin (2002), Williams and Phillips (2009)

The main factors affecting these grades of gum arabic quality are different botanical sources, tapping methods and harvesting period, soil conditions and climatic factors (Chikamai and Odera, 2002). To maintain gum quality during gum collection, collectors need to apply good tapping techniques and tap at the appropriate time (following climatic and ecological cues), respecting the waiting period after tapping. They should harvest gum off the tree carefully without taking the bark, and prevent it from touching the soil. Post-harvesting handling is also important; indeed cleaning, drying or storage improve the quality of gum arabic.

While different prices are associated with different grades at the export level, the same rule should be applicable within the gum producing countries at the level of collectors so that a high price rewards the efforts in conversion from low to high quality either during or post harvesting. A predicting model that explains relationships between gum grading, costs and price is included in the appendix A1. This model investigates reasons as to why collectors

seem to supply gum of standard quality and not implement quality maintenance or improvement when conversion costs are too high vis-à-vis price premiums (which are quasi-absent on local markets in Senegal). Yet, arguably, quality maintenance, improvement and hence grading can potentially improve the price of gum for collectors and increase their incomes. Yet, the model in A1 also attempts to explain why traders do not provide these incentives for enforcing quality maintenance or improvement[8].

5.4 Methodology

1. Formalisation of quality

A first step in investigating the quality of gum supplied by collectors is to test the understanding of its meaning by collectors and traders on the one side and by users on the other side. The collector's assessment of gum quality was done on the field whereas the users' assessment is determined in the laboratory by analysis of the chemical components which determine its properties and thereby its usage in different industries. Both assessments are brought together in a comparative analysis that is based on specifications recognized by FAO and Valdafrique.

Field assessment

A field assessment of gum samples was conducted during the visit of 11 random villages from the Sylvopastoral zone and Eastern region of Senegal between March and April 2010. In total, 27 random samples of gum were taken from the gum intended for sale and these samples were assessed by collectors and traders in the village. In this assessment, samples were classified as of best, first, second or standard quality on the basis of a visual inspection of quality attributes including the size of the gum nodule, clarity of colour, and cleanliness.

[8] Currently, gum sales are not rewarded according to quality but collectors receive a low price for their product. The lack of statistics in relation to different grades of gum arabic has made that the available data could not substantiate this model.

Laboratory chemical analyses

Chemical analyses were done in the laboratory to determine the intrinsic invisible quality attributes of the gum samples. These samples were ground in powder on a cutting mill (Retsch SM100) with a sieve of aperture size of 1mm. They were then solubilized in distilled water at a rate of 10 per cent w/w (weight by weight). The solution was then filtrated on a filter with porosity P2 in order to eliminate the particles in suspension (sand, bark etc.). The laboratory analysis include measurements such as dry matter (determined on gum powder by heating at 103°C during 24h), mineral matter or ashes (determined on gum powder by combustion at 550°C during 4h), and the specific rotatory power (determined by direct reading of rotator power on a Bellingham + Stanley's ADP220 polarimeter).

Linking the field to the laboratory

Results from the chemical analyses were compared with the field assessment to determine the extent to which the samples graded in the field fulfilled users' requirements. Users' quality requirements provided the basis for comparison namely the JECFA specifications for food products in general on the international level, and Valdafrique specifications for chemical products on the national level. These specifications of gum arabic are found in appendices A2 and A3 respectively.

2. Determinants of quality supply by gum collectors

In the second step we analyse the determinants of supply of quality for two attributes namely the size and cleanliness of the nodules: the bigger and/or the cleaner the gum nodule, the higher is its quality.

The variable indicating the size of gum nodules is defined by the quantity brought by the collector to market which includes many nodules that are smaller than 2cm (0), a few nodules that are smaller than 2 cm (1), a few nodules that are larger than 2cm (2), and many nodules that are larger than 2cm (3). The variable indicating the cleanliness of nodules is

defined by the quantity brought by the collector to market which includes a few nodules that are clean (0), about half of the nodules that are clean (1), and many nodules that are clean (2). These values indicate attributes of the ordered observed outcome in the supply of quality.

Determinants of the attributes of quality include tapping aspects, post-harvest handling, market characteristics, and environmental factors.

Tapping aspects include:

- Time between tapping the *Acacia senegal* tree and collecting the gum off the tree: the recommended minimum time between tapping and collection is 14 days so that gum has sufficiently matured. Any time lesser than 14 days has a negative effect on quality in terms of size and hardness, because a wet nodule will easily carry impurities. A dummy variable expressing this time takes the value of 1 if 14 days or more are taken between tree tapping and collecting gum or 0 if there is no information regarding the time or less time was taken between tapping and collection.

- Forest management: refers to private or common ownership of gum trees and/or plots. Private plots are found with collectors who have planted their own trees or through permanent ownership by inheritance, requests from village chiefs, or by formal or informal divisions of plantations. Communal plots are obtained through temporary ownership or just through collection with or without permit from the forestry service. Generally no investment in management practices is done (such as pruning, coppicing, or fertilization); hence there is no difference in tree management between private and common plots. However, the risk of appropriation of the gum oozing from the tree by competing collectors who are unrestricted to the common plots is high; hence this is expected to have a negative effect on the quality of gum collected. A dummy variable expressing forest management takes the value of 1 if collection is organized in communal plots or 0 if collection is organized in private plots.

Post-harvest handling includes:

- Participation in training on quality: a training that pertained to quality aspects of gum arabic was specifically organized for collectors at the beginning of the collection season of 2009-2010. Collectors who participated in such training were expected to supply gum of better quality than those who did not participate in the training. The variable expressing participation in training takes the value of 1 if the collector participated or 0 if he did not participate.

- Post-harvest time per kg of gum arabic: this is the number of minutes spent in post-harvest activities such as cleaning, grading and sorting gum before taking it to the buyer. This is calculated as the total time (in minutes) the collector devoted to post harvest activities divided by the total amount of gum he sold The longer the time, the better the quality.

Market characteristics include:

- Sale place choice: village shop owners, whose cost of quality inspection may be low because they were established in the village, might enforce quality requirements more rigorously than mobile traders. These mobile traders come to the market with an interest in gathering large quantities in order to minimize their marketing costs. The variable expressing the collector's choice of sale place[9] takes the value of 1 if gum was sold to a village *boutiquier* or 0 if gum was sold to a mobile trader.

- Trader experience: the effect of the trader's experience on gum quality depends on the supply base and type of markets where the trader in turn sells the gum. A less experienced trader who wants to establish himself in business might put a bigger emphasis on the gum quality to satisfy the buyer or as he needs to establish a large customer base, he may not need to enforce strong quality requirements.

- Price in previous season: the price received by collectors last year gives an indication of the expected price. The higher this price, the higher the incentive to upgrade quality.

[9] Both boutique and mobile trader may accept all grades of gum, but they are mutually exclusive for a single transaction: the collector sells to either one place.

However, as the number of collectors increases (the higher expected prices may attract non-professionals), the quality of gum may go down as competition in common forests increases. Furthermore, if the price is high, quality may also deteriorate as there is relatively more demand for lower quality.

Environmental factors are control variables on which the collector has no influence. They include:

- Seasonal differences: the time in the season when the quantity is supplied, assuming that storage is not done for a long time and, the collector did not bring to the market in period 2 the gum harvested in period 1. Seasonal differences capture the differences in quality due to variations in exogenous climatic differences (e.g., heat). The variable for seasonal time takes the value of 0 for collection at the beginning of season, 1 for the mid-season and 2 for the end of season.

- Regional differences: there might also be environmental factors which differ across regions (e.g., rainfall) that affect the quality of gum. The variable for region takes a value of 1 for Eastern Senegal or 0 for the Sylvopastoral zone.

3. Data and econometric model

Two training sessions on gum quality aspects were conducted in the Sylvopastoral Zone and Eastern region at the beginning of the gum season of 2009-2010 previous to starting collection. Following these sessions, monitoring of markets was done between January and May 2010 such that the quality brought to the markets was immediately recorded together with the specific details that could be the determinants of this quality. This monitoring was done fortnightly in 16 markets and resulted in 219 formal records.

The analysis of determinants of quality aspects is done through an ordered logit model whereby the observed attributes of the size or cleanliness of gum nodules are the dependent

variables. According to Greene (2008), the ordered logit model is built around a latent regression:

$$y^* = \boldsymbol{x\beta'} + \varepsilon \quad (1)$$

where *y** is unobserved.; **x** is the vector of independent variables, and $\boldsymbol{\beta}$ is the vector of regression coefficients which are estimated.

Categories of response of response are observed:

$$y = \begin{cases} 0 \; if \; y^* \leq 0 \\ 1 \; if \; 0 \leq y^* \leq \mu_1 \\ 2 \; if \; \mu_1 \leq y^* \leq \mu_2 \\ . \\ . \\ . \\ n \; if \; \mu_{n-1} \leq y^* \end{cases} \quad (2)$$

Then the ordered logit technique will use the observations on *y*, which are a form of censored data on *y** to fit the parameter vector $\boldsymbol{\beta}$, n is the number of categories in the dependent variable and μ are the cut-off points.

Cameron and Trivaldi (2010) show that the ordered logit is a model of cumulative probabilities associated with the ordered categories such that:

$$\Pr(y = n) = \begin{cases} \Pr(\mu_{n-1} < \; y^* \leq \mu_n) \\ \Pr(\mu_{n-1} < \; \boldsymbol{x\beta'} + \; \varepsilon \leq \mu_n) \\ \Pr(\mu_{n-1} - \; \boldsymbol{x\beta'} < \; \varepsilon \leq \mu_n - \; \boldsymbol{x\beta'}) \\ \mathrm{F}(\mu_n - \; \boldsymbol{x\beta'}) - F(\mu_{n-1} - \; \boldsymbol{x\beta'}) \end{cases} \quad (3)$$

Where *F* is the cumulative distribution function of ε which is logistically distributed.

5.5 Results

1. Assessment of quality

The classification of samples according to the field criteria and the results from chemical analyses are presented in Table 5.3.

Table 5. 3. Field assessment of quality and results of chemical analyses for 27 gum arabic samples

Village of origin	Reference	Field	Description		DM (%)	MM[a] (%)	SRP[a] (° of angle of rotation)
			Size of nodules	Cleanliness			
L1	CEH1	1st best	large pieces	Clean	88.76	4.30	-28.11
L1	CEH2	1st	small pieces	Clean	89.33	3.49	-22.03
L1	CEH3	1st	small pieces	Clean	88.92	9.71	-30.26
L1	CEH4	2nd	small pieces	Dirty	89.89	7.55	-29.17
G1	CEH5	1st	large pieces	Clean	89.10	3.65	-31.48
G1	CEH6	2nd	large pieces	Dirty	89.94	16.58	-32.33
G1	CEH7	standard	large pieces	A bit clean	89.49	4.74	-29.41
Y	CEH8	1st	large pieces	A bit clean	88.97	3.99	-32.35
Y	CEH9	2nd	large pieces	Dirty	90.00	6.78	-30.50
V	CEH10	1st 'best'	large pieces	Clean	89.26	3.66	-29.79
V	CEH11	1st	large pieces	Not quite clean	88.55	3.44	-32.27
V	CEH12	2nd	small pieces	Very dirty	88.59	3.81	-29.54
T	CEH13	1st	large pieces	Clean	88.63	3.39	-25.04
T	CEH14	2nd	large pieces with debris	Clean	88.90	3.89	-29.21
T	CEH15	standard	large pieces with debris	Clean	88.73	4.14	-31.70
L2	CEH16	1st	large	Dirty	89.30	3.37	-29.62
L2	CEH17	2nd	large	Dirty	89.42	9.69	-18.96
L2	CEH18	3rd	large	Dirty	88.48	14.47	-28.85
S1	CEH19	standard	small pieces	Clean	88.08	3.01	-30.36
D	CEH20	standard	small pieces	Clean	88.33	2.72	-34.11
G2	CEH21	standard	very small pieces	Clean	88.53	3.19	-31.86
S2	CEH22	1st	small pieces	Clean	88.11	8.07	-29.84
S2	CEH23	2nd	small pieces	Clean	88.44	8.22	-27.48
S2	CEH24	3rd	small pieces with debris	Quite clean	88.40	3.70	-32.19
K	CEH25	1st	very small pieces	Dirty	88.69	4.82	-36.96
K	CEH26	2nd	very small pieces with debris	Very dirty	88.90	4.77	-32.66
K	CEH27	3rd	very small pieces with debris	Most dirty	88.63	5.50	-37.30

DM: dry matter; MM: mineral matter; SRP: specific rotatory power

[a] Results on DM basis

There are some clear findings derived from the above analysis: (1) there is a subjective description of quality that differs from village to village, what is considered as good quality by one village may not be the same in another village; (2) generally, the good quality (best,

first or standard quality) is associated with the gum cleanliness whereby the lower mineral matter confirms the gum to be less contaminated.

The above results were checked to find out whether the two assessments jointly fulfil the user's requirements. The two quality criteria of gum arabic retained for comparison are that (1) Ash content (mineral matter) should not exceed 4% (JECFA, 2006 and Valdafrique, 2011), and (2) Optical rotation between -26 and -34 degrees (Osman et al., 1993) (Table 5.4).

Table 5. 4. Assessment of fulfilment of quality requirements for samples of gum arabic

Village of origin	Total number of samples	Laboratory assessment		Field assessment 1st or standard (16)	Field vs. Lab (16)
		Ash content (27)	Optical rotation (27)		
L1	4	1	3	3	0
G1	3	1	3	2	1
Y	2	1	2	1	1
V	3	3	3	2	2
T	3	1	2	2	0
L2	3	1	2	1	1
S1	1	1	1	1	1
D	1	1	1	1	1
G2	1	1	1	1	1
S2	3	1	3	1	0
K	3	0	1	1	0
Total	**27**	**13**	**22**	**16**	**8**

Out of the 27 tested samples, only 13 samples fulfil the ash content criterion whereas 22 samples fulfil the optical rotation criterion. Among the 27 samples, 16 samples were considered of first (best) or good standard quality (quality that is generally supplied irrespective of any quality grading) in the field assessment. In comparing the laboratory assessment to the field assessment, only 8 samples among these 16 were correctly found to fulfil the optical rotation and ash content criteria. Among the samples of low quality as assessed on the field, only 2 were incorrectly classified by collectors as they were found to be of good quality in accordance to the laboratory analyses.

Although gum arabic can find usage for almost all quality levels, by jointly comparing the field and laboratory assessment of gum quality to the users requirements in the international food and local pharmaceutical industries, it is found that (1) low quality is in most cases confirmed to be bad by any assessment, the visual attribute for low quality is the lack of cleanliness irrespective of any size of the nodule; and, (2) high quality from the perspective of collectors and traders on the field is not always good in terms of laboratory assessment; in this case, only 50 per cent of high 'field' quality samples were correctly classified. Furthermore, more samples were considered of bad quality by the laboratory tests than after visual inspection. This may influence the rejection rates at higher levels in the supply chain. However, if supply of high quality on the field was increased, there would be more likelihood to fulfil quality requirements in terms of laboratory assessment; this observation leads us to investigating the determinants of quality supply.

2. Determinants of quality supply by gum collectors

Table 5.5 shows the distribution of gum supplied by collectors with regard to the size and cleanliness of gum nodules.

Table 5. 5. Two-way table: Gum cleanliness by Size of gum nodule

Gum Cleanliness	**Size of gum nodule**				Total
	Many < 2cm	Few < 2cm	Few > 2cm	Many > 2cm	
Few clean	0	7	11	1	19
Half clean	72	29	28	7	136
Many clean	17	38	7	2	64
Total	89	74	46	10	219

Pearson $\chi^2(6) = 52.18$***

A cross tabulation between cleanliness and size of gum nodules shows that these attributes of quality are significantly different. For instance, more than 70 per cent of gum supplied contains nodules which are small, at the most less than 2cm in diameter. These small nodules

are mostly clean. The gum which is not clean consists of less than 10 per cent of all the gum supplied, but this unclean gum is of big nodules, at least larger than 2cm in diameter. Such differences justify the treatment of these attributes as separate dependent variables in subsequent analyses

Tables 5.6 and 5.7 show the descriptive statistics of the variables used as determinants of quality supply in terms of size of gum nodules and cleanliness and the ordered logit results for quality supply, respectively.

