A seasonal model of contracts between a monopsonistic processor and smallholder pepper producers in Costa Rica

Fernando Sáenz-Segura [a,b,*], Marijke D'Haese [b,c], Robert A. Schipper [b]

[a] International Centre of Economic Policy Research for Sustainable Development (CINPE), Universidad Nacional, Apdo. 7192-1000, San José, Costa Rica
[b] Development Economics Group, Wageningen University, Hollandseweg 1, 6706KN Wageningen, The Netherlands
[c] Department of Agricultural Economics, Ghent University, Coupure links 653, 9000 Gent, Belgium

ARTICLE INFO

ABSTRACT

We model the contractual arrangements between smallholder pepper (*Piper nigrum* L.) producers and a single processor in Costa Rica. Producers in the El Roble settlement sell their pepper to only one processing firm, which exerts its monopsonistic bargaining power by setting the purchase price of fresh pepper. It also sets quality norms that result in the rejection of considerable amounts of the pepper produced by individual farmers. Because the firm is not able to produce its own raw pepper and requires a sufficiently stable flow of the fresh product to be processed into high quality white pepper, it usually relies on contracts with individual smallholders. Nevertheless, the latter considered collective marketing and took the initiative to propose a group contract with the firm. Such a contract increases the producers' bargaining power vis-à-vis the processing firm and reduces rejection rates as more care is taken when transporting the pepper to be processed. Although a group contract causes the firm to lose part of its monopsonistic rents, it also reduces transaction costs as only one contract must be negotiated instead of many. Both the firm and the producers benefit, yet from the very beginning of the association, the producers breached the group contract. We have used a mixed integer linear model which, given a set of constraints, maximises the weighted sum of the expected incomes of the firm and producers. We modelled the contract chosen by the firm and the producers according to the conditions included, such as minimum income requirements and risk considerations of both processor and farmers. We calibrated the model with data from pepper producers and the firm in El Roble. The results show that at different fresh pepper prices, the contract preferred changes with the bargaining power attributed to the firm and smallholders. However, in general, it can be concluded that fresh pepper prices high enough to cover the costs, for the farmers, of a group contract lead to lower rejection rates, and thus to more pepper of an acceptable quality, increasing the incomes of both the processor and the farmers. This is also of interest in agricultural policy-making.

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1. Introduction

This paper presents an analysis of the contractual arrangements for pepper (*Piper nigrum* L.) in the El Roble settlement in Costa Rica. Pepper is a suitable crop for small-scale production due to the high labour requirements for crop management (i.e., preventive disease control through cultural practices) and the almost continuous harvest. Similar to the pepper producers described in Wadley and Mertz (2005), Costa Rican pepper smallholders react to changes in the market situation. However, in the research area the ability of pepper producers to react to the market is limited due to the monopsonistic market situation they face. Their livelihoods are obviously constrained by the selling price offered by this single buyer and the type of contractual arrangements made with the buyer. The only pepper processing firm in El Roble sets these prices for fresh pepper at a particular level with the intention of generating a maximum supply of fresh pepper of an acceptable quality at the lowest cost, and of establishing a stable relationship with the farmers, by satisfying their minimum income and risk requirements, to ensure a continued supply in future years.

In the absence of a spot market or full vertical integration for pepper in Costa Rica, it is traded between the smallholders and the processor on a contract basis. Most producers deliver individually to the processor, who in turn coordinates the harvest and organises the transport of fresh pepper to the processing facility. In an attempt to increase their bargaining power in the negotiations, the producers in the El Roble settlement considered collective marketing and took the initiative of proposing a group contract with the

* Corresponding author. Address: International Centre of Economic Policy Research for Sustainable Development (CINPE), Universidad Nacional, Apdo. 7192-1000, San José, Costa Rica. Tel.: +506 22634550; fax: +506 22601270.
E-mail address: fsaenz@una.ac.cr (F. Sáenz-Segura).

firm. On the one hand, collective action by producer organisations is recognised as increasing bargaining power in factor and product markets (World Bank, 2007; D'Haese et al., 2005). On the other hand, contract farming is mentioned as a possible way to overcome, or at least considerably reduce, transaction costs caused by market limitations, and thus provide a better institutional environment to integrate primary producers into agro-industry (Glover, 1984; Key and Runsten, 1999). Along with securing a market outlet, contracts may have several additional benefits for smallholders such as (better) access to market information, technology, inputs, legal expertise, credit, and insurance (see Key and Runsten, 1999; Simmons et al., 2005).

Mainstream economics predicts that the pepper buyer would resist the establishment of an association because this could limit his influence on the price of pepper. In an economy where transaction costs are ignored, a monopsonistic firm would have full power to dictate price and quantity in order to maximise its profits depending on its own cost structure and marginal product. Arguably, with a group contract the firm could lose these prerogatives because this new arrangement has the characteristics of a bilateral monopoly. However, individual contracts are expensive for the firm to implement, and give rise to high search, monitoring and enforcement costs which make the contracts 'costly, cumbersome, time-consuming and unpredictable' (Fafchamps, 2004). Group contracts may save some of these costs due to the bulking of the pepper and the negotiation of one contract for the group instead of multiple contracts with individual farmers. Group contracts through collective actions are feasible when prices are properly negotiated between the two parties and a regular supply of produce is assured (Sivramkrishna and Jyotishi, 2008); yet these authors criticise the 'confrontational approach' under which farmers' collective actions are suggested in the literature as a way to increase bargaining power in price negotiations with a buyer. They warn about the possibility of the firm moving or changing to another activity as a final outcome of confrontational bargaining.

In this study we develop a model to simulate the contractual relations between the group of small-scale pepper farmers and the monopsonistic processor. The aim of these simulations is to identify the model's level of sensitivity in its outcome of contract choice regarding the price at which pepper is traded between producers and the processor and their relative bargaining power. We believe that the processing firm can foster group contracts without losing its power to define procurement prices and without giving full bargaining power to the farmers. The firm can provide a combination of prices as an incentive mechanism that ensures that group contracts will be honoured.

We use a mixed integer linear model (MIP model) to analyse the determinants of contractual arrangements, building on an approach developed by Dorward (2001). Our model differs from his in a number of aspects so that it will be more tractable and require fewer coefficients, which would be difficult to estimate. Like Dorward's, it uses a Target-MOTAD approach to model risk and risk behaviour of both sellers and buyers. The MIP model uses the expected net incomes of the parties involved as arguments in the objective function and not, as in Dorward, the differences between expected incomes and deviations between these expected incomes and certain target incomes. Finally, whereas Dorward (2001) used artificial data, we have modelled an existing market system corresponding to the El Roble farmers introduced above, using data collected from farmers and a pepper processor.

The model estimates the combinations of procurement prices in the low-and high-supply pepper production seasons in which the farmers and the firm switch between individual contracts and a group contract. The sensitivity of the model to switch at a certain price level between contractual forms depends on the distribution of bargaining power between the farmers and the processor.

In Section 2, we present background information on the pepper production and market in Costa Rica. In Section 3, we explain the rationale behind the model and show how the model was operationalised; this is followed by a description of the main outcomes and a discussion of the results. We conclude in Section 6, by indicating the price conditions under which the firm can reach a stable institutional market arrangement with the El Roble farmers.

2. Study area

2.1. Development of pepper production

Pepper (*P. nigrum* L.) production began in Costa Rica in the 1970s as an experimental crop for large plantations. The pioneer was Charles Hunter, an entrepreneur from the US, who established a plantation of about 15 hectares and a small processing facility in the northern region of Sarapiquí. The crop expanded rapidly in the lowlands of Costa Rica and covered a maximum area of 500 ha in 1990 (Rojas-Zuñiga, 1994).