Table 5. 6. Descriptive statistics of determinants of quality supply

Variable	Undistinguished quality			Size of gum nodules			Cleanliness				Equality test	
	Senegal (219)	SPZ (155)	ES (64)	Many < 2cm (89)	Few < 2cm (74)	Few > 2cm (46)	Many > 2cm (10)	Few clean (19)	Half clean (136)	Many clean (64)	Size X region	Clean X region
Distribution of quality attributes				0.41 (0.033)	0.34 (0.032)	0.21 (0.028)	0.04 (0.014)	0.09 (0.019)	0.62 (0.033)	0.29 (0.031)		
Time between tap and harvest (1 if ≥14 days)	0.33 (0.470)	0.33 (0.471)	0.32 (0.469)	0.32 (0.471)	0.30 (0.460)	0.39 (0.493)	0.22 (0.441)	0.23 (0.427)	0.33 (0.485)	0.37 (0.484)	0.79	1.37
Forest management (1: commune)	0.52 (0.501)	0.39 (0.490)	0.84 (0.368)	0.44 (0.527)	0.37 (0.488)	0.67 (0.471)	0.48 (0.502)	0.61 (0.502)	0.41 (0.494)	0.73 (0.445)	7.45***	9.92***
Unity post-harvest time (minute/quantity)	5.83 (6.092)	4.93 (3.908)	8.01 (9.178)	4.65 (4.640)	7.14 (7.773)	5.764 (5.612)	6.82 (3.432)	5.82 (4.720)	4.68 (4.190)	8.27 (8.690)	2.31*	8.04***
Participated in training (1:yes)	0.72 (0.452)	0.64 (0.480)	0.89 (0.317)	0.44 (0.527)	0.75 (0.434)	0.63 (0.488)	0.76 (0.432)	0.61 (0.502)	0.71 (0.454)	0.75 (0.175)	3.46***	6.22***
Sale place (1: village boutique)	0.56 (0.497)	0.63 (0.484)	0.38 (0.489)	0.45 (0.500)	0.58 (0.497)	0.76 (0.431)	0.44 (0.527)	1	0.54 (0.500)	0.48 (0.504)	5.89***	6.45***
Trader experience (year)	15.6 (9.387)	19.0 (7.596)	7.3 (8.169)	17.7 (9.099)	12.3 (10.303)	17.2 (7.757)	13.2 (1.716)	17.2 (6.907)	18.1 (8.730)	9.9 (8.975)	18.03***	21.74***
Price in previous season (CFA/kg)	616.0 (158.82)	529.35 (77.666)	825.78 (96.770)	584.83 (133.87)	711.5 (171.33)	543.6 (116.38)	516.7 (86.60)	560.53 (149.61)	564.34 (124.56)	742.19 (157.41)	17.84***	38.33***
Begin-season (1: if harvest and sale at start of season)	0.30 (0.458)	0.32 (0.469)	0.24 (0.429)	0.61 (0.491)	0.15 (0.358)	0	0	0.06 (0.236)	0.37 (0.484)	0.22 (0.417)	20.99***	5.75***
Mid-season (1: if harvest and sale in mid-season)	0.32 (0.469)	0.37 (0.484)	0.22 (0.419)	0.19 (0.395)	0.38 (0.488)	0.43 (0.501)	0.67 (0.500)	0.5 (0.514)	0.3 (0.480)	0.22 (0.417)	4.70***	5.14***
End of season (1: if harvest and sale at end of season)	0.38 (0.485)	0.31 (0.464)	0.54 (0.502)	0.20 (0.404)	0.47 (0.503)	0.56 (0.501)	0.33 (0.500)	0.44 (0.511)	0.28 (0.450)	0.56 (0.500)	7.64***	18.69***
Region (1: Eastern Senegal)				0.13 (0.036)	0.62 (0.057)	0.11 (0.046)	0	0.17 (0.090)	0.10 (0.025)	0.73 (0.055)		

[a]Equality test refers to ANOVA test for continuous variables and Pearson chi-square test for categorical variables.
*** significant at 1% level, ** significant at 5% level; * significant at 10% level, + significant at 15% level.

Table 5. 7. Ordered logistic results (Nodule size: 4 categories in SPZ, 3 categories in ES; Nodule cleanliness 3 categories in SPZ and ES)

Variable	Size of gum nodules			Cleanliness		
	Senegal (219)	SPZ (155)	ES (64)	Senegal (219)	SPZ (155)	ES (64)
Time between tap and harvest (1 if 14 days or more)	0.444+ (0.353)	0.603+ (0.486)	1.140+ (0.911)	0.492+ (0.391)	0.392 (0.524)	0.310 (0.801)
Tree management (1: commune)	-0.388+ (0.328)	-0.359 (0.393)	-1.986* (1.117)	-0.094 (0.358)	-0.520+ (0.455)	-0.843+ (0.799)
Unity post-harvest time (ln minute/quantity)	0.251* (0.142)	0.157 (0.275)	0.099 (0.308)	0.306* (0.178)	0.016 (0.324)	0.224 (0.296)
Participated in training (1:yes)	0.777** (0.404)	0.321+ (0.522)	1.554+ (1.098)	0.063 (0.439)	0.522+ (0.580)	0.615 (0.956)
Sale place (1: village boutique)	1.502*** (0.366)	1.311*** (0.498)	2.177** (0.988)	-0.570+ (0.410)	-0.930* (0.581)	-1.822* (1.064)
Trader experience (year)	-0.036* (0.023)	-0.046+ (0.031)	-0.172*** (0.066)	0.036+ (0.027)	0.022 (0.0388)	0.036 (0.067)
Price in previous season (CFA/kg)	-0.002* (0.001)	-0.004* (0.002)	-0.010** (0.005)	-0.001* (0.002)	-0.006** (0.003)	-0.009* (0.005)
Mid-season (1: if harvest and sale in mid-season)	3.172*** (0.438)	7.280** (3.099)	1.564+ (0.993)	-0.453+ (0.389)	-0.999* (0.561)	4.643 (1.682)
End of season (1: if harvest and sale towards the end of season)	2.391*** (0.444)	7.168** (3.133)	-0.140 (0.913)	0.241 (0.445)	2.325*** (0.757)	-2.011* (1.164)
Region (1: ES)	-1.072 (0.649)			2.692*** (0.755)		
Cut-off1	0.736 (1.192)	5.590 (3.353)	-13.259 (5.649)	-0.976 (1.317)	0.718 (1.671)	-11.052 (5.341)
Cut-off2	2.819 (1.204)	6.859 (3.360)	-7.715 (5.333)	3.141 (1.343)	6.197 (1.778)	-9.050 (5.253)
Cut-off3	5.122 (1.228)	9.217 (3.367)				
Log-likelihood	-208.14	-129.46	-36.62	-148.71	-83.81	-36.04
LR-chi square	106.70***	104.94***	25.73***	82.53***	34.48***	20.56**
Pseudo R-square	0.204	0.288	0.260	0.217	0.171	0.222
% good predictions	53.88	62.58	76.56	78.08	69.73	65.63

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

In comparing determinants of the nodules size and cleanliness in pooled data or across the region, we observe differences in forest management, participation in training, choice of sale outlet, the buyer's experience, price in previous season, and harvest and sale of gum arabic either at start or middle of the season.

Large gum nodules were supplied by collectors who can respect the sufficient duration required for gum maturity between tree tapping and gum harvesting, spend sufficient time on post-harvest activities (including cleaning and sorting), have participated in training, and choose to sell to the boutique. In comparison with the beginning of the season, larger gum nodules are best obtained during the mid or towards the end of season of collecting and selling the gum. Collection in communal forests has a negative effect on the size of nodule as probably the competition to collect gum off the tree leads to picking it before its maturity; such competition increases due to higher expected price, hence this also has a negative effect on quality. Traders who are newer in gum business prefer large nodules.

The clean gum is supplied by collectors who can respect a sufficient duration required for gum maturity between tapping and harvesting of gum, and spend sufficient time on post-harvest activities (including cleaning and sorting). Experienced traders prefer cleaner nodules; Eastern Senegal is the region where cleaner gum is mostly produced. However, the choice of boutique as the sale place and the expected price have a negative effect on cleanliness. Furthermore, in comparison to the beginning of the season, the gum collected during the mid-season is less clean.

Although quality remains determined by selection of tree species, tapping methods, harvesting period, edaphic conditions and climatic factors; the harvest and post-harvest handling were also found to have a positive influence on quality implying that there is need for an emphasis on the basics of the techniques of gum harvesting and practices to maintain and improve its quality. Collectors can acquire the related knowledge and skills through

experience, and trainings are also needed specially in terms of linking the collector's knowledge to the quality aspects that are important to the users; the training conducted at the beginning of the season proved to be important in that respect. The behaviour of a village boutique owner is not consistent in regard to quality attributes: he is interested in large nodules whose inspection can be quickly established and hence involves a low cost in addition to being associated with quantity. An emphasis on cleanliness may not only reduce the quantity to trade but also lead to a problem of enforcing the cleanliness requirements as it is hard/costly to reject gum: if a trader consistently rejects the supplied gum, this has a bad social outcome and collectors may not go to him in the future which means that he loses a market altogether. The effect of the trader's experience implies that younger traders are interested in larger nodules than the older traders probably because the size of nodules is easy to monitor and describe, while proper assessment of cleanliness is achieved from experience; experienced traders indeed may be more interested in clean gum.

High price expectations create competition which not only restrain the gum maturity but also make the nodules prone to more impurities; this competition mainly results from organising collection in communal forests. The effect of price on quality can also be due to differences in relative demand for quality: at high price levels, there is relatively more demand for lower quality whereas at low price levels, there is relatively more demand for high quality; such relationships are further explored below.

Differences within the season are also observed. These differences confirm the studies by Chikamai and Odera (2002) that gum quality is influenced by environmental conditions such as differences in moisture, wind or heat. Taking the beginning of season as the base, we found that the size of nodules increases throughout the season except for ES where towards the end of the season, gum nodules were smaller than nodules harvested at the beginning of season; cleanliness declines in mid-season to increase again at the end of season except again

for ES where towards the end of the season, gum nodules were less clean than gum harvested at the beginning of season.

With regard to spatial differences, there are soil, rainfall and heat conditions that lead to a combination of the size and cleanliness but not always in the same direction. On a regional level, SPZ is endowed with bigger nodules than ES whereas ES offers cleaner gum than SPZ. Note that ES has 2 cut-offs for the size of nodules.

As mentioned above, the effect of price received in the previous season on gum quality supply deserves our attention. Based on the estimation results of the ordered logit model, simulations were performed to illustrate the response to changes in price on probabilities associated with quality attributes. The probabilities are computed following equation (3). Figure 5.1 shows simulation results of pooled data at the average values in Senegal and for specific values of certain explanatory variables separately for the Sylvopastoral zone and Eastern Senegal for a gum price ranging from 350 to 900 CFA.

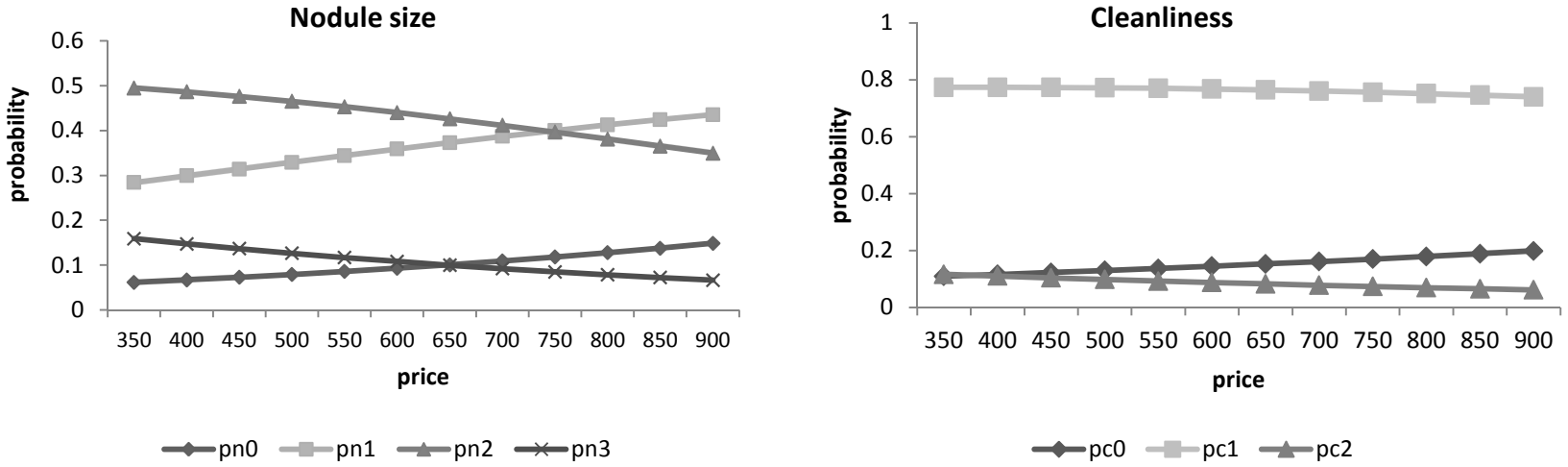

Figure 5. 1a. Simulation of quality supply response to changes in price at average values (pooled data)

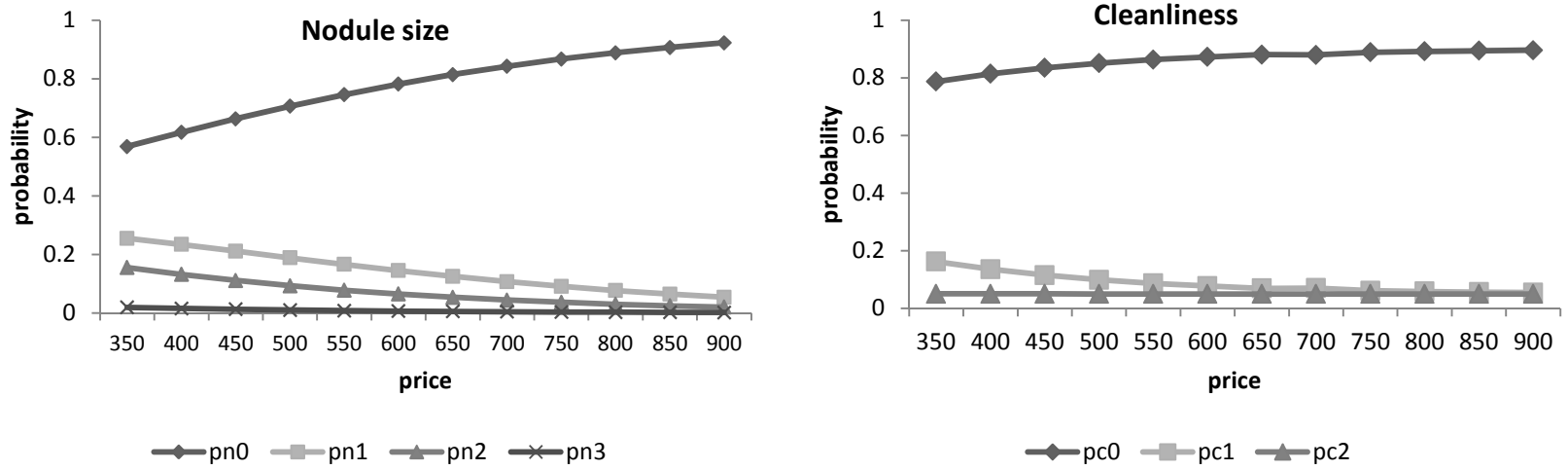

Figure 5. 1b. Simulation of quality supply response to changes in price in SPZ if management=0, training=1, sale choice=1

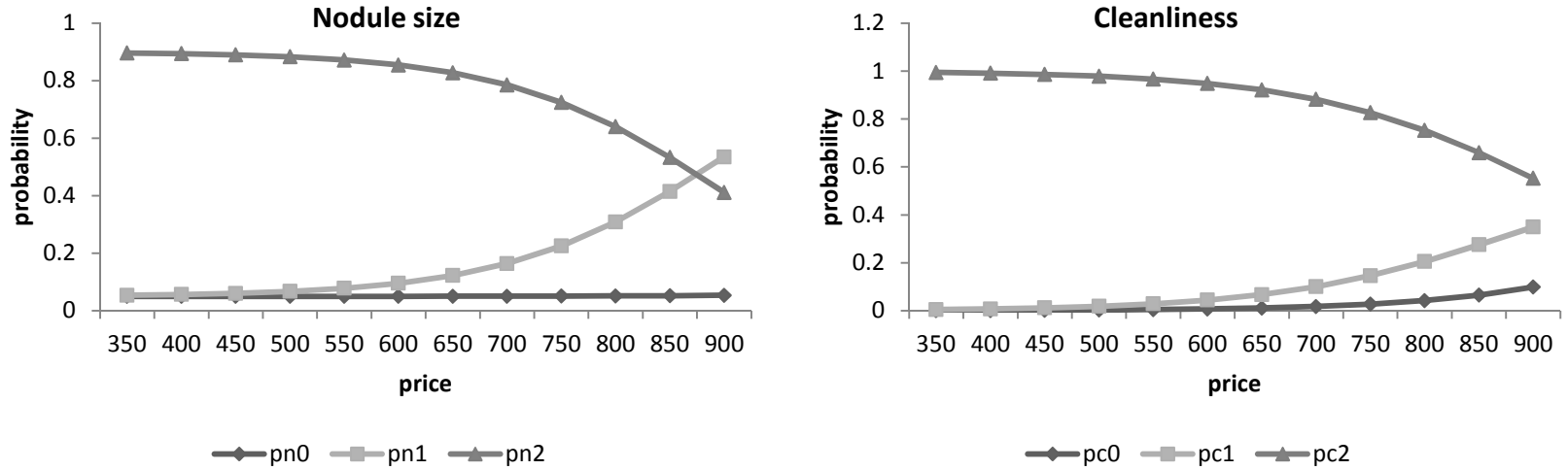

Figure 5. 1c. Simulation of quality supply response to changes in price in ES if management=1, training=1, sale choice=1

pno: probability of supplying nodules that are smaller than 2cm
pn1: probability of supplying a few nodules that are smaller than 2 cm
pn2: probability of supplying a few nodules that are larger than 2cm
pn3: probability of supplying many nodules that are larger than 2cm
pco: probability of supplying a few nodules that are clean
pc1: probability of supplying about half of the nodules that are clean
pc2: probability of supplying many nodules that are clean

At the average values of the explanatory variables in the pooled data, the probability of supplying low quality (pn0 or pn1 associated with nodules of small size and pc0 associated with less clean nodules) directly increases with expected price whereas the probability of supplying high quality (pn2 or pn3 associated with nodules of large size and pc1 or pc2 associated with cleaner nodules) declines with expected price increases. Apart from small variations, the same results hold for simulations within the SPZ and ES (assuming that collection is organised in private property in SPZ or communal forests in ES, collectors are trained, and sales are made to the village shop): as the effect of an increase in expected price in SPZ, pn0 increases while pn1, pn2 and pn3 decrease, pc0 increases while pc1 and pc2 decrease. In ES, as the effect of an increase in expected price, pn0 and pn1 increase while pn2 decreases, pc0 and pc1 increase while and pc2 decreases.