From the mid-1980s onwards, small farmers in Sarapiquí also began to cultivate pepper. In 1988, the price of processed pepper was around US$12/kg, which was considered attractive for a new commodity. In 1989, an adverse price trend began and in the following five years prices dropped to US$0.80/kg. This decline in international prices was caused by the collapse of the Soviet Union, occasioning the interruption of pepper imports from India, the largest world producer of pepper. India started delivering its surplus on the international market, with the consequent dramatic drop in prices. By 1990, to make matters worse, fungus attacks had done extensive damage to the Costa Rican plantations, leading most producers to withdraw from the activity. Only smallholders with low production costs and small plots could survive this combination of low international prices and fungus attacks (Cubillo, 2000, personal communication).

Production is now concentrated in farmers' settlements in the Huetar Norte region, which has adequate soil and climatic conditions, as well as good access. The current cultivated area is around 52 ha, the average pepper plot is around 0.9 ha, and production has increased to 2458 kg per farmer, per year, most of which is processed and sold in the domestic market.

Pepper production requires a relatively hot and humid climate typically found at altitudes below 1000 m. The crop produces bunches of berries that are processed into black or white pepper. A simple drying and fermentation process of the fruit suffices to obtain black pepper. The process for white pepper is more complex and requires wet fermentation to remove the peel of the fruit before it can be carefully dried. Pepper generally takes 1.5–2 years until the first harvest. Start-up costs for cuttings and material inputs add up to about US$2500/ha. Harvesting takes place year-round throughout the lifetime of the plants (12–15 years). There is a clear production peak in the relatively dry season of the year, reaching yields that can be 10 times higher than during the rest of the year. Yields also vary with the age of the plant. Under optimal conditions, expected yields of fresh pepper are 1.6 ton/ha in the third year, 7.5 ton/ha in the fourth year and 15 ton/ha in the fifth year. After the fifth year, yields slowly stabilise to a maximum production around the eighth year. The life cycle of the plant ranges from 12 to 15 years (Mora, 2000, personal communication).

2.2. Marketing chain of pepper in Costa Rica

The marketing chain for pepper is relatively short and uniform. Individual farmers sell their harvest of fresh pepper directly to wholesaler-assemblers (in 2000 at US$0.89 per kg) that process it to obtain dried black and/or white pepper and package it. Before

2000, there was no price differentiation per production season. After 2000, the main processor started to define a combination of procurement prices twice per year. Processors can sell on both the national and the international market. For the international market, pepper is packed in sealed bags of 50 kg and sold either to a broker or directly to a wholesaler. The broker sells pepper on the spice market; and wholesalers repack and distribute the pepper to retailers. In the national market, processed pepper is sold directly to food industries that repack the pepper for retailers or use it as input for processed food. In 2000, the price of processed pepper in Costa Rica was US$8.00 per kg, which is equivalent to US$1.90 per kg of fresh pepper given the industrial yield of 1 kg of processed pepper from 4.2 kg of fresh pepper. A small fraction of the processed pepper is directly distributed to retailers or restaurants (Sáenz-Segura, 2006).

In Costa Rica six companies actively export and import pepper, operating mainly as processors by importing non-milled dried pepper, milling and repacking the pepper and either exporting or selling it in the domestic market. Exports of pepper increased significantly between 1996 and 1998, reaching a peak of 2.7 million kg, and then collapsed to only 100,000 kg in 2001 (Dirección General de Aduanas (DGA), 2003). This decline in exports is due to the fact that many of the processing firms have gradually abandoned the activity, except for a small group of three enterprises. Major export destinations for pepper include North America, Central America and Panama, the Caribbean and the European Union. Imports show a more constant behaviour with an average amount of pepper ranging from 100,000 to 138,000 kg per year. The food processing industry measures the quality of pepper in terms of the amount of piperine found in the grains and by the degree of dryness. For processors, it is essential to have good raw material in order to obtain a high-quality end product. Fresh bunches of pepper must be at a medium stage of maturity – neither immature nor over-ripe – to be accepted. This is a crucial issue, in particular for companies specialising in the production of white pepper (80% of total production), because producing one kg of white pepper requires about 4.2 kg of high quality, ripe, fresh pepper. Proper tests for determining the amount of piperine are available but are not extensively used, and the technology for the adequate drying of pepper grains is costly. Low quality is one of the primary causes of pepper rejection (Sáenz-Segura, 2006).

In the consumer market, milled pepper is sold in bulk or mixed with other spices in packages of different weights. Supermarkets and grocery stores also offer pepper in packages of 100 gr. However, consumers in Costa Rica generally do not have the custom of using pepper as a table spice as it is used in Europe or the United States. The largest amount of pepper is consumed in processed foods, such as sauces, chips and the like. Users are barely informed of the properties of pepper itself, but they do consume a large amount of pepper in processed food (Sáenz-Segura, 2006).

The processing firm fixes the purchase price twice a year (approximately at the beginning of each season), trying to establish prices that will strengthen the contractual relationship. Rejection rates average 10% of each delivery; this can result in important income losses for both the producers and the firm. Pepper is rejected if it has been damaged during transport or if it was picked when it was still immature. Rejected pepper is not used in any form and is eventually destroyed by the processor. Fixing prices and high rejection rates are a source of distrust between the pepper producers and the processor. As mentioned above, the El Roble producers responded to their relatively weak bargaining situation, by founding a farmers' association for pepper selection and delivery, and by bulking the pepper transactions into a single group contract. The activities of the association have three purposes: (1) the reduction of rejection rates by monitoring the quality of produce at the collection point, (2) the improvement of product coordination, and (3) an expected increase in bargaining power in price negotiations (i.e., the negotiation of a group contract).

3. Methods

3.1. Rationale behind the model

Williamson (1991) explained how trading agents search for the best model of governance according to the characteristics of the transaction in order to minimise its costs while allowing for risk. These costs are determined by the uncertainty (positive) and the frequency (negative) of the transaction and the degree of specific investment involved (positive) (Williamson in Ménard, 2005). Uncertainty in the trade of fresh pepper is significant since it is a perishable product with variable quality. Two important sources of uncertainty include the opportunistic behaviour of both the firm and the producers, as well as the bounded rationality of each. Opportunistic behaviour refers to the possibility of agents to act out of self-interest, and has been defined as 'self-interested behaviour unconstrained by morality [and] includes providing selective and distorted information, making promises which are not intended to be kept, and posing differently from what the person actually is' (Slangen et al., 2008). Bounded rationality refers to the physically-limited capacity of agents to evaluate all potential gains and losses from a given market decision accurately, such as a contractual choice (Simon, 1961).

As a governance structure for reducing transaction costs, contracts become particularly important in governing long-term relationships or when a long time passes between purchase and delivery (Slangen et al., 2008). In the case of pepper trade, contracts are mainly justified by transaction frequency, which is high because pepper is harvested throughout the year and sales are made every two weeks. During the low-production season, transaction frequency may drop to one delivery every three weeks.

Asset specificity is high for both producers and processors. Asset specificity refers to the 'degree to which a resource is committed to a specific task and thus cannot be redeployed to alternative uses without a substantial reduction in its value (Slangen et al., 2008). Pepper producers devote land, time and money to their plantation. In addition, pepper is a perennial crop with a life cycle of approximately 15 years; this makes it difficult to substitute it for other crops in the short term. On the other hand, the processing factory is built to process only pepper. This specificity makes a processor less interested in being integrated with the production side, but also reluctant to rely on a spot market for its supply; the processor needs to secure a maximum and continuous amount of fresh pepper, which is less likely in the absence of a contract. However, transaction costs may arise because producers will try to maximise their sales and thereby offer all pepper harvested, disregarding the quality levels. Higher levels of rejected pepper mean less efficient product coordination for both parties. Furthermore, farmers are found to breach individual contracts easily. Enforcement by both parties is problematic because the contracts are informal and few in quantity and therefore remain costly to enforce in court. Moreover, even if the producers were prosecuted for breaching a contract, they have few assets that could be seized (cf. contracts by African traders in Fafchamps, 2004).