The simulation results confirm that at high prices, supply of low quality gum increases whereas when prices are low, the gum supplied is of good quality. These results can be associated with the effort of the collector towards achieving a certain quality level, his expected income and competition in communal forests. They can also be explained by the trader's behaviour: at a high price, the collectors whose supply of low quality is not rejected by a trader will continue supplying low quality whereas at the low price, the collectors whose supply of low quality may be rejected by a trader will have to put more effort to increase quality at least to a top segment of the gum quality, in order to reach a target income.

5.6 Discussion and conclusion

Linking field assessment to laboratory measurements of quality and then investigating determinants of quality has led to several interesting findings. First, the results proved the divergence in quality definition not only between collectors and users but also among the collectors, and from village to village. Furthermore, it has become apparent that the study of quality needs to be inclusive of the main stakeholders in order to achieve a common

understanding which can then be translated to each stakeholder's language and be acted upon. In this study of the quality of gum arabic, it was found that the measured quality was not always directly in accordance with visible quality attributes in the field. Among visible attributes, cleanliness (or low mineral matter) is a good indicator of quality. Hence field assessment was found not to consistently correspond to the user requirements; while bad quality is identified both on the field and in the laboratory, good quality gum is not always correctly identified.

Secondly, even if any quality of gum arabic can find usage, it became evident that collectors should be encouraged to put effort specially in cleaning gum, thereby supplying their good quality as this would increase the likelihood of obtaining the true good quality on the basis of invisible attributes. The sensitization of collectors should be accompanied by price incentives by which high quality is rewarded by a quality premium. As simulation showed, quality is not stimulated by price but by price differentiation; consequently, in the situation when quality is not differentiated, producers/collectors are paid a price that is only associated with low quality (as corresponding to equation (8) in appendix 5A.1). Also Leakey and Izac (1996) found that non-timber forest products do not get a premium for their physical or genetic improvement. In case conversion is undertaken to achieve high quality, this conversion involves a cost which will be in line with the quality premium in efficient supply chains: while for welfare reasons it is common to suggest that the premium be paid to producers/collectors to improve their livelihoods, quality conversion could still be performed by traders who have advantages of economies of scale.

Thirdly, the improvement in quality calls for practices to be respected both in harvesting and post-harvest handling. Lamien et al. (1996) for instance showed that the non-respect of harvesting practices and notably the maturity time reduces the quality of the product. Therefore, even if these practices may not always be directly rewarded as Fafchamps

et al. (2008) found, they nevertheless have an effect on the visual attributes such as cleanliness and size of nodules as we find for gum arabic. Traders are hereby called upon as their behaviour is rather ambiguous towards the quality attributes. As actors in the supply chain and intermediaries between the collectors and users, they should have a definition of quality that is coherent and responsive to the actions and needs of collectors and users respectively. As quality uncertainties may also negatively affect the price that traders pay, these traders could play important role on transmission of quality information.

Finally, the current study has strengthened the need to understand the role of forest (tree and/or land) management on the quality of the gum. Clear rules of management are needed to counteract the influence of market forces (price) on competition in forests. Forest management is also a pertinent issue as recurrent competitions may be detrimental to the resource and lead to degradation.

Appendix 5A

5A.1. A theoretical model for quality supply and demand

Let the quality of gum be differentiated into low (ungraded) and high quality on the basis of intrinsic attributes. Suppose producers supply a product with a certain quality, and traders offer a price, based on demand for this product split into high quality demand and ungraded quality demand. Let there be two demand curves:

$$d^h = a^h - b^h p^h \quad (1)$$

$$d^l = a^l - b^l p^l \quad (2)$$

We expect $b^l > b^h$, indicating that at high prices, low quality may suffice ($d^l > d^h$); but when prices are low, more consumers demand high quality ($d^l < d^h$).

A trader faces supply of *q*, which can be split into a quantity of high quality q^h, and a remaining fraction which is sold as low quality. The conversion towards grading and selecting high quality can – in the simplest approach – be done a fixed cost per unit. If these costs are *c*, then we have the following set of equations determining the prices and the quantity converted into high quality

$$p^h - p^l = c \quad (3)$$

$$d^h = q^h \quad (4)$$

$$d^l = q - q^h \quad (5)$$

Exogenous variables are the total quantity produced (q) and the unit conversion costs (c). With the demand equations (1) and (2), this leads to:

$$p^h = \alpha/\beta + \beta^l c - q/\beta \quad (6)$$

where $\beta = b^h + b^l$; $\alpha = a^h + a^l$ and $\beta^l = b^l/\beta$

$$q^h = a^h - \beta^h(\alpha + cb^l) + \beta^h q \quad (7)$$

where $\beta^h = b^h/\beta$

Thus, with higher supply q, there is higher supply of high quality, which is sold at a lower price. Rising costs of conversion c would increase the price of high quality, and lower its demand and therefore its supply. Where the trade in high quality rise more or less than proportionally with q depends on the sign of the intercept $a^h - \beta^h(\alpha + cb^l)$. If this is positive, the overall share of high quality will fall with rising *q*. The intercept will be positive if $c < \frac{a^h}{b^h} - \frac{a^l}{b^l}$, which is the gap between the intercepts of the demand function at the vertical price-axis.

The price received by the producers in this model will equal p^l, the price of the ungraded quality. It falls with higher overall supply, and it also falls if conversion costs rise. If producers are price-sensitive, we can extend the model. Let the supply function be

$$q = r + sp^l \quad (8)$$

Combining this with (3) and (6), we can relate equilibrium supply q^e to its determinants. The solution is that in the long run,

$$q^e = (\beta r + \alpha s - b^h sc)/(s + \beta) \text{ and } p^l = (\alpha - r - b^h c)/(s + \beta) \quad (9)$$

These solutions for the equilibrium differ from the standard solution by the term $b^h c$ in the numerator: the higher the conversion costs, the lower the equilibrium supply and the lower the equilibrium price. Conversion costs thus acts as the margin between producer and consumer prices and lowering it would benefit all.

In this setting, producers could also capture the margin between high and ungraded quality by supplying high quality directly to the traders. Traders do, however, face demand characterized by a certain composition of high and low quality, and cannot accept large quantities of high quality if there is not a corresponding supply of ungraded quality.

Their equilibrium demand is as given above in (9). Therefore, following from (7) in equilibrium traders will convert a quantity equal to:

$$q^{eh} = a^h - \beta^h c b^l + b^h \frac{r - s - \beta^h cs}{s + \beta} \quad (10)$$

The higher the conversion cost, the lower will be the quantity of high quality converted by the trader. The conversion cost per unit of product may fall through economies of scale.

5A.2. JECFA specifications for gum arabic[10]

Prepared at the 51st JECFA (1998) and published in FNP 52 Add 6 (1998); republished in FNP 52 Add 7 (1999) to include editorial changes. Supersedes specifications prepared at the 49th JECFA (1997), published in FNP 52 Add 5 (1997). ADI "not specified", established at the 35th JECFA in 1989.

Synonyms	Gum arabic (*Acacia senegal*), gum arabic (*Acacia seyal*), Acacia gum, arabic gum, INS No. 414
Definition	Gum arabic is a dried exudate obtained from the stems and branches of *Acacia senegal* (L.) Willdenow or *Acacia seyal* (fam. *Leguminosae*). Gum arabic consists mainly of high-molecular weight polysaccharides and their calcium, magnesium and potassium salts, which on hydrolysis yield arabinose, galactose, rhamnose and glucuronic acid. Items of commerce may contain extraneous materials such as sand and pieces of bark, which must be removed before use in food.
C.A.S. number	9000-01-5
Description	Gum arabic (*Acacia senegal*) is a pale white to orange-brown solid, which breaks with a glassy fracture. The best grades are in the form of whole, spheroidal tears of varying size with a matt surface texture. When ground, the pieces are paler and have a glassy appearance. Gum arabic (*Acacia seyal*) is more brittle than the hard tears of gum arabic (*Acacia senegal*). Gum arabic is also available commercially in the form of white to yellowish-white flakes, granules, powder, roller dried, or spray-dried material. An aqueous solution of 1 g in 2 ml flows readily and is acid to litmus.
Functional uses	Emulsifier, stabilizer, thickener
Characteristics	
IDENTIFICATION	
Solubility (Vol.4)	One gram dissolves in 2 ml of water; insoluble in ethanol
Gum constituents (Vol.4)	Proceed as directed under Gum Constituents Identification (FNP 5) using the following as reference standards: arabinose, galactose, mannose, rhamnose, galacturonic acid, glucuronic acid and xylose. Arabinose, galactose, rhamnose and glucuronic acid should be present. Additional spots corresponding to mannose, xylose and galacturonic acid should be absent.

[10] http://www.fao.org/ag/agn/jecfa-additives/details.html?id=766

Optical rotation	Gum from *Acacia senegal*: aqueous solutions are levorotatory Gum from *Acacia seyal* : aqueous solutions are dextrorotatory Test a solution of 10 g of sample (dry basis) in 100 ml of water (if necessary, previously filtered through a No. 42 paper or a 0.8 µm millipore filter), using a 200-mm tube.
PURITY	
Loss on drying (Vol.4)	Not more than 15% (105º, 5 h) for granular and not more than 10% (105º, 4 h) for spray dried material. Unground samples should be powdered to pass through a No. 40 sieve and mixed well before weighing
Total ash (Vol.4)	Not more than 4%
Acid-insoluble ash (Vol.4)	Not more than 0.5%
Acid-insoluble matter (Vol.4)	Not more than 1%
Starch or dextrin	Boil a 1 in 50 solution of the sample, cool and add a few drops of Iodine T.S. No bluish or reddish colour should be produced.
Tannin-bearing gums	To 10 ml of a 1 in 50 solution of the sample, add about 0.1 ml of ferric chloride TS. No blackish colouration or blackish precipitate should be formed.
Microbiological criteria (Vol.4)	*Salmonella* spp.: Negative per test *E. coli:* Negative in 1 g
Lead (Vol.4)	Not more than 2 mg/kg Determine using an atomic absorption technique appropriate to the specified level. The selection of sample size and method of sample preparation may be based on the principles of the method described in Volume 4, “Instrumental Methods.”

5A.3. VALDAFRIQUE specifications for gum arabic[11]

VALDAFRIQUE®
LABORATOIRES CANONNE
FICHE TECHNIQUE
GOMME INSTANTANEE GAS-60-120 TYPE SENEGAL

Description

Nature	Gomme arabique atomisée soluble purifiée type Sénégal (gomme dure)
Aspect	Poudre blanchâtre sans odeur ni goût
Classification	E 414, 96/77/Ec, 95/2/Ec, USP/NF, Fcc
Norme	Pharmacopée européenne

Propriétés physico-chimiques

pH solution à 25%	4,2 – 4,8 à 25°C
Couleur solution à 25% (méthode Lovibond)	B5 – B6
Viscosité Brookfield solution à 25%	Entre 60 et 120 mPa/s à 25°C
Perte à la dessiccation	< 10 % à 105°C
Matières insolubles	< 0,1 %
Cendres	< 4 %
Pouvoir rotatoire	-20° à -40°
Tanin	Non décelable

Propriétés microbiologiques

Germes totaux	< 10 000 g/g
Salmonelle	Absence / 25g
E. Coli	Absence / 2g

Conditionnement

Sacs	double enveloppe de 25 kg net
Stockage	Stocker l'abri de la chaleur et de l'humidité
Durée de stockage	Maximum 3 ans recommandé

Propriétés fonctionnelles
Facilement soluble dans l'eau. La viscosité peut être ajustée en fonction de l'utilisation souhaitée.

[11] http://www.valdafrique.com/ftech_gomme_eng.htm

Private versus communal tenure systems in gum arabic collection

Abstract

Communal management systems of acacia stands are still prominent in the semi-arid gum producing areas. Competition in the plots leads to lower quantities per household and compared with private access systems, the gum collected is of lower quality. These communal systems also decrease the collectors' incentives for tree management, may lead to overexploitation and even be sources of conflict over resources. Private systems are emerging in some villages either at the individual level or through companies; in a gradual transition, mixed systems are found in which privately owned properties and communal forests co-exist. This study investigates factors that influence the currently observed transition from communal to private collection systems at the village level. We derive a theoretical model to show the advantages of either system in relation to population density and tree productivity. Using data from 53 villages in Senegal, a probit model is used to analyse the choice of organising collection in communal systems or mixed systems and a fractional logit model explains the gradient of transition in systems of collection. Mixed system are preferred if resource is available, markets are developing, labour for collection is available, competition for resource is high, forests where gum is collected are located near to the village, or market prices are high enough to attract occasional collectors who reinforce the effect of competition.

Keywords: resource governance, evolution, transition, fractional logit, gum arabic.

6.1 Introduction

Theories of transition in farming systems suggested on the one hand, that the shift to agriculture/animal husbandry was due to decreasing productivity in hunting and gathering production systems (Grigg, 1974; Jones, 2001); the causes of decreasing productivity include increased population pressure and sedentism, and the resulting overexploitation of the environment. Technological progress was hence regarded as pushing the shift to agriculture

(Grigg, 1974; Myers and Marceau, 2006). Environment is also among the recognised factors of change; Layton et al. (1991) suggested that climatic change pushed the shift from hunting and gathering to intensive husbandry. An interplay between population pressure and technological sophistication in explaining the adoption of agriculture was suggested by Baker (2008) following the theories developed by Boserup. According to him, societies that practice agriculture are indeed more technologically sophisticated, have greater population densities and operate in environments which appear to be richer and more amenable to agriculture. Specific to animal husbandry, besides the influence of the above factors, animal domestication was driven by resource conservationism (Alvard and Kuznar, 2001). Resource conservation is also one the main reasons for domesticating forest trees but their morphology may be a constraint to its adoption especially for thorny trees such as *Acacia senegal* (Mallet et al., 2002).

Changes in farming systems, animal husbandry or tree domestication were almost always accompanied by a change in resource governance from open to exclusive property rights system. North and Thomas (1977) confirmed that the private system provided a direct incentive for innovation in order to improve efficiency. According to Ruttan (1989, 2002), the change in governance systems originates both from the demand for and supply of institutions. On the demand side, changes in factor productivity and product demand; and on the supply side, distribution of political resources, cost of achieving social consensus and cultural endowments (e.g., ideology and religion) could explain the change in institutions. Ruttan (2002) gave examples of the enclosure movement in England during the 15^{th} and 16^{th} centuries whereby the expansion in the export demand for wool required the conversion of open arable and common lands to private pastures. Also, an increase in the demand for rice in Thailand in 19^{th} century made investments in land development for rice production profitable. This induced a demand for the reform of property rights. Note that authors like Cohen and

Weitzman (1974) however dispute the wool trade story as a factor of enclosures, arguing that the opposite was the case. What is important here is to realize the contribution of market developments to the dynamics of transition by adding value to the resource and motivating decisions to enforce property rights which are necessary to give individuals the long-term incentives to invest in resources and use them efficiently (Demsetz, 1967; Alchian and Demsetz, 1972; Behnke, 1997). Another source of institutional change includes land scarcity. Production in agriculture can be increased from expansion in land area by deforestation which however reduces the stock of natural resources; as continued population pressure constrains the availability of land, a formalisation of land ownership becomes a requirement in order to undertake investments so that the land productivity can be increased (Ruttan, 1989; Quisumbing and Otsuka, 2001; Grimm and Klasen, 2009).

Similar to farming, market developments and higher demand or prices provide incentive for increasing the production of non-timber forest product. According to Belcher and Schrekenberg (2007), higher production can be achieved through intensive or extensive harvesting or by intensified management. Intensive harvesting to obtain more product per unit area may lead to over-exploitation of the species and a decline in resource base depending on the resource tenure system and the reproductive capacity of the resource: in conditions of open access and common management, increased value leads to uncontrolled competition for resources, inefficient and damaging harvesting through the pressure to harvest immature product, or harvest beyond sustainable levels with the explanation that another person would harvest the product. Marshall et al. (2006) support that in such circumstances, profits for harvesters are pushed to the minimum. Extensive harvesting implies the possibility of extending the area under collection which can happen when competition for the resource and hence pressure are low. In situations where the resource base is limiting and the competition among harvesters is too high, intensified management (such as cultivation or tree

domestication) is the only option for increasing the quantity of production. Intensified management can also give better quality products and more control over the timing of production. Hence, as demand or prices increase, the rewards for intensified management also increase. Intensive production is possible where producers have access to individually held land or trees or if the resource is held under communal tenure with clear management rules.

From the above review, private property is always presumed to be efficient and to increase production whereas open resource management is found not only to decrease the producers' incentives for resource management, but also to lead to overexploitation and cause conflicts over resources (e.g., Hardin, 1968; Dafinger and Pelican, 2006). The question remains however that if the private property system is recommendable, why are there still several cases where communal and open systems are preferred? In other words, it is pertinent to understand reasons behind the slow transition to private property. To answer this question, an exogenous context is needed whereby the influence of factors such as population pressure, market, resource availability (land or trees) on resource governance systems can be investigated. Gum collection in Senegal provides a relevant study case: the currently observed slow transition from communal to private collection systems helps us to analyse why communal systems continue to exist despite that competition may intensify in communal plots and decrease the individually collected quantity (in chapter 3) and that these communal systems directly have negative consequences on the quality of gum collected (in chapter 5).

As collection is mostly done through tapping (the collector makes a cut to the tree and returns to the tree several days later to harvest the gum that has exuded), the collector should hold certain ownership or user rights to the tree and/or property such that he has certainty to find the gum; hence private collection systems would generally emerge together with tapping. These private systems also provide an incentive to plant and manage trees as suggested by agroforestry literature (e.g., Fortmann, 1985; Wiersum, 1997). In Senegal, however, even if

tapping has been performed as early as the 18th century, the communal system of management of Acacia plantations is still prominent. Private systems slowly emerge in some gum producing villages where collectors or companies (e.g., Asylia Gum Company) can have ownership of forest plots[12]. In such gradual transition, mixed systems are found where privately owned properties and communal forests coexist. We examine whether the transition in systems of gum collection may be explained by the expansion of the market for gum arabic, competition in and for property, or resource availability.

In the next section, we present an account of the historical evolution of the gum arabic collection systems. A methodology section then follows where we first develop a model showing the household's behaviour in different collection governance systems and secondly present an empirical strategy of analysing factors that influence the choice of collection systems. Subsequently results are presented. In the last section we discuss these results, and present conclusions.

6.2 Brief historical evolution of the gum arabic collection systems in Senegal

Gum collection in West Africa was practiced as early as the 15th century when Muslim merchants (Trarza emirs in Southwest Mauritania) used to send slaves into forests to collect gum either as organized slave groups or as part of their daily labour; these emirs tightly controlled trade with the Djolof (an area which is part of the current Sylvopastoral zone in Senegal) (Freudenberger, 1993a; Webb, 1985, 1995). Until the 18th century, wild collection prevailed in the Djolof, and it is only during the 19th century that the black maures (from Mauritania) introduced tapping and showed the use of bush fire to induce higher yields from *Acacia senegal* trees. With the colonisation, the French administration built an infrastructure of roads, wells and railroad in an effort to draw Wolof cultivators and fulbe pastoralists into gum collection: villages were coerced to collecting gum through debt peonage by European

[12] A distinction was not made between land rights and tree rights because it is not evident that they are substitutes (see for e.g. Bruce and Fortmann (1999) for cases when tree rights substitute for land rights).

merchants in which villagers were required to pay back in terms gum arabic the loans granted at usurious rates. By the 1910s, gum arabic had become one of the principal cash crops exchanged for over-valued imported items such as fabrics. Hence *Acacia senegal* rapidly evolved from being a user-value species, long employed by the fulbe and wolof for livestock forage and timber, into an exchange-value species highly esteemed for the readily marketable gum (Webb, 1985).

According to Freudenberger (1993a), the expansion of the market for gum arabic stimulated a transformation in labour relations and in the tree tenure systems that determined access rights and resource management practices: the wolof nobility was granted access to the areas with the densest concentration of *Acacia senegal* and hired the black maures to harvest and transport gum to the market centres; the wolof farmers collected gum in a second zone found primarily around the villages of the Senegal river valley, here heads of lineages received gum collection rights from the chief and then allocated subsections to relatives and dependents. Surprisingly, the maures were also granted access to the forests in the far north-eastern of the Djolof through seasonal collection rights. This was achieved through the intervention of Muslim clerics who in turn received tithes in form of the collected gum.

In the 1930's, French hydrologists discovered the Maestrichian aquifer which enabled the construction of boreholes. As a consequence, pastoralists changed their transhumance patterns in the dry season and settled around these boreholes and their presence in the zone attracted them to gum collection: young fulbe herders could furtively collect gum nodules after the maures had tapped their trees (Freudenberger, 1993a,b; ISRA/BAME, 1999). Moreover, while pastoralism by transhumant fulbe was previously complementary to gum collection by maures along the seasonal patterns, competition over gum resources ensued especially as the settled fulbe also took on gum collection. The competition increased even more during the Great sahelian drought of 1968-1974 that decimated the livestock;

pastoralists took collection as a coping strategy (Adriansen 1999; Wane et al., 2006). Conflict over the forest areas followed and the fulbe were granted collection rights on trees found within the immediate vicinity of their scattered encampments. Maures migrated to the south-eastern part of Linguère (in SPZ) were they pioneered gum collection. There, they were in competition over land with wolof agriculturalists. Continued mobility of collectors in search for trees and land lead to the spread of gum collection farther to Eastern Senegal. However, the decrease in international prices of gum arabic in the 1990s resulted in a decline of gum collection to a marginal activity, used as a survival strategy (Adriansen 2006, Freudenberger, 1993a).

The historical overview of gum collection in the Sylvopastoral zone reflects the involvement of different ethnic groups through their establishments and economic activities, differences in collection rights, and market pressures. It has also shown problems associated with competition over resources induced changes in collection systems, based on ethnicity and movement. The boxes illustrate such process of change towards the current collection systems where we observe not only the traditional communal collection but also a trend towards privatisation by division of the area into individualised family plots and formal acquisition of private plots.

Illustration 1. Louguéré Thioly, Sylvopastoral Zone

Lougéré Thioly was formed around 1920 by migrant fulbe pastoralists who found a water pond and pastures and camped in the area. In 1950s with the construction of a borehole (DPS, 2005), the pastoralists were joined by wolof agriculturists. The borehole facilitated sedentism; occasional livestock migrations only occur during the dry season towards the southern Fouta. Cultivators who grew millet during the rainy season were the first to discover the importance of *Acacia senegal* using its bark as ropes for tying their sacks of millet. In decorticating the tree off its bark, these cultivators noticed the gum oozing from

the tree. They collected and sold it to traders who passed by the village in search of water. The gum attracted not only the attention of agriculturalist, but also of pastoralists and later of the maures who were professional gum collectors. The maures settled in and they would go into the forest, tap trees and collect gum until the end of the season. While forests were open to collection by anybody, the increased number of collectors led to the division of forests into individualised plots according to the size of the family. In this division, markings were made on trees such that each mark would be associated with a single family; a family could have several plots. Such markings ushered in privatised systems with clear distribution of plots and recognised exclusion rights. Theft cases were referred to authorities. However, these markings confer only seasonal or at the most lifetime ownership; permanent ownership is only conferred by legal registration. Nevertheless, as competition over land is not excessive, the need for registration has not yet arisen.

(Recorded in Louguéré Thioly, 15-03-2010)

Illustration 2. Kadiel, Eastern Senegal

In the old times, agriculture used to be the main economic activity in Kadiel. But due to declining soil productivity resulting from degradation, the agro-pastoral system is now common practice in the village; it is supplemented by gum exploitation. There are about 30 gum collectors in the village. They collect mainly from natural forests; but there are also plantations by past tree planting projects such as PROVOBIL (*Projet de Boisement Villageois*) (Dione and Sall, 1988) and private initiatives (e.g., Tijaane, a Muslim community, planted more than 2000 seedlings); some collectors have even started plantations on their own land properties whereas other collectors obtained portions of the forests through formal requests from the rural community administration.

There are different management systems of the above properties: owners of private plots are able to exclude collectors who are not their relatives with the advantage of having

permanent control over the use of the product and appropriation of the income realized from collection. The common forests/plantations are so large that rules of collection have to be agreed upon by six other villages that also have access to these forests/plantations.

Within the coverage of Kadiel, an informal division of the forest exists, however, there are many cases of theft when a collector deliberately crosses the limits of his 'property' to harvest gum from another person's property. Such conflict cases are generally resolved within the village. Private properties seem to produce more gum than common property. Soil degradation and bushfires are the main problems faced by the village; they lead to declines in tree density and production.

(Recorded in Kadiel, 16-04-2010)

6.3 Methodology

The above historical trend and illustrations show that a change is slowly taking place in systems of governance of gum arabic collection. The change is not however spontaneous; it is part of a decision that involves an optimization of utility from collection. Such decision is theoretically modelled in terms of the number of trees and distance between them, competition in labour time between collection and leisure, and competition over resources. Beshai (1984) believed in the existence of resource excess capacity such that collection only depends on the intensity of effort and there is no diminishing marginal productivity. We hereby show that the utility of a collector reduces if there is competition from others especially when collection is unregulated.

A model of gum arabic collection

Consider first a single household in a setting without competition. Let production per tree be dependent on the labour per tree:

$f = f(\ell)$, say ℓ^{τ}, with $0 < \tau < 1$ (1)

Let the distance walked per tree take a time equal to d. Total time needed to collect gum from n trees then equals $n(\ell + d)$, yielding a production of $nf(\ell)$.

Let the utility function of the household be:

$$U = U[nf(\ell); T - n(\ell + d)] \quad (2)$$

where T is the time endowment of the household. We can then derive the first-order conditions for the labour time spent per tree and the number of trees that the household harvests:

for the time:

$$U_1 nf' = U_2 n, \text{ so that } f' = \frac{U_2}{U_1} \quad (3)$$

for the number of trees:

$$U_1 f = U_2(\ell + d) \text{ so that } f = \frac{U_2}{U_1}(\ell + \mathrm{d}) \text{ or } f = f'(\ell + d) \quad (4)$$

The ratio $\frac{U_2}{U_1}$ represents the value of time for the household resulting from the trade-off between collection and leisure, expressed in units of gum in this case. The ratio is seen to affect both the time spent per tree and the number of trees, but actually time per tree and production per tree can be derived; if we use the exponential production function $f(\ell) = \ell^{\tau}$, we can derive that in the optimum:

$$\ell = \frac{\tau d}{1-\tau} \quad (5)$$

$$f^* = (\frac{\tau d}{1-\tau})^{\tau} \quad (6)$$

$$\ell + d = \frac{d}{1-\tau} \quad (7)$$

Hence $U = U[nf^*, T - \frac{nd}{1-\tau}]$ and the optimal number of trees then follows from:

$$\frac{U_2}{U_1} = f^* \frac{(1-\tau)}{d} \quad (8)$$

Figure 6.1 illustrates the influence of the number of trees on labour productivity and value of time.

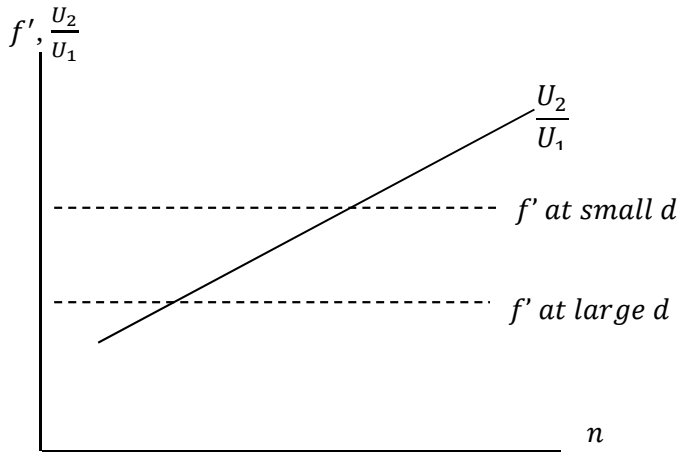

Figure 6. 1. Labour productivity and value of time

The marginal product of labour (f') in the optimum tends to be lower if trees are farther apart (at large d, more time is spent per tree). As normally the value of time is a positive function of n, the optimal number of trees will be smaller for larger distances.

For a simple Cobb-Douglas utility function $U = Y^a\ (T - t)^b$, where Y is income and t is time spent in collection, it is straightforward to derive that the optimal number of trees would be:

$$n = \frac{aT}{(a+b)(\ell+d)} \text{ or } \frac{a(1-\tau)T}{(a+b)d} \quad (9)$$

This equation shows that the number of trees picked increases if the household has more time available, attaches more value to income (parameter a), or less to leisure (b), or the forest is more dense (lower d).

If the household would not have nf as income Y, but other sources of income too, say c, then the expression for optimal n changes to:

$$n = \frac{a(1-\tau)T - bdc/f^*}{(a+b)d} \quad (10)$$

in which the relative importance of other income, expressed as $\frac{c}{f^*}$, induces the household to spend less time in collection.

More households with competition for trees

If there are more households collecting gum, and the total optimally chosen number of trees of the households exceeds the total number of available trees, two options arise to regulate competition as of privatisation of the resource or to let competition follow from unregulated collection.

In the privatization process, trees are allocated to households. Typically, if we have m households (presumed identical) that optimally would each exploit n^* trees, a case may arise that $m.n^* > N$, the total number of trees available. Privatization would then entail a division of the N trees over the m households, each receiving $n = \frac{N}{m}$. This implies that an individual household will collect less than the optimal number of trees, and the only optimizing variable is the amount of time it will spend in collection. Thus only the first of the first-order conditions will apply. The restricted lower level n will imply that the ratio $\frac{U_2}{U_1}$ will be lower, leading to a lower shadow price for the labour of the household, and (using (3)) somewhat lower marginal product of labour f', implying that more time per tree is spent.

In the example of a Cobb-Douglas utility function, the optimum with a restricted value for n is given by:

$$\ell = (\frac{T}{n} - d)/(\frac{b}{a\tau} + 1) \qquad (11)$$

This expression is different from what we had before in (5). In the unrestricted case of a single household, time spent per tree increased with distance, and the adjustment was made in the number of trees (n^* falls if d increases). In the restricted case, larger distances between the trees induce the household to spend less time per tree so that the household can visit the given number of trees. Total time spent in the optimal case (and the simple Cobb-Douglas function) would be $\frac{n^* d}{1-\tau}$, with n^* as shown above in (9), or optimal labour equal to $\frac{aT}{a+b} - d$. In the restricted privatized case, total labour time for gum picking comes at $\frac{a\tau T + bnd}{a\tau + b}$. From this,

the corresponding utility can be derived. This case applies where the community responds to competition by regulating access and dividing the trees equally amongst collectors.

Suppose there is an exogenous factor λ that affects the productivity of labour such as making a good collection in a year if $\lambda > 1$ or bad collection if $\lambda < 1$. The production per tree is thus $f = \lambda\, f(\ell)$. This factor does not have any effect on the household's value of time but leads to new equations for the optimal number of trees in the unrestricted case and optimal labour in the restricted, privatized case respectively as:

$$n = \frac{aT}{(a+b)(\lambda\ell+d)} \tag{12}$$

$$\ell = \frac{T/n-d}{(b/a\tau+1)\lambda} \tag{13}$$

This implies that in a good year, the collector needs to harvest fewer trees or spend less time in collection (for e.g., harvesting from nearby branches) whereas the reverse would happen in a bad year.

Furthermore we can extend the case of regulation to include a monitoring cost. The process of entering into privatisation itself involves a cost to reach an agreement as to how to divide the area. Additional costs are fixed (e.g., investment in fencing or lump sum payment to a third-party to assure protection of trees) and variable (labour for monitoring). Suppose that the household pays a fixed cost k out of his income Y. Then the expression for optimal labour becomes:

$$\ell = \frac{a\tau T}{n(a+b)-(bk/f^*)} \tag{14}$$

The household utility falls with increasing cost of privatisation and due to the relative cost $\frac{k}{f^*}$, the household has to spend more time in collection.

Unregulated access with competition

The unregulated case is elaborated to allow for competition even when trees are still abundant. It reflects the possibility that households can hinder one another by (deliberately or not) harvesting trees that are also visited by other households. Hence, we model this case as if households randomly select trees, for each tree covering a distance d, and collect gum from the tree if it is there. If another household had selected this tree before, no gum is there and the time costs d are made without returns to this effort.

Let there be m households interested in gum collection, all presumed identical. The first trees selected (out of N trees) will bring each household gum, $f = f(\ell)$. The effort involved is $d + \ell$. The trees selected form a share x of all trees $x = \frac{m}{N}$. The second collection round costs d again, but a share x of the trees visited will bear no gum anymore. A share $1 - x$ will be picked with an effort ℓ again. Hence production is $(1 - x)f(\ell)$; effort is $d + (1 - x)\ell$. The n^{th} round will require an effort of $d + (1 - x)^{n-1}\ell$ with a harvest of $(1 - x)^{n-1}f(\ell)$. In total, therefore, picking n trees will require nd plus the sum of the picking efforts which is $z\ell$ with:

$$z = \sum_0^{n-1}(1 - x)^i = \frac{1-(1-x)^n}{x} \quad (15)$$

Each household then maximizes utility $U = U(Y, T - t)$ with Y being the gum collected equal to $zf(\ell)$ and t being the time spent in collection equal to $z\ell + nd$. First-order condition for a maximum of $U[zf(\ell), T - (z\ell + nd)]$ for ℓ is that:

$$U_1 zf' = U_2 z \text{ or } f' = \frac{U_2}{U_1} \quad (16)$$

First-order condition for n requires differentiation of:

$$\frac{dz}{dn} = -\frac{1}{x}(1 - x)^n \ln(1 - x) = v \quad (17)$$

The condition for optimal n then becomes:

$$U_1 vf = U_2(v\ell + d) \quad (18)$$

so that now

$$f = f'\left(\ell + \frac{d}{v}\right) \tag{19}$$

This is different than in the original case (equation (4)).

To get a grasp of the significance of this result, consider that the share x is the ratio of households to trees or $\frac{m}{N}$. Typically $m.n \approx N$ (roughly all trees are harvested), so that x could be roughly $\frac{1}{n}$. Inserted in the formula for z, this would lead to:

$$z = \frac{1-(1-x)^n}{x} \approx n[1 - \left(1 - \frac{1}{n}\right)^n] \tag{20}$$

The limit of $(1 - \frac{1}{n})^n$ for n tending to ∞ is $\frac{1}{e}$ or roughly 0.37, so that for larger n, z comes close to $0.63n$ which means that n visits to trees lead to $0.63n$ visits that are successful, i.e., to trees that are bearing gum. This shows the inefficiency of the system which occurs even when the resource is not fully utilised. As the number of competitors increases, the number of trees being the size of the resource on which the household has control gets smaller and smaller, households therefore need to spend more time per tree to obtain higher production per harvested tree. Table 6.1 illustrates the effect of the number of household and trees on effort.

Table 6. 1. Values of $\frac{z}{n}$ at N=1000

n \ m	5	10	20
50	0.89	0.79	0.64
100	0.79	0.63	
200	0.63		

The table also shows that even with underutilization of the resource there can be substantial inefficiency if tree selection would be completely unregulated: with 5 households and 50 trees per household, only a quarter of trees is harvested, but 11 per cent of the trees visited would have already been picked by others. For m rising to 10, this increases to 21 per cent. Furthermore, the first derivative of z with respect to n, v, takes on values in the range of 0.3 to 1. As shown by the equation (19), this implies that the unregulated competition acts as if

the distance between trees increases from simply d to something that can be as 3 times as large.