Individual contracts in pepper trade are costly because they need to be negotiated with one farmer at a time. A group contract could be less expensive for the processor in terms of contracting and other transaction costs. It could also improve product coordination to ensure a regular provision of fresh pepper with the desired quality characteristics (Glover, 1987; Singh, 2002). To achieve this more efficient governance structure, the processor needs to look for a certain level of price coordination that can

permit a group contract, during both production seasons. For the farmers, a group contract may limit the effects of skewed bargaining power caused by the processor's monopsonistic market power. This can be compared with co-operatives that have contractual purposes to deal with perceived market failures (Cook, 1995), and with bargaining co-operatives described by Knoeber (1983) as collective organisations to contract with processors for the sale of their members' crops. Furthermore, the farmers' association may have external economies, also described as passive collective efficiency (Nadvi in McDormick, 1999), such as improved access to market information and labour pooling in sorting, packaging, supervision and transport.

3.2. Model specifications

A mixed integer linear simulation model (MIP model) was set up to assess the contractual agreement that maximises the processor's and farmers' income. The sum of the expected incomes of the farmers and processor is maximised, taking into account their relative market power and risk preferences. Income is defined as the value of sales minus the value of variable and fixed costs.

The main features of the model are highlighted below, but it is described in detail in the Appendix. Individual farmers (sellers) offer fresh pepper to one processor (the only buyer). Mature pepper plants are harvested throughout the year, yet there is a clear harvesting peak in two marketing seasons (index s): low-supply (March to November) and high-supply (December to February). The contractual forms (k) include individual contracts and group contracts. The model accounts for the opportunistic behaviour of both processor and farmers. The opportunistic behaviour of the farmers and the processor (j) is considered to be significant (high), or not (low). Probabilities of occurrence and expected losses are associated with this behaviour. For a given party, it is assumed that in individual contracts high probabilities are attributed to another party's high opportunistic behaviour, while in group contracts high probabilities are attributed to the low opportunistic behaviour of the other party. It is expected that rejection rates and supervision costs are highest in the case of the high opportunistic behaviour of farmers and the processor. We also assume that the firm's production costs are lower under group contracts because the fresh pepper is of higher quality, with the lowest costs when opportunistic behaviour is low.

This model makes it possible to calculate the income levels of the farmers and the firm with the quantity of fresh pepper transacted as the main variable in the model. These incomes should be equal to at least a reservation income that the firm and farmers could make in alternative activities. Furthermore, risk behaviour is modelled using a Target MOTAD approach (Tauer, 1983; Hazel and Norton, 1986). In this model, the expected sum of the income deviations below a target income should be lower, for both the farmers and the firm, than their respective willingness to accept such deviations. This willingness, expressed by the Target MOTAD 'lambda' parameter, represents attitude to risk.

The objective function is designed to allow for analysing the changing distributions of bargaining power between the farmers and the firm. This is done through a coefficient $w(k)$, which may differ depending on the contractual arrangement k. In the objective function, this coefficient is multiplied by the expected incomes. In $w(k) = 0$, the objective function represents the expected income of the farmers, whereas if $w(k) = 1$, this function represents the expected income of the processor. For values of $w(k)$ between 0 and 1, the objective function is a weighted average of both these incomes.