Equation (13), in combination with an assumed production function of $f(\ell) = \ell^{\tau}$, leads to optimal labour:

$$\ell = \frac{\tau}{1-\tau} . \frac{d}{v} \tag{21}$$

so that total labour input $t = z\ell + nd$ comes at:

$$t = \frac{nd}{1-\tau}\left[\left(\frac{z}{vn} - 1\right)\tau + 1\right] \tag{22}$$

The factor $\frac{nd}{1-\tau}$ is the labour input without competition or restriction, which is multiplied by a term which is greater than 1 if $\frac{z}{vn} > 1$. This is normally the case; e.g., for the values in Table 6.1, the ratio $\frac{z}{vn}$ ranges from 1.72 on the diagonal to 1.13 in the top-left cell. Hence more labour in total is typically spent compared to the situation without competition irrespective of the value of n, and the more so, where the competition for scarce resources is fiercer.

As to the choice of number of trees to be visited, a larger n leads to smaller v, and thereby to marginally larger optimal values of ℓ. While more effort per harvestable tree may be made, a smaller share of harvestable trees is found as n increases. The optimal number of visited trees was given in equation (9). To include the effect of competition, d is replaced by $\frac{d}{v}$, so that the new expression for an approximate value of the number of trees in the unregulated case is:

$$n^{unreg} \approx \frac{a(1-\tau)vT}{(a+b)d} = v.n^{orig} \tag{23}$$

This number of trees is typically much lower than in the original case.

The model shows that utility of a household increases with less competition; in case of privatisation, a maximum utility will be reached such that for fewer competing households, more trees will be (privately) available than the household would choose to use. The utility of

a household in an unregulated environment continues to improve with less competition, as there will be some interference even with a few households. The regulated case of privatisation of the resource is preferable to unregulated competition, unless the net gains from privatisation (having taken into account the cost of monitoring) do not exceed the decline in utility due to competition in unregulated system. Figure 6.2. illustrates the comparison of unregulated system with regulated systems following equations (8), (14) and (16).

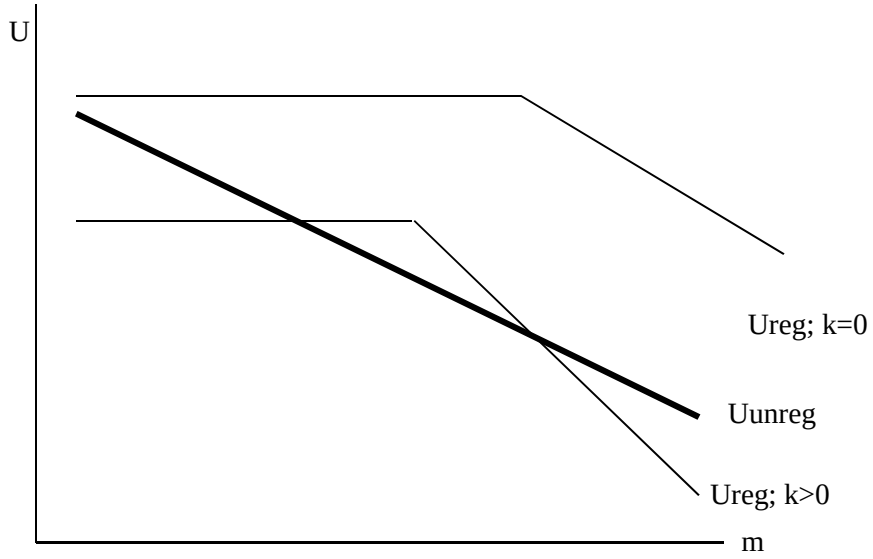

Figure 6. 2. A comparison of the regulated and unregulated systems

In the unregulated system, utility falls even at low levels of competition. In the restricted system, with low levels of competition, households can maximize their utility which is fixed as long the available number of trees that they can visit exceeds the optimum ($n > n^*$). With an increase in number of collecting households (m) such that a household does not have access to n^*, the utility falls. Without costs (k=0), utility in the regulated system is always higher than the utility in unregulated system. A maximum is reached when m is large, because then more trees are privately allocated. With costs (k>0), the utility curve of the regulated system shifts downward and becomes steeper, so that for higher values of m, utility falls

below the unregulated system. At low values of m, the unregulated system is preferred, but this is due to the application of the cost even when the regulated system is not constraining. This will not normally occur as it implies that something is regulated at a cost without bringing additional benefits. In case where the cost is low, even at low population levels, a private system is preferred. But with increasing population and fixed costs per household, the unregulated system may be again preferred. This is counterintuitive, but is explained by the fixity of the costs per household, which weigh heavily in case of small allocations of trees (and large m).

A threshold line of the ratio of the population to the cost of regulation can be derived at which the household chooses to change from unregulated to a regulated private system (Figure 6.3.)

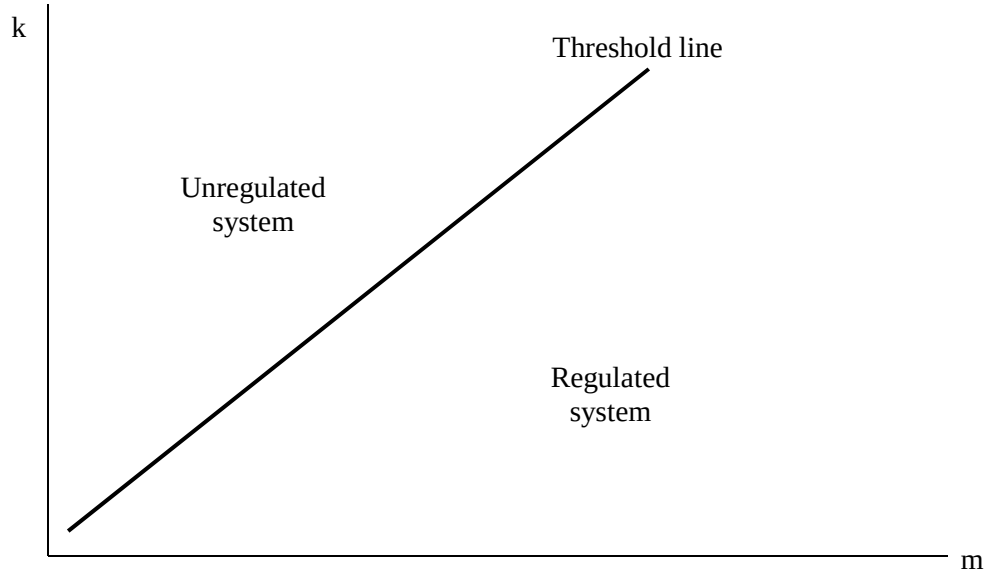

Figure 6. 3. Threshold in tenure systems

There are clear cases of preference of tenure system: private regulated system is preferred when competition is high and regulation cost is low (high m, low k) and the communal unregulated system is preferred when competition is low and cost is high (low m, high k). Moreover, due to the fixed costs per household, the threshold level where mixed systems may occur is identified such that when competition is low and cost is low (low m, low k),

privatisation is preferred, whereas when competition is high and cost is high (high m, high k), communal system is preferred. In conclusion, the (fixed) cost of regulation seems to be more as important as competition in the choice of governance system: where the cost is high, unregulated systems are preferred and when the cost is low, private systems are preferred[13].

Empirical strategy

Determinants of the choice model as to why a village organises collection either in private or communal system are mainly derived from our theoretical model. The model predicted factors that are important in the governance systems of gum collection. These include the number of trees (n), distance between trees (d); total labour availability (T) competition in labour time between collection and leisure[14]; outside sources of income(c), competition over resources with other collectors (m); environmental influences on the productivity of tree (λ); and cost of regulation (e.g., monitoring cost) (k). Furthermore, following Yang et al. (2009), we also include market characteristics. Different sources of data were used to obtain variables associated with the above determinants that are exogenous to the choice of a collection system (Table 6.2).

Table 6. 2. Exogenous variables and data sources to the analysis of transition in gum arabic collection systems in Senegal

Variable	Description	Data source
Number of trees		
Tree coverage	The land covered by shrub trees gives an indication of the presence of *Acacia senegal* trees in the domain area where the acacia species is prevalent.	GLCN (2009)
Distance between trees		
Tree density	The amount of tree material per hectare. The density is very important in accounting for the sparseness of trees.	GLCN (2009)

[13] The model can also include the cost of governance of unregulation, such as organising collection collectively.
[14] We assume the labour/leisure ratio to be constant.

Income source		
Livestock ownership	The average TLU per household is an indication of the village's source of livelihoods and income but also of dependence on the tree resource. TLU values are 1.4 camel, 1.0 cattle, 0.5 donkey, 0.1 sheep/goat (FAO, 2004)	Survey (2009, 2010)
Labour availability		
Village size	If at least one adult person per household is able to collect gum, the village size roughly indicates the size of prospective collectors	PEPAM (2006)
Competition over resource		
Collector density	The average number of people per square kilometre of land covered by trees, the higher this density, the higher the competition for trees.	GLCN (2009)
Environmental influence		
Rainfall	Average of the cumulated rainfall during June-October in the period 1991-1998; it gives an indication of degradation	UMR HydroSciences (2005)
Monitoring cost		
Average distance to furthest property	If the tree plot is located far from the village, monitoring for protection (surveillance) will be very costly unless it can be collectively organized.	Surveys (2009, 2010)
Market sources of competition		
Change in average gum sale price	This is the change in average gum price between 2008 and 2010. As an incentive to collection, an increase in price attracts collectors.	Surveys (2008, 2010)
Distance to nearest market	Access to market increases acts as an incentive to collection	Surveys (2009, 2010)

GLCN: Global land cover network
PEPAM: Programme d'eau potable et d'assainissement du millénaire
Survey refers to primary data collection by researcher.

Additionally, we include a regional dummy as a control variable; regions correspond to the gum arabic production areas in Senegal which include the villages in Sylvopastoral Zone and in Eastern Senegal.

There is concern about the endogeneity of the livestock ownership and collector density to the governance system. The availability of resource may be constrained by livestock herding where over-grazing causes the resource deterioration. This is especially

relevant because the negative impacts of grazing on tree and land resources in arid/semi-arid regions are strong. Schlesinger et al. (1990) and Milchunas and Lauenroth (1993) found that (over) grazing causes the loss of soil fertility and leads to desertification of formerly productive grassland. All the same, while these effects are important at the village level, the emphasis on livestock ownership in the current analysis is its income generating capacity function to the household. On the other hand, the collector density is perhaps the closest representative of competition for Acacia trees as where the Acacia area is vast in communal forests, the collector density tends to be low. Forests that are efficiently managed tend to attract many collectors such that collector density remains high until some regulation can be put into operation. As no valid instruments were found to control for the possible correlation, the estimation results shall be carefully interpreted.

The theoretical model was developed at household level while the empirical model is done at village level, as reflected in the choice of variables. This level of analysis does not influence the main results and it has the advantage of explicitly recognising that a change in governance is effected from the higher level[15]. Data relate to 53 random villages in the Sylvopastoral Zone (22 villages) and Eastern Region (31 villages) in Senegal. Twenty-four (24) villages continue to organise collection in a communal system whereas 2 have purely adopted a private system, the remaining 27 villages have mixed systems where communal and private systems coexist.

Econometric analysis

Two models are proposed for the empirical analysis:

(1) A probit model is used where the observed outcome is either to exploit gum in communal management systems (0) or in mixed systems (1). The presence of only 2 villages which

[15] Collectors can collectively demand for a change in system of governance, but the change is often effectively realised at the village level whereas an individual collector will choose to implement the change and enforce his rights in consideration of the behaviour of other collectors. Young (2002) and Berkes (2002) established that there are interplays between institutions at different level while de Meza and Gould (1992) showed how an individual decides to enforce his rights.

adopted the pure private system did not enable us to have a separate category for a multinomial analysis; hence these villages were included in the category of mixed systems.

(2) A fractional logit model is used with the dependent variable as the gradient of transition; the extremes represent the communal and private systems (values of 0 and 1 respectively) and in-between are the proportions of collectors who manage their collection in private systems within the village sample. The motivation for using a fractional logit model is the explicit recognition that collection systems are not always binary but that they are mixed at different levels. The fractional logit model generates efficient estimates because the dependent variable is a proportion between and including 0 and 1; the model is fitted with the generalized linear model command (for details see Papke and Wooldridge, 1996).

6.4 Results

Table 6.3 compares the statistics of determinants of the choice of a village's organisation of collection system between villages according to the management of gum collection in a communal management system (CMS) and mixed management system (MMS).

Table 6. 3. Characteristics of collection management system

Variable	All villages (53)	CMS villages (24)	MMS villages (29)	Equality test[a]
Tree coverage ('000 km^2)	0.33	0.20	0.44	0.92
	(0.890)	(0.232)	(1.183)	
Tree density (tree/km^2)	34.6	41.7	28.7	6.51**
	(19.363)	(14.059)	(21.335)	
Livestock ownership	17.8	12.3	22.3	9.11***
(TLU)	(12.856)	(8.665)	(14.097)	
Village size (households)	40	31	47	5.53**
	(25.889)	(25.367)	(24.379)	
Collector density	0.42	0.30	0.52	1.64+
(person/km^2)	(0.622)	(0.379)	(0.760)	
Rainfall ('000 mm)	0.54	0.60	0.48	22.81***
	(0.112)	(0.081)	(0.104)	
Average distance to	15.8	18.7	13.6	3.80*
furthest property (km)	(9.560)	(9.881)	(8.817)	
Distance to market (km)	11.5	14.3	9.2	5.32**
	(8.437)	(9.453)	(6.804)	

Change in average gum sale price (percentage)	34.86 (45.59)	42.23 (52.892)	28.76 (38.442)	1.15+

[a]ANOVA test: *** significant at 1% level, ** significant at 5% level; * significant at 10% level, + significant at 15% level.

In comparison with villages that organize gum collection communally, the villages that have adopted mixed (and purely private) collection systems have significantly lower tree density, higher livestock ownership, high collector density and lower rainfall levels. Furthermore, these villages are larger, organize collection in forest plots located at shorter distances, and are on average established nearer to physical markets, whereas they have experienced a smaller increase in average gum sale prices in the period from 2008 to 2010.

A closer look at these villages in mixed systems enabled us to have a gradient of transition which is the proportion of collectors in the village who organize their collection in private systems. The gradient ranges from 0 to 1 from communal to private systems respectively; the intermediary values represent mixed systems. The average gradient of transition within mixed villages is 0.58. Certain characteristics of mixed systems are shown in table 6.4; the classification of villages into communal or private dominant is based on the gradient of transition: if the gradient is 0.50 or smaller, the village has a tendency to communal dominance.

Table 6. 4. Characteristics of mixed management systems

	MMS (27)	**Communal dominant (14)**	**Private dominant (13)**	**Equality test[a]**
n cases	157	61	96	
Categorical factors (%)				
Acquisition of property through inheritance	39.5	31.1	44.8	2.91*
Acquisition of property through request	55.1	61.7	51.0	1.91+
Use of exploitation permit	52.9	49.2	55.2	0.54
Tree markings in property	41.4	19.7	52.9	19.41***
High frequency of thefts	42.0	45.9	39.6	1.09+

occurrence				
Continuous factors[b]				
Experience in collection (years)	24.5 (11.413)	24.2 (11.043)	24.6 (11.697)	0.044
Tree age (years)	10.5 (5.123)	11.4 (4.968)	10.0 (5.170)	2.901*
Labour productivity (kg/day)	34.3 (16.023)	34.4 (15.390)	34.2 (16.491)	0.011

[a] Chi-square test for categorical variables, ANOVA test for continuous variables.
[b] Standard deviation in brackets
*** significant at 1% level, ** significant at 5% level; * significant at 10% level, + significant at 15% level.

Within mixed villages whether they are communal or private dominant, there are no significant differences with respect to the use of exploitation permits, average experience of the collectors, or average daily labour productivity. There is no active land market in gum producing villages in Senegal. Hence, in villages where the private collection system is dominant, inheritance is the main mode of the acquisition of property whereas in villages where the communal collection system is dominant, property is acquired mainly through request from the village chief, however, the cases of continued collection in the same communal forests are commonly found. Tree marking as proof of property is more popular in villages where private system is dominant than in villages where communal system is dominant each family has its unique marking[16]. The frequency of thefts is higher in villages where communal system is dominant than in villages where private system is dominant.

Determinants of the choice of organisation of gum collection systems are analysed through probit and fractional logit (flogit) models (Table 6.5).

[16] The intuition behind the marking of tree resembles that of traditional livestock branding in pastoral communities where livestock is marked in order to identify the owner.

Table 6. 5. Probit model (0: CMS, 1: MMS) and Flogit Model (Gradient of transition) of transition in gum arabic collection systems in Senegal[a]

	Probit Model (53)		Flogit Model (53)	
	I	**II**	**III**	**IV**
Tree coverage (‘000 km^2)	0.009	0.005	0.035*	0.039*
	(0.060)	(0.059)	(0.024)	(0.027)
Tree density (tree/km^2)	-0.160	-0.110	-0.056	-0.001
	(0.317)	(0.319)	(0.364)	(0.353)
Livestock ownership (TLU)	0.522**	0.543**	0.130+	0.106+
	(0.269)	(0.276)	(0.207)	(0.200)
Village size (households)	0.284+	0.437*	0.149+	0.313+
	(0.243)	(0.284)	(0.264)	(0.261)
Collector density (person/km^2)	0.055	0.079	0.197+	0.142*
	(0.129)	(0.137)	(0.100)	(0.098)
Rainfall (‘000 mm)	-0.264	0.691	-0.806	0.108+
	(1.385)	(1.641)	(1.182)	(1.370)
Average distance to furthest property (km)	-0.583**	-0.557*	-0.400*	-0.397*
	(0.313)	(0.325)	(0.313)	(0.322)
Distance to market (km)	-	0.147		-0.176
		(0.248)		(0.328)
Gum sale price change	-	0.142*		0.227*
		(0.115)		(0.199)
Zone (1: Eastern)	-0.489+	-0.516***	-0.411+	-0.635+
	(0.283)	(0.258)	(0.364)	(0.425)
Log (pseudo) likelihood	-19.353	-18.538	-22.493	-21.977
LR Chi-square	34.29***	35.93***	-	-
Correct classification (%)	77.36	81.13	-	-
Pseudo R-squared	0.470	0.492		
Predicted probability (y=mixed system)	0.641	0.654	-	-
Predicted mean (y=gradient of transition)	-	-	0.303	0.300

CMS: communal management systems
MMS: mixed management systems
[a] Marginal effects (standard errors):
*** significant at 1% level, ** significant at 5% level; * significant at 10% level, + significant at 15% level.

Model I and III show the influence of the resource availability, labour availability and competition over resources, other sources of income, environmental influences, monitoring costs and market characteristics on the (gradual) choice of a village to organise collection either in a communal or mixed system. High livestock ownership and a large size of the village increased the likelihood of organising collection in mixed systems whereas long distances to the plot decreased the likelihood of organising collection in mixed systems.

Besides in Model III, the collector density positively influenced the transition towards mixed systems (although the effect is weakly significant).

Model II and IV include market competition in addition to the resource availability and village competition. The above results are robust and in addition, the increase in average market price positively influenced the choice of transition towards private collection systems.

The marginal effect analysis shows that on the one hand, one per cent increase in livestock ownership and village size (I and II), rainfall, gum sale price change and distance to market (II) increased the probability of shifting towards mixed system by more than one per cent; also livestock ownership, village size and collector density (III and IV), rainfall and gum sale price change (IV) increased the gradient of transition towards mixed systems by more than one per cent. On the other hand, one per cent increase in tree density and average distance to furthest property (I and II) and rainfall (I) decreased the probability of shifting towards mixed system by more than one per cent; also rainfall (III), average distance to furthest property (III and IV) and distance to market (IV) decreased the gradient of transition towards mixed systems by more than one per cent.

The probit and flogit models reveal interesting results behind the process of transition: the probability to move towards mixed (and private systems) is high with about 60 per cent of villages that have shifted from communal systems. However, the gradient of transition is still low with on average only 30 per cent of collectors in villages who have readily shifted from communal systems.

In terms of tree coverage, the availability of resource is found to be important in making the change. It suggests that attempts to regulate the resource are interesting if in the first instance enough trees are available, and in other words, degraded areas are not attractive for privatisation.

Ownership of livestock also influences the tendency towards private/mixed systems despite that pastoralism is another source of income that would normally indicate less dependency on gum resource for livelihoods and hence less competition. This is not the case however, as in the first instance, income from livestock (sales of animals or animal products) is not profitably generated in the dry season when gum is collected. In the second instance, livestock ownership as sign of wealth at the village level can be linked to institutional development and better market access.

Competition within the village implies that on the one hand, large villages, which are an indication of the number of prospective collectors, prefer to orient collection towards private/mixed systems as stronger competition in the forest would lead to lower collection quantities for each collector. The cost of communal organisation or the risk of conflict over resource may also be very high if the number of involved potential users is high. Indeed, if there are several collectors competing for the resource such that the collector density is high, the village would prefer to adopt a mixed system.

If the plots/forests where gum is collected are located far away from the village, then communal systems are preferable because the monitoring cost is too high for a private owner to enforce his rights and protect the plot. Also in this case, not many collectors would venture into those plots and hence competition is also lower.

Market competition is straightforward in impact: higher prices attract occasional collectors whose behaviour is in contrast with that of professional gum collectors. Professionals are regular collectors but occasional collectors collect only when the price and market conditions are good. They do so because there are no (strong) exclusive mechanisms to the communally governed forests. Such non-professional behaviour leads to reduced productivity in communal resources and thereby creates the need for organising collection in private/mixed system.

6.5 Discussion and conclusions

Theories of origin and transition in farming systems advanced population pressure, environmental aspects and technological developments as the main factors influencing a shift in farming systems. These changes were accompanied or associated by changes in systems for resource governance. In the current study, we investigate the case of a non-timber forest product, gum arabic, with respect to changes in governance systems of collection from communal systems towards private systems, with mixed systems in the transition. These systems are distinguishable by the mode of the acquisition, with tree marking as an effective proof of property that limits the frequency of thefts; such markings are an indication of exclusive use rights (Wiersum, 1997).

The theoretical model confirms the early theories whereby the utility of a household was found to increase with less competition (or less pressure); factors that might influence the change in governance systems include resource and labour availability, competition over resources, monitoring costs, and market characteristics.

Empirical results confirm that the choice of private systems depends on resource availability. This is important as it directly determines the amount that a collector can expect to harvest and gives incentives for possible division of resource area into private plots. If the resource area is large, there is a possibility to practice extensive collection and at the same time increase productivity and quality of the harvested product (Belcher and Schrekenberg, 2007). However, it should be noted that very large resource areas may be difficult to manage (Yang et al., 2009); hence the area should be proportionate to the available labour as exemplified by the village size. The reverse side implies that resource degradation should be contained. Not explicitly included in the current study, but also an important factor causing the resource degradation in gum producing regions are bush fires as consistently found in the monitoring of such fires by the *Centre de Suivi Ecologique* in Senegal (CSE, 2009); if these

fires are not controlled, they can be devastating. Privatisation the resource can thus be associated with limiting destructive action and resource conservation (Homma, 1996; Alvard and Kuznar, 2001).

Livestock ownership and gum collection were presumed to be complementary sources of livelihoods which means that earning some income from livestock eases the necessity to collect gum and hence reduces the burden on the resource. Perhaps, a direct measure of income (which could be generated off-farm or by remittances) would have clarified the relationship between supplementary income and collection. What is observed here is a possible market development. Livestock ownership can be associated with development of livestock markets which can subsequently attract buyers of gum. As the markets develop and buyers are not exploitative as found in chapter 5, there is a possibility to increase income through collecting and marketing gum. However, these market developments will attract an increasing number of collectors and the result suggests that competition indeed plays a role in governance choice or change. This competition was found mainly to be the result of price incentives. In case of rise in price, these occasional collectors compete with professionals in plots to collect gum thereby reducing the individual quantity of gum obtained by each collector. Also in order to obtain the gum before the other collector gets it, gum may be harvested before maturity, thereby leading to inconsistent quality. The influence of market and related competition on systems of collection is also found in commercialisation of agricultural products (e.g., Quisumbing and Otsuka, 2001) or other non-timber forest products (e.g., Yang et al., 2009). These trends are in line with Ruttan's (2002) description of the change in governance.

While the organization of collection in private system is preferable for the purpose of increasing productivity and quality, preventing overexploitation of the resource, and generating short and long term incentives for tree management, there are cases when the cost

of enforcing such system is economically and socially too prohibitive such that communal systems are maintained. This cost is for instance related to monitoring: the monitoring cost would depend on the size of and distance to the collection area. If the area is located far away from the village, surveillance is efficiently done collectively by the villagers. Another reason not directly included here is of the mutual insurance offered by communal area. As resource users live in drylands where income streams are uncertain, communal systems may be indeed be more appropriate as they allow flexible and mobile responses to uncertainty and risk. In the case of study, this implies that the collector will not be restricted to his private plot particularly in a bad year. Hence, as popularised by authors like Grell and Kirk (2000), communal systems of resource governance would be preferred because they are an insurance mechanism in high-risk environments.

Discussion and conclusions

7.1 Introduction

Senegal is in the rank of small producers whose exports total to less than 5 per cent of world export, its registered exports have not exceeded 1,000 tons in the last decade (ITC, 2008; COMTRADE, 2011). Low exports imply that the country may lose some export revenues and that collectors of gum arabic may fail to see their livelihoods improved from larger incomes that could have been generated from the sale of gum. Such livelihoods, in the arid and semi-arid regions where gum arabic is harvested, revolve around short and erratic rains, and poor and fragile soils on which agriculture is not widely suitable except for some cereals and irrigated vegetables. Pastoralism is practiced in these regions, allowing for transhumance in the drought period.

Acacias species including *Acacia senegal* trees are among the drought-tolerant vegetation naturally suitable for the arid and semi-arid regions. These trees which have ecological benefits, household functionalities and palatable attractiveness to animals, also exudate gum arabic. Collection of gum arabic, similar to other non-timber forest products, is done with the purpose of labour diversification, consumption smoothing, coping with emergencies or accumulating wealth.

In Senegal, gum arabic is collected in the Sylvopastoral Zone (SPZ) commonly called the Ferlo and the agro-sylvopastoral zone also known as Eastern Senegal (ES). The SPZ covers almost all parts of the regions of Louga, Saint Louis and Matam; ES covers the region of Tambacounda. An average collector of gum arabic could annually harvest and market near to 900 kilograms in the SPZ and 120 kilograms in ES (in chapter 3), thereby earning about 500,000 CFA and 120,000 CFA respectively[17]; at prices prevailing in the season of 2009. Such income is substantial to the household given that collection is often a secondary activity.

[17] About 760 EUR and 180 EUR respectively.

Collection is open to rural households; however, continued low production and exports levels observed in the country imply that there might be inefficiencies on the marketing side that result from the lack of necessary price incentives. These prices are indeed very low compared to the efforts that are needed to collect gum. Hence the current study's main aim was to link the market side to the collection side in order to investigate sources of inefficiencies and explore ways to improve the performance of markets and thereby collection production/collection. Four questions became the focus: (1) do collectors have enough incentives from the market in terms of the net returns from collection and marketing? (2) do consecutive traders along the marketing chain exploit each other leading to low prices to collectors and therefore low supply? (3) are collectors supplying the gum of quality that is required by users? and (4) why is the transition from communal systems is slow despite their too many inefficiencies? Chapters of this thesis are an attempt to respond to these particular issues.

7.2 Summary of the main findings

Market incentives are fundamental to gum collection

The behaviour of gum collectors involves a decision of whether to collect or not with an intention to participate in the market where they can sell their product (as gum is only marginally consumed by households and a decision to collect can be made instantly at harvest time). The purpose of the decisions is to maximize their net expected returns. These returns are a function of the expected price excluding marketing costs and taking into account the distance to the nearest town and honouring the commitment to transact with a certain trading partner. The amount of gum collected is optimised depending on availability trees, usage of inputs and level of competition in gum producing forests.

Once the gum is collected, a choice of where to sell gum among the available alternative markets either in the village or at distant town market needs to be made. This

choice depends on the assessment of differences between village and town market prices which should be large enough to pay for going to the market. The choice also depends on the level of competition between collectors and the preference for certain a trader. While transport costs restrain the collector from going to a distant market, the investment incurred in concluding a transaction and repeated transactions with a trader increase the probability of going to the town market particularly when the household is able to combine its other activities with travelling to the market in order to sell gum.

The results suggested that gum collection is largely determined by marketing incentives in terms of price expectations. The choice of physical market where he sells his gum is the result of an evaluation of the price prevailing in markets and other market characteristics but also the level of proportional costs and the possibility to reduce the household labour opportunity cost through combining gum sales with other activities such as acquisition of household items. Methods to increase the amount collected can be adopted such as increasing labour productivity and regulating competition in forests, yet, market incentives are essential for the continuation of collection; they should be sufficiently high to cover for the costs of collection and marketing gum.

Traders cannot always be accused of exploitation

Traders of gum arabic operate in oligopsonistic market structures. These structures are observed consecutively along the gum arabic supply chain in Senegal, from primary traders to transporters and then wholesalers. The latter earn the highest margins as they transact large quantities and their unit costs remain relatively low because of economies of scale. High unit marketing costs are found in primary markets because of the small size of transactions occurring in dispersed markets. As a consequence, payments to gum collectors are low.

In this chapter, market shares of traders in their respective markets were computed and corresponding Herfindahl indices were derived. The results proved an increase in market

power as the number of buyers becomes smaller along the supply chain. However, they were not sufficiently high to confirm strong oligopsonistic tendencies.

The findings implied that, traders in the gum market, while working towards enlarging their supplies, do not necessary behave as oligopsonists by exercising their power in an exploitative manner. Their entry and performance in the market depends on the capital invested (human, financial, physical, communication and social capital) but they are constrained by competition. The value distribution along the chain (margins taken by each trader) depends on marketing costs, supply conditions, uncertainty and risk. The magnitude of risk could also be the main cause of market exit.

Benefits that traders obtain from gum trading are limited by poor market access conditions such as poor transportation, lack of infrastructure and market information in addition to individual and market related risks. The study also reminds of the important functions that these traders play in the gum sector in spite of the difficult marketing conditions. It is also a contribution towards breaking the myth that traders are always exploitative.

Supply of quality does not always meet the user's requirements

Gum quality assessed by collectors and traders does not always coincide with the users' assessment of quality. Collectors and traders' assessment is highly subjective and differs from village to village. The bad quality recognised by collectors and traders is confirmed by the users' assessment, but good quality from the perspective of collectors and traders may not always be good in terms of user's requirements; the link between the assessment by collectors and traders and that of users is cleanliness or low mineral matter which is a visible attribute of quality. Yet, other minimal quality attributes are also needed. This finding implies that when gum is supplied as being good quality, it may be rejected by users when this quality does not meet the users' requirements. Yet, the increase in the supply of good quality after visual

inspection increases the probability of obtaining the quality that meets the users' requirements.

Important are also the findings on how this quality could be increased. Quality supply in terms of the size and cleanliness of the gum nodules depends on harvest and post-harvest practices. It is also a response to market conduct and market-driven collection incentives. The market conduct shows inconsistencies in the preference for quality attributes because the traders' knowledge of quality is not very much higher than that of collectors unless they have long experience in the trade.

Results also showed that undifferentiated price incentives offered by the market restrict the supply of good quality because these incentives create competition in communal forests where gum is collected by attracting occasional collectors. Competition for gum inhibits its maturity as the collector targets to harvest the gum before another collector. Immature gum has high probability of not reaching its full size and is more likely to attract impurities. These price incentives also have an effect on the relative demand for quality: at high price levels, there is relatively more demand for undifferentiated or lower quality whereas at low price levels, there is relatively more demand for high quality. An incentive to supply high quality gum is a price differentiation such that good quality is rewarded by its premium.

Change of tenure systems is mainly driven by economic considerations

Communal systems are preferred to private systems when the cost of regulation is high particularly when competition over resource is low. In Senegal, the current change in tenure of *Acacia senegal* resource from communal to private collection systems is slow; mixed systems are found in a gradual transition where privately owned properties and communal forests coexist.

The study found that private systems emerge when the resource is sufficiently available in proportion to labour such that the collector can expect to increase his collection. The environmental function of privatisation is thus acknowledged where the collector has the incentive to protect the resource and limit destructive action.

Market developments and incentives are a source of competition that also generates the need for moving towards private systems. The competition arises from the unrestricted entry of occasional collectors. These findings imply that privatisation is undertaken because of its economic benefits by regulating competition which may not only restrict the quantity but also the quality of gum collected.

Results confirmed the reason for the maintenance of communal systems as the high cost of regulation; e.g., if monitoring cost that depends on the size of and distance to the collection area is high, communal tenure is preferred because surveillance can be efficiently done by the community. The social function fulfilled by these systems in the community is also very important: communal systems may be more preferred than private systems because they act as an insurance mechanism in the drylands. As such, a collector can spread the risk from environmental uncertainties instead of solely relying on his own plot. The transition from communal organisation of collection to efficient private collection systems hence depends mainly on the assessment of economic benefits and costs. However, the importance attached to environmental and social considerations may also play a role in the process of change.

With the objective of investigating factors that influence the performance of the gum arabic supply chain, the study has therefore found that (1) the main determinants of the collector's decision to collect gum and amount to collect are the expected marketing incentives whereas the choice of physical market where a collector sells his gum is determined by the comparison of prices and costs associated with different market outlets ; (2)

value distribution along the gum arabic supply chain depends on market power and also marketing costs, supply conditions, uncertainty and risk in trade; (3) the quality supplied by collectors does not consistently correspond to users' quality requirements as good quality gum is not always identified on the field and harvest and post-harvest practices, market conduct and market-driven collection incentives are the main factors influencing the supply of quality by gum collectors; and (4) the transition from communal organisation of collection to efficient private collection systems mainly depends on an evaluation of the benefits and costs associated with any governance system of collection taking into account the environmental and social considerations.

7.3 Policy implications

Interventions in the gum arabic sector require a wide approach that ranges from aspects of resource governance to functioning of markets. Some policy opportunities are suggested for improving collection and marketing of gum arabic.

Acacia senegal resource

Although (*Acacia senegal)* trees are naturally grown, the resource base should be expanded, or at least maintained. Hence, efforts in tree planting and maintenance are required to preserve the resource base such that production/collection and supply of gum are sustained. The community and forestry services should be empowered to control degradation through social and economic means or by law enforcement respectively. Most importantly, the population should constantly be sensitized to improve their knowledge of resource potential in order to limit destructive action and conserve the resource.

Clear rules of management are needed to counteract the influence of market forces (price) on competition in forests and motivate collectors to manage their plots and thereby increase collection and quality of the product. The legislative and institutional aspects of managing acacia trees offer the best strategy; but these should also take into account the

consistency between the formal codes and forestry opportunities for people to manage trees. Also the role of government, particularly the forest administration should be clearly outlined.

As forest resources serve to improve the livelihoods of resource users who live in the high-risk drylands where income streams are uncertain, there is need to explore and extend the diversification of livelihoods sources not only off-farm but also off-forest in order to reduce over-dependence on resource especially in the dry season.

Direct market interventions

Direct market interventions are required. These would involve a consolidation of the position of Senegal as a producer country so that a regular demand can be maintained: this regular demand implies that traders would be insured of having a market for the acquired products and hence act competitively towards their suppliers. An emphasis on market regularity is needed because of the fragile balance between the professional collection and casual high demands lead to over-harvesting of gum trees thereby destroying the resource.

Another option is the provision of price incentives in terms of higher price or price guarantees. For the price transferred by traders to really be an incentive, this price should be attractive. As this price is a transfer from the international price, it is important that exporters aim to achieve a higher price in international markets. On these markets, several factors could influence price such as the availability of industrial substitutes. Market consolidation should be explored and the supply of good quality gum emphasized so that users who have discovered the uniqueness of the gum arabic continue to demand the product. There might be a need for market regulation in terms of supply or price stabilization to retain incentives for efficient and sustainable collection. A clear price differentiation policy should also be formulated to stimulate quality in the supply of the product.

Training

Continuous sensitization of collectors and traders is desirable. It can be achieved through trainings where knowledge and skills are exchanged. These training would focus for instance on harvesting practices, post-harvesting handling and quality upgrading, management of forest resources, or market requirements. These exchanges lead to improving product quantity and quality and an opportunity to explore different market niches with a purpose of obtaining a higher price. Sensitization is needed as knowledge and awareness creation are probably the first entry points in markets in the absence of a third control party.

Organisation of the marketing system

A better organization of the marketing system is required with the purpose of distinguishing professional collectors and reducing costs from marketing. In this context, a market information system can be developed at the local level so that collectors have easy access to information on market demands and prices. This can lead to various choices regarding the market outlets with the advantage of reducing the cost associated with selling gum and benefitting from better market opportunities.

Traders will also benefit from such information systems which provide information on market and product quality in terms of reducing transaction costs and price and quality uncertainties. Infrastructural developments are required in terms of road construction and maintenance so that transport costs are reduced. Financial institutions should be improved in terms of easy access to credit such that traders could improve access to the capital needed to conduct their business.

Associations

Associations of collectors should be encouraged: marketing groups/associations reduce transaction costs and thereby encourage production. They also bargain higher prices because they are in direct contact with buyers. Associations can stimulate partnerships with exporters

and industry and be a channel through which services could be provided such as financial assistance or training.

The possibility of creating a traders' cooperative can also be explored so that provision of trade services could be done collectively at a low cost. Such services could for instance be in relation to market assurance, design and enforcement of contracts, provision of market information, building storage facilities, and facilitating access to finance. However, the cooperative should act in accordance with certain regulations to avoid that it curbs the interests of collectors. It should encourage competition for better market performance and serve as a potential entry and expansion of the market.

7.4 Limitations and future research

Further research is recommended to keep improving our understanding of aspects of the gum sector in Senegal. In general, the current study has focused on supply markets of gum arabic in Senegal. However, it has become apparent that the study of a component of the supply chain needs to have information of other components which may not be its direct target. Therefore, it is important to have information on the consumer side and understand the functioning of demand markets.

Specific to the study of quality aspects in chapter 5, we presumed that as different prices are associated with different grades at the export level in countries that have adopted a grading system, the same rule should be applicable within the gum producing countries at the level of collectors so that a high price rewards the efforts in conversion from low to high quality either during or post harvesting. A theoretical model that explains relationships between gum grading, costs and price was suggested (appendix 5A.1). It would be interesting to test the applicability of this model to investigate reasons as to why collectors seem to supply gum of standard quality and not implement quality maintenance or improvement when conversion costs are too high vis-à-vis price premiums and why traders do not provide these

incentives for enforcing quality maintenance or improvement. Furthermore, there is need to know the influence of specific environmental factors on quality so that collectors can anticipate quality changes between and during seasons, such a study would be beneficial in terms of determining the consistency of quality.

While it was suggested that associations should be encouraged, there are specific areas that should be explored in the performance of such associations. A research area would be to investigate their role in the adoption of grades and standards aimed at improving quality and safety of products. As such adoption may be constrained by capital and transaction costs that might hinder the development of high quality products (Vandeplas et al., 2009), it is presumed that these associations can better deal with these challenges compared to individual producers/collectors; research would confirm whether the associations are indeed able to be pro-active in the issue of gum quality improvement and maintenance. This is pertinent as previous studies (e.g., Francesconi, 2009) found that cooperatives/associations may not do well in terms of quality improvement and products safety.

Specific to chapter 6, we concluded that social and environmental considerations may be important in the change of systems of tenure. While the environmental aspect has received attention in the early farming theories, the role of social factors should also be studied.

Finally, another aspect of research could be to explore other forms of institutions in the gum supply chain (such direct contracts with collectors) and investigate their effects on livelihoods of collectors and performance of other stakeholders in the gum sector.

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Summary

Gum arabic has an important international market due to its in various industries. Senegal is a small producing country whose exports are low probably due to problems of developing internal markets resulting from the lack of price incentives. The study's main aim is to link the market side to the collection side in order to investigate factors influencing the performance of the supply chain of gum arabic. Two themes are the main focus: (1) market effectiveness in terms of behaviour, decision making process and performance of gum collectors and gum traders; and (2) market-driven production effectiveness in terms of quality aspects in marketing of gum and aspects of governance systems of gum collection. The study area comprises the Sylvopastoral zone and Eastern Region of Senegal where *Acacia senegal* trees are found and gum arabic is commercially exploited.

Chapter 2 describes the context of gum arabic collection and trade in Senegal, highlights the livelihood settings in the study area and lists the constraints to gum marketing which also limit the people's incentives to collect gum.

Chapters 3 and 4 examine the market effectiveness in terms of the behaviour and performance of market chain actors. Chapter 3 examines the behaviour of gum collectors concerning the decision and amount of gum to collect and subsequently the choice of where to sell among the available alternative markets. The hypothesis is that access to better and more remunerative markets provides incentives to collect and market gum; these incentives are restrained by high transaction costs. Collectors choose to collect and participate in market with the aim of maximizing their net returns. The quantity collected increases with better market incentives (i.e., higher expected price), through the use of more inputs such as labour and by expansion of the area under harvest. Although price is an incentive factor to collect and sell, it is associated with competition in the communally governed forests. Collectors prefer to sell in a market where the price is highest and competition with other collectors is

lowest or prefer to transact with a regular partner particularly when there are no differences in prices offered by different traders. In the price-cost trade-off for alternative markets, collectors also take into consideration transaction costs proportional to the quantity to sell and the possibility to combine travelling to the market with other activities such as buying consumer goods.

Chapter 4 focuses on the sequential chain of gum traders and investigates whether the oligopsonist structure of the chain leads to lower prices following multiple marginalisation tendencies. Gum traders are classified in primary, transport and wholesale markets depending on the size of their transactions. Benefiting from economies of scale, wholesalers earn the highest margins whereas primary traders have high unit costs, which results in low payments to gum collectors. Shares of traders in markets are calculated and corresponding Herfindahl indices are derived. The Herfindahl indices are not sufficiently high to point to strong oligopsonistic tendencies. The market share of a trader is positively influenced by their access to capital and market infrastructure and negatively by the level of competition in the market in which they operate. The market power does not influence the margins earned by traders. These margins seem to depend more on supply conditions, marketing costs, perception of price uncertainty and risk. High risk perception is probably the most important cause of market exit.

Chapters 5 and 6 examine the production/collection effectiveness in terms of the quality of the gum supplied and the property rights systems for gum collection. In chapter 5, the field and laboratory assessments of quality are compared. On the field, collectors and traders classified gum samples based on visible quality attributes. The laboratory assessment was based on the analysis of chemical components of these samples which were matched to the minimal chemical quality requirements set by users (defined in terms of cleanness and low mineral matter). The comparison of field and laboratory assessments shows that the

assessment of good gum quality by collectors and traders does not always match the laboratory minimum standards. The assessment by collectors and traders is highly subjective and differs from village to village. The bad quality gum as indicated by collectors and traders was also bad in the chemical assessment, but gum that was classified as good by collectors and traders was not always good in terms of user's requirements. An examination of the determinants of quality supply for two visible attributes (size and cleanliness of gum nodules) shows the importance of good harvest and post-harvest practices. Supply of quality gum is also a response to market conduct and market-driven collection incentives. The market conduct shows inconsistencies in the preference for quality attributes because the traders' knowledge of quality is not much higher than that of collectors, except for traders with a long experience. In the current market setting, no price premiums are given for better quality gum. High gum prices in one season seem to attract occasional collectors to the communal forests, which again reduces the collector's incentive to invest in gum quality. These price incentives also have an effect on the relative demand for quality because at high price levels, demand for undifferentiated or lower quality gum increases whereas demand for high quality gum is relatively higher at low price levels. Therefore, only quality premiums may have a positive effect on the supply of good quality gum.

Chapter 6 investigates factors that influence the currently slow transition from communal systems of gum collection to efficient private systems. The theoretical model predicts that private systems may be preferred to communal systems when competition increases because the household utility declines and communal systems are preferred when the cost of regulation is high. The systems of management of Acacia resources in Senegal are distinguished by the mode of acquisition, and tree markings, these are an indication of exclusive use rights. Empirical results confirmed that the emergence of private systems in gum collection depends on the availability of the gum resource which should be proportionate

to the available labour in such a way that the collector can expect to increase his collection. Market developments are also important but they lead to an increase in competition over resources notably when the price is sufficiently high to attract occasional collectors. Private systems are preferred because of their economic and potential environmental benefits. Communal systems are maintained when the monitoring cost of regulation and enforcement of the property rights in private systems is economically and socially high and when the insurance function performed by these communal systems is important. While the transition from communal organisation of collection to efficient private collection systems mainly depends on the assessment of economic benefits and costs, the transition process is guided by the importance attached to environmental and social considerations.

In chapter 7, the main findings of the study are summarized and their policy implications are discussed. The study limitations and future research areas are also given. The findings are that, first, productivity-enhancing methods may be adopted such as increasing labour productivity and regulating competition in forests where gum is collected. Market incentives are also fundamental for the continuation of collection; they should be sufficiently high to cover for the costs of collection and marketing gum. Secondly, traders in the gum markets do not necessarily take advantage of their oligopsonistic structure and exercise their power in an exploitative manner. A trader's accession and share in the market depends on the access to various forms of capital and the market characteristics. The margin he earns reflects the costs, uncertainty and risk of trade which may even cause his exit from the market. Thirdly, quality as required by the user may not be directly linked to the visible quality attributes in the field; an opportunity to increase good quality on the field increases the likelihood of obtaining chemically good gum. Good harvest and post-harvest practices are crucial to the supply of quality. To stimulate the supply of good quality gum, a price differentiation is required such that good quality is rewarded with a premium. Finally, the

transition from communal organisation of collection to efficient private collection systems depends mainly on the assessment of economic benefits and costs. However, the importance attached to environmental and social considerations may also play a role in the process of change of governance systems especially in the drylands where gum arabic is collected.

The main policy implications include the need for expansion and maintenance of the *Acacia senegal* resource base, direct market interventions, continuous sensitization of collectors and traders, and a better organization of the marketing system. Furthermore, associations of collectors and of traders could potentially contribute to market access because of the various functions that these associations may possibly perform in the gum sector.

Samenvatting

De internationale markt voor arabische gom is belangrijk voor verschillende industriële sectoren. Senegal is een klein productieland voor arabische gom; het lage productiecijfer is mede een gevolg van problemen die de ontwikkeling van een interne markt verhinderen, waardoor de prijs die aan gom producenten/verzamelaars wordt aangeboden, te laag wordt bevonden. Het doel van deze studie is om marktontwikkeling te linken aan de productie-aspecten om zo de factoren te kunnen bepalen die een invloed hebben op het functioneren van de keten voor arabische gom. De focus ligt op twee thema's, namelijk (1) de markt effectiviteit in termen van het gedrag, de besluitvormingsprocessen en de economische bijdrage van producenten, en handelaren in gom; en (2) de marktgestuurde effectiviteit van productie in termen van kwaliteit en het beheer van de productie gebieden van gom. Het studiegebied is de Sylvopastoral zone en de Eastern Region van Senegal waar Acacia senegal bomen voorkomen en arabische gom wordt gecommercialiseerd.

Hoofdstuk 2 beschrijft de context waarin arabische gom wordt verzameld en verhandeld in Senegal; het bespreekt de vormen van levensonderhoud in het onderzoeksgebied en geeft een overzicht van de beperkingen in de handel van gom, die op hun beurt de prikkel tot het verzamelen van gom negatief beïnvloeden.

Hoofdstukken 3 en 4 bespreken de markteffectiviteit in termen van het gedrag en de prestatie van de actoren in de markt. Hoofdstuk 3 bestudeert de beslissingen van verzamelaars om al dan niet gom te verzamelen en hoeveel gom er wordt verzameld, met daaropvolgend de keuze in welke van de alternatieve toegankelijke markten de gom wordt verkocht. De hypothese is, dat de toegang tot een betere en meer winstgevende markt een aansporing zal zijn tot het verzamelen en vermarkten van gom: deze prikkel wordt echter sterk beïnvloed door de hoge transactiekosten. Verzamelaars van gom kiezen er voor gom te verzamelen en te vermarkten met het doel om netto winsten te maximaliseren. De hoeveelheid gom die wordt

verzameld, neemt toe met betere marktprikkels (meer bepaald door een hogere verwachte prijs), met een grotere inzet van inputs zoals arbeid en een uitbreiding van het gebied waarin de gom wordt verzameld. Een hogere prijs wordt echter geassocieerd met een grotere mate van concurrentie van verzamelaars in de wouden die gemeenschappelijk beheerd worden. Verzamelaars verkiezen om hun gom te verkopen in een markt waar ze de hoogste prijs zullen krijgen en waar de concurrentie met andere verzamelaars het laagst is, of ze verkiezen om hun gom te verkopen aan een vertrouwde handelspartner als er geen duidelijk prijsverschil is tussen de prijzen die worden aangeboden door de verschillende handelaren. De verzamelaars houden ook rekening met variabele transactiekosten (dit zijn de transactiekosten die proportioneel zijn aan de te verkopen hoeveelheid) en de mogelijkheid om het transport naar de markt te combineren met andere activiteiten zoals het aankopen van algemene benodigdheden van het gezin.

Hoofdstuk 4 focust op de opeenvolgende handelaren in de keten van gom met het doel te onderzoeken of oligopsonistische structuren leiden tot lagere prijzen als gevolg van meervoudig marginalisatie in de keten. Verschillende groepen handelaren in gom kunnen worden onderscheiden op basis van de omvang van hun transacties, meer bepaald gaat het over primaire handelaren, transporteurs, en groothandelaren. Als gevolg van schaalvoordelen kunnen groothandelaren de hoogste marges realiseren, terwijl de primaire handelaren de hoogste kosten per eenheid hebben wat resulteert in een lage prijs die wordt betaald aan gomverzamelaars. Het marktaandeel van de individuele handelaren in de markten werd berekend evenals de overeenkomstige Herfindahl indices. Deze zijn echter niet voldoende hoog om te kunnen zeggen dat er sterke oligopsonistische tendensen zijn in de markten. Het marktaandeel dat een individuele handelaar realiseert, is positief gerelateerd met diens kapitaal en marktinfrastructuur terwijl meer concurrentie in de markt het marktaandeel van een handelaar doet dalen. Kapitaal en marktkarakteristieken bepalen eveneens de mogelijke

markttoegang. Marktmacht heeft ook verder geen invloed op de marges die de handelaren realiseren. Deze marges blijken af te hangen van het aanbod, marketingkosten, en perceptie van onzekerheid over de prijs en risico. Een hoge perceptie van risico is waarschijnlijk één van de belangrijkste oorzaken van het verlaten van de markt.

Hoofdstukken 5 en 6 bepalen de effectiviteit in productie/verzameling in termen van de kwaliteit van gom en het systeem van eigendomsrechten voor gomverzameling. In hoofdstuk 5 worden kwaliteitswaarnemingen in het veld en uit laboratoriumtesten vergeleken op basis van specificaties die de gebruikers aangeven. In het veld werden verzamelaars gevraagd om de gomstalen te klasseren op basis van visuele kwaliteitsattributen. De resultaten uit het laboratorium zijn gebaseerd op een analyse van de chemische componenten van deze stalen. Een vergelijking van beide resultaten toont dat de waarnemingen van gomkwaliteit door de verzamelaars en de handelaren niet altijd overeenkomen met de evaluatie in het laboratorium van wat gebruikers aan chemische kwaliteit van de gom eisen. Verzamelaars en handelaren bepalen kwaliteit op een subjectieve manier en de beoordeling verschilt van dorp tot dorp. Gom die door verzamelaars en handelaren als van slechte kwaliteit wordt beschouwd, werd ook steeds zo aangeduid door de laboratoriumtesten. Gom die door de verzamelaar of handelaar als van goede kwaliteit werd aangeduid, voldeden echter niet aan de minimale chemische kwaliteitsnormen van de gebruikers. Voor de waarneming van kwaliteit door zowel de verzamelaars en handelaars, en de gebruikers, zijn helderheid en laag mineraal gehalte van belang. Een analyse van de determinanten van gom kwaliteit gemeten door de twee visuele attributen (grootte en zuiverheid van de gom klompjes) wijst op het belang van oogsttechnieken en de verwerking na de oogst. De kwaliteit van de aangeboden gom reageert ook op de markt en de prikkels die deze verschaft. De markt lijkt niet consistent te reageren op de voorkeur voor kwaliteitsattributen omdat de handelaren kwaliteit niet beter kunnen onderscheiden dan verzamelaars tenzij zij al een langere tijd in de handel van gom actief zijn.

De prijs is niet gedifferentieerd naar de verschillende kwaliteitsniveaus van gom, waardoor het aanbod van gom van betere kwaliteit beperkt blijft. Dit is ook omdat bij een hogere prijs meer verzamelaars worden aangetrokken om gom te verzamelen in de communale bossen. De prijs zou ook een effect hebben op de relatieve vraag voor kwaliteit. Bij hogere marktprijzen is er een grotere vraag naar niet-gedifferentieerde gom of gom van lagere kwaliteit, terwijl de vraag naar gom van hoge kwaliteit groter is wanneer de marktprijzen relatief laag zijn. Er ontstaat dan een prijstoeslag die aanzet tot het aanleveren van gom van hogere kwaliteit.

Hoofdstuk 6 onderzoekt de factoren die een invloed hebben op de trage transitie van een communaal systeem van gomverzameling naar een efficiënter privaat systeem. Het theoretische model voorspelt dat private systemen te verkiezen zijn boven communale systemen wanneer de concurrentie van verzamelaars toeneemt omdat het nut van een individueel huishouden dan afneemt. De netto winsten van privatisering moeten echter ook groter zijn dan het nut van het communale systeem. Dit communale systeem is te verkiezen wanneer de kosten van regulering te hoog oplopen. De beheerssystemen van Acacia bomen in Senegal zijn te onderscheiden naar de manier waarop de bomen zijn verworven, en de aanduiding op de bomen. Deze aanduidingen geven exclusieve gebruiksrechten weer. De empirische resultaten bevestigen dat huishoudens gom verzamelen op privaat land als er voldoende Acacia bomen aanwezig zijn, en als er navenant voldoende arbeidskrachten zijn in het gezin om de gom te verzamelen. De ontwikkeling van de markt is ook belangrijk maar het verhoogt de concurrentie om Acacia bomen, zeker wanneer de prijs voor gom voldoende hoog is om occasionele verzamelaars aan te trekken. Private systemen zijn te verkiezen omwille van de economische voordelen en het mogelijk positief effect op de milieubescherming. Communale systemen blijven behouden wanneer de sociale en economische kosten voor het controleren van het naleven van de wetgeving en het opleggen van de toegangsrechten hoog zijn, en wanneer het communale bos een vorm van verzekering

betekent voor de huishoudens. De transitie van een communale organisatie van de gomverzameling naar een efficiënte privaat systeem voor verzameling hangt voornamelijk af van een afweging van economische baten en kosten, terwijl het transitie proces meer afhangt van het belang dat wordt gehecht aan milieu en sociale randvoorwaarden.

Hoofdstuk 7 vat de belangrijkste bevindingen van de studie samen en bespreekt de beleidsimplicaties. De beperkingen van de studie en de mogelijke vragen voor toekomstig onderzoek worden gegeven. De bevinding zijn dat, ten eerste, er maatregelen om de productiviteit te verhogen kunnen worden genomen: de arbeidsproductiviteit kan hoger en de concurrentie in het bos waar gom wordt verzameld kan beter geregeld worden. Verder is de markt bepalend om van gomverzameling een blijvende activiteit te maken. De prikkels door de markt gecreëerd, moeten voldoende groot zijn om de kosten van verzameling en het vermarkten van gom te dekken. Ten tweede, handelaren in de markten van gom profiteren niet noodzakelijk van de oligopsonische structuren en ze buiten hun markmacht niet uit. Het toetreden van een handelaar en het marktaandeel hangen af van de toegang tot verschillende vormen van kapitaal en marktkarakteristieken. De marge die een handelaar verdient, is meer een weergave van de kosten, onzekerheidsgevoel en perceptie van risico; deze factoren kunnen zelfs een exit uit de markt betekenen. Ten derde, kwaliteit zoals minimaal aanvaardbaar door de gebruiker is niet steeds gelinkt aan de uiterlijke kwaliteitskenmerken zoals die in het veld kunnen worden waargenomen; toch is de kans groter op een goede chemische kwaliteit als de gom ook als goed werd bevonden in het veld. Gepaste oogst- en na-oogsttechnieken zijn cruciaal voor het aanleveren van kwaliteitsgom. Om het aanbod van kwaliteit te stimuleren is echter wel een prijsdifferentiatie nodig. Tot slot, hangt de transitie van een communale organisatie van Acacia bossen naar meer efficiënte private verzamelsystemen voornamelijk af van het afwegen van economische baten en kosten.

Daarnaast is zijn ook sociale aspecten en milieu belangrijk in het veranderingsproces van de beheerssystemen, voornamelijk in de droge gebieden waar arabische gom wordt verzameld.

Een belangrijke implicatie voor het beleid zijn de vragen naar een uitbreiding en onderhoud van de bossen met Acacia senegal, directe marktinterventie, voortdurende sensibilisering van verzamelaars en handelaars en een betere organisatie van het marktsysteem. Daarenboven kunnen associaties of groeperingen van verzamelaars en handelaren worden aangemoedigd omdat deze op tal van vlakken mogelijk kunnen bijdragen tot de gomsector.

Résumé

La gomme arabique a un marché international important dans diverses industries. Le Sénégal est un petit pays producteur de la gomme arabique dont les exportations sont faibles sans doute en raison des problèmes de développement des marchés internes, ceux-ci résultent de l'absence des prix incitatifs. L'objectif principal de cette étude est de relier le côté du marché à celui de la récolte de la gomme arabique afin d'étudier les facteurs qui influencent la performance de la chaîne de valeur de la gomme arabique. Deux thèmes font l'objet principal de l'étude: (1) l'efficacité du marché en termes de comportement et de processus décisionnel des récolteurs de la gomme, ainsi que le comportement et la performance des commerçants de la gomme; et (2) l'efficacité de la production axée sur le marché en termes d'aspects de la qualité lors de la commercialisation de la gomme, et des systèmes de gouvernance de la récolte de la gomme. La zone d'étude comprend la Zone Sylvopastorale et la Région Orientale du Sénégal où les arbustes d'*Acacia senegal* sont localisés et la gomme arabique y est exploitée commercialement.

Le chapitre 2 décrit le contexte de la récolte et du commerce de la gomme arabique au Sénégal, souligne les moyens de subsistance de la zone d'étude et dresse la liste des contraintes à la commercialisation de la gomme qui, également limitent les incitations des gens pour récolter la gomme.

Les chapitres 3 et 4 examinent l'efficacité du marché en termes de comportement et de performance des acteurs du marché dans la chaîne de valeur. Le chapitre 3 examine le comportement des récolteurs de la gomme concernant la décision d'effectuer la récolte et la quantité de la gomme à récolter. Par la suite, le choix se porte sur le marché de vente parmi les marchés alternatifs disponibles. L'hypothèse de l'étude est que l'accès aux marchés plus efficaces et plus rémunérateurs est un facteur incitant la récolte et la commercialisation de la gomme; l'effet incitatif est atténué par les coûts de transaction élevés. En effet, les récolteurs

choisissent de récolte et de participer au marché dans le but de maximiser leurs rendements. La quantité collectée est stimulée par le marché (meilleurs prix) tout en augmentant l'usage d''intrants tels que le labeur ou l'expansion de la zone de récolte. Bien que le prix est un facteur d'incitation à récolter et vendre la gomme, il est associé à la concurrence dans les forêts gouverne en commun. Lors de la commercialisation, les récolteurs choisissent un point de vente où le prix est plus élevé et la concurrence avec d'autres récolteurs est plus basse. Dans plusieurs cas, ces récolteurs préfèrent traiter avec un partenaire régulier et en particulier quand il n'existe pas de grandes différences dans les prix offerts par différents commerçants. Dans leurs décisions, les récolteurs prennent également en considération les coûts de transaction proportionnels à la quantité à vendre, et la possibilité de combiner la fréquentation du marché avec d'autres activités telles que l'acquisition d'autres articles ménagers.

Le chapitre 4 enquête sur la chaîne séquentielle des commerçants de la gomme. Le but de l'étude est de savoir si leur structure oligopsoniste conduit à une baisse des prix dans une tendance de marginalisation multiple. Une classification des commerçants de la gomme arabique est effectuée dans les marchés primaires, de transport et des grossistes en fonction de la taille de leurs opérations. Grâce aux économies d'échelle, les grossistes gagnent de très élevées marges tandis que les commerçants primaires ont des coûts unitaires élevés qui résultent de faibles paiements aux récolteurs de gomme. Les parts des commerçants dans les marchés ont été calculés et les correspondants indices de Herfindahl ont été tirées. Ces indices n'étaient pas suffisamment élevées pour confirmer de fortes tendances oligopsonistiques. La part d'un opérateur dans un marché dépend positivement du capital et de l' infrastructure du marché alors que la concurrence sur le marché la réduit. Les caractéristiques du capital et du marché déterminent également les possibilités d'accès au marché. Le pouvoir du marché n'a aucune influence sur les marges perçues par les commerçants. Ces marges semblent dépendre des conditions d'approvisionnement, des coûts de commercialisation, de la perception de

l'incertitude du prix et du risque. L'ampleur du risque est probablement la cause la plus importante de la sortie du marché.

Les chapitres 5 et 6 examinent l'efficacité de production/récolte en termes de la qualité de la gomme et des systèmes des droits de propriété associés à la récolte de la gomme. Dans le chapitre 5, une comparaison basée sur les spécifications des usagers de la gomme arabique a été effectuée. Cette comparaison incluait différentes évaluations de la qualité de la gomme, l'une faite sur terrain par les récolteurs et les commerçants de la gomme arabique et l'autre faite au laboratoire. Sur terrain, les récolteurs et les commerçants ont classé les échantillons de gomme en fonction des attributs visibles de la qualité. L'évaluation au laboratoire a été basée sur l'analyse des composants chimiques de ces échantillons. La comparaison montre que l'évaluation de la qualité de gomme par les récolteurs et les commerçants ne coïncident pas toujours avec l'évaluation de la qualité par les utilisateurs. L'évaluation par les récolteurs et les commerçants est en fait très subjective et diffère d'un village a un autre. La mauvaise qualité reconnue par les récolteurs et les commerçants est néanmoins confirmée par l'évaluation des utilisateurs, mais la bonne qualité du point de vue des récolteurs et des commerçants n'est pas toujours trouvée bonne en termes des besoins des usagers ; le lien commun entre l'évaluation par les récolteurs et commerçants et celle des utilisateurs est la propreté ou la faible contenance de la matière minérale. L'analyse des déterminants de l'offre de la qualité de la gomme arabique en termes de deux de ses visibles attributs (taille et propreté des nodules de gomme) montre l'importance du respect des procédures de récolte et d'après la récolte. La qualité dépend également de la conduite des marchés et des incitations de récolte axées sur le marché. Le comportement du marché montre des incohérences dans la préférence des attributs de qualité parce que la connaissance de la qualité par les commerçants n'est pas plus élevée que celle des récolteurs à moins qu'ils aient une longue expérience dans le commerce. Les prix plurivalents offerts par le marché limitent l'offre de bonne qualité parce

que les prix incitatifs créent une concurrence dans les forêts communales où la gomme est recueillie en attirant les récolteurs occasionnels. Ces incitations par les prix ont également un effet sur la demande relative de la qualité : en raison des prix élevés, la demande pour la qualité indifférenciée ou moins bonne est plus élevée alors que la demande de haute qualité est relativement plus élevé à un bas prix. Par conséquent, une incitation effective à fournir la gomme de haute qualité est une différenciation des prix de telle sorte que celle de bonne qualité est récompensée par sa prime.

Le Chapitre 6 examine les facteurs qui influencent la lente transition en cours dans les systèmes de gouvernance de la récolte de la gomme des systèmes collectifs aux systèmes privés efficaces. Entre les extrêmes de ces systèmes se trouvent des systèmes mixtes. Le modèle théorique prédit que les systèmes privés peuvent être préférés des systèmes collectifs lorsque la concurrence s'intensifie, parce que l'utilité recueillie par les ménages baisse, alors que les gains nets provenant de la privatisation dépassent l'utilité acquise lors de la récolte dans les systèmes collectifs. Ces derniers sont préférés lorsque le coût de réglementation est élevé. Les systèmes de gestion des ressources d'acacia au Sénégal se distinguent par le mode d'acquisition et le marquage des arbres. Celui-ci est une indication des droits d'utilisation exclusifs. Les résultats empiriques ont confirmé que l'émergence des systèmes privés dans la récolte de gomme dépend de la disponibilité des ressources qui doivent être proportionnée à un main-d'œuvre disponible de telle sorte que le récolteur peut s'attendre à augmenter sa collection. L'évolution du marché est également importante, son seul inconvénient est qu’elle conduirait à une augmentation de la concurrence sur les ressources, notamment lorsque le prix est suffisamment élevé pour attirer les récolteurs occasionnels. Les systèmes privés sont préférés en raison de leur potentiel économique et des avantages environnementaux. Les systèmes collectifs sont maintenus lorsque le coût des droits de réglementation et leur application est économiquement et socialement élevé en termes de coût de la surveillance et la

fonction d'assurance effectuées par ces systèmes. Alors que la transition de l'organisation communale de la récolte aux systèmes de récolte privés dépend principalement de l'évaluation des avantages et des coûts économiques, le processus de transition résulte de l'importance accordée aux considérations environnementales et sociales.

Dans le chapitre 7, les principales conclusions de l'étude sont résumés et leurs implications politiques sont discutées. Les limites de l'étude et les domaines de recherche futurs sont également indiqués. Les conclusions sont que, premièrement, pour accroître la productivité, différentes méthodes peuvent être adoptées telle que l'augmentation de la productivité du travail et la régulation de la concurrence dans les forêts où la gomme est recueillie. Les incitations du marché sont également fondamentales pour la poursuite de la récolte, ils devraient être suffisamment élevées pour couvrir les coûts de récolte et de commercialisation de la gomme. Deuxièmement, les commerçants dans le marché de la gomme arabique ne sont pas nécessairement exploiteur de leur structure oligopsoniste en exerçant leur pouvoir de manière abusive. L'entrée d'un commerçant dans un marché et ses parts dépendent de l'accès à diverses formes du capital et aux caractéristiques du marché. La marge qu'il gagne reflète les coûts, l'incertitude sur les prix et les risques du commerce qui peuvent même causer sa sortie du marché. Troisièmement, la qualité tel que requise par l'usager n'est pas toujours directement liée aux attributs de la qualité observés sur le terrain; une occasion d'améliorer la qualité dès la collecte augmente la probabilité d'obtenir une bonne gomme selon une analyse chimique. De bonne pratiques lors de la récolte et post-récolte sont cruciales pour la provision de la qualité. Pour stimuler cette provision, une différenciation des prix est nécessaire de telle sorte que celle la bonne qualité soit récompensée par une prime de qualité. Enfin, la transition de l'organisation collectif aux systèmes privés de récolte dépend principalement de l'évaluation économique des avantages et coûts. Toutefois, l'importance accordée aux considérations environnementales et sociales devrait également jouer un rôle

dans le processus de transition dans les systèmes de gouvernance des ressources en particulier dans les milieux arides où la gomme arabique est récoltée.

Les implications politiques principales comprennent une nécessité d'expansion et maintenance des ressources de base, notamment *Acacia senegal*, des interventions directes sur le marché, une sensibilisation continue orientée aux récolteurs qu'aux commerçants de la gomme et une meilleure organisation du système de commercialisation. En outre, les associations des récolteurs et celles des commerçants devraient être explorées et encouragées en raison de différentes fonctions qu'elle pourraient éventuellement effectuer dans le secteur de gomme.

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Gaudiose Mujawamariya
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the course	Department/ Institute	Year	ECTS (28hrs)
General part			
Research Methodology: From topic to proposal	Mansholt Graduate School	2008	4
Techniques for Writing and Presenting a Scientific Paper	Mansholt Graduate School	2008	1.2
Career Assessment	Wageningen Graduate Schools	2011	0.3
Mansholt-specific part			
Mansholt Introduction course	Mansholt Graduate School	2008	1.5
Mansholt Multidisciplinary Seminar	Wageningen School of Social Sciences	2011	1
'Limited farmer response to revived cooperatives initiatives in Rwanda's coffee sector'	Management in AgriFood Chains and Networks-Wageningen	2008	1
'Gum arabic production and marketing in Senegal: interlocked transactions and supply chain implications'	EAAE 2011 Congress Change and Uncertainty-Zurich	2011	1
"Behaviour and performance of traders in the gum arabic supply chain in Senegal: Investigating oligopsonistic myths"	28th ICAE Conference Foz do Iguaçu, Brazil	2012	1
Discipline-specific part			
New institutional economics: Governance of transactions, incomplete contracts, and bargaining	Mansholt Graduate School	2007	4
Economic models (AEP30806)	Wageningen University	2008	6
The Bayesian approach in theory and practice	Mansholt Graduate School	2008	1.5
Advanced Microeconomics (ENR32306)	Wageningen University	2008	6
Advanced Game Theory	The Netherlands Network of Economics (NAKE)	2008	6
Experiment! A workshop on experimental methods in Social Science and Interdisciplinary research	Wageningen Graduate Schools	2009	1.5
Participatory forest management as practice and performance	Wageningen School of Social Sciences	2011	3
Teaching and supervising activities			
Supervision of 3 Master Students		2009, 2010, 2011	4
Total			**43**

Curriculum Vitae

Mujawamariya Gaudiose was born on 10th September, 1981 in Rwanda. After completing high school in Rwanda, she joined Stella Maris College affiliated with the University of Madras in India to study economics, obtaining a Bachelor of Arts Degree in Economics in 2003. In 2003-2005, she worked as a Research Officer and subsequently as a Planning Officer in the National Unity and Reconciliation Commission in Rwanda.

With a scholarship from the Netherlands Fellowship Program (NFP-NUFFIC), Gaudiose joined Wageningen University in 2005. She obtained a Master of Science Degree in International Development Studies in 2007. In February 2008, she joined the Development Economics Group of Wageningen University to pursue a PhD degree under the European Union funding of the INCO-DEV ACACIAGUM Project.

From May 2012, Gaudiose is a lecturer at the Independent Institute of Lay Adventists of Kigali in Rwanda. In October until December 2012, she is going to work as an intern within the United Nations University at the World Institute for Development Economics Research in Finland.