The parameter $w(k)$ is thus defined as a measure of the processor's bargaining power with respect to that of the farmers under a specific contractual arrangement with a value ranging from 0 to 1

($0 \leqslant w(k) \leqslant 1$). Under individual contracts ($k = $ IC), w always has the value of one [$w($IC$) = 1$], indicating that the firm as a monopsonist buyer has full bargaining power. Under group contracts ($k = $ GC), $w($GC$)$ might take all values from 0 to 1. Three cases are considered for the distribution of bargaining power in group contracts, namely: (a) monopsony: the firm conserves all the bargaining power [$w($GC$) = 1$]; (b) monopoly: the farmers gain all the bargaining power [$w($GC$) = 0$]; and (c) joint profit maximisation with $w($GC$) = 0.5$, which might be seen as the result of negotiations between the buyer and the farmers (Henderson and Quandt, 1980). In the case of a monopsony in individual and group contracts, the model assures that GC (the farmers as a group) should at least receive a margin (income) that is attractive enough to stay in the pepper cultivating business, referred to above as income and risk considerations. If the GC group of farmers can exert a monopoly situation [$w($GC$) = 0$], the buyer should have a profit (equal to the margin between the value of sales and production and transaction costs) that is at least attractive enough to stay in the pepper processing business.

We present the results of the sensitivity of the model in its change of contractual choice, under different combinations of procurement prices, in both seasons, for the three different levels of bargaining power in case of group contracts [$w($GC$)$] as outlined above; under individual contracts [$w($IC$)$], this parameter in each simulation remains equal to one. The prices for fresh pepper differ every season and are within a range of prices with an upper and a lower limit, derived from 'staying-in-business' requirements (see above) of either the farmers (lower limit of fresh pepper price) or the processor (upper limit of fresh pepper price). Both price ranges are divided into 10 segments, resulting in 11 prices in each season (Table 1). In order to analyse preferred contract choices as a function of the fresh pepper price, under each of the three relevant settings of the parameter w, we run the model for the $11 * 11 = 121$ combinations of these prices in each season.

Our model is restricted to the market system without feedback to the production system, i.e., we are uncertain of the effect of changes in the contractual arrangements on smallholders' production practices. Moreover, based on survey information (described below), we do not expect the total production in El Roble of fresh pepper to exceed a maximum of 60,000 kg per season, unless farmers would change their current technology level considerably, and/or gain more access to credit and labour resources. In addition, 60,000 kg per season is already nearly double the 2000 production.

3.3. Data

The model uses data from research in markets and contracts for smallholder pepper producers in Costa Rica. This information was collected in 2000 and 2001 from farmers' surveys and in-depth interviews with processors and employees of the governmental institutions involved. Because the identity and number of the

Table 1
Fresh pepper prices (US$/kg) in low-and high-supply season, used for simulations.

	Low-supply season	High-supply season
Price 1	0.681	0.632
Price 2	0.710	0.675
Price 3	0.738	0.718
Price 4	0.767	0.761
Price 5	0.795	0.804
Price 6	0.824	0.847
Price 7	0.853	0.890
Price 8	0.881	0.933
Price 9	0.910	0.976
Price 10	0.938	1.019
Price 11	0.967	1.062

producers were not known at the beginning of this research, we implemented a non-random sampling method, known as the 'snowball' method (Babbie, 1992). In total, 75 active pepper producers were found, 65 of whom were interviewed (including 19 farmers from El Roble). We chose this settlement for our study since it is the most important source of fresh pepper for the processor, and it is the oldest pepper-producing area, with the largest concentration of the most experienced farmers in the production of pepper. Finally, it is the only settlement with an active producers' organisation.

4. Results

4.1. Pepper farmers in El Roble

The agrarian production structure of Costa Rica is characterised by a diversity of farm types. Besides large capital-intensive farms and cattle production units, there is a large group of smallholders that are mainly family-based enterprises. These smallholders can be split into two groups: (1) a traditional peasant sector, comprised of low-income farmers living in former agrarian frontier zones and in rural settlements created by the Agrarian Development Institute; and (2) a significant group of semi-commercial farmers that produces traditional crops (i.e., coffee, bananas, sugar cane) and non-traditional crops (i.e., tropical fruits, vegetables and ornamental plants) usually reaching competitive production performances. The traditional peasant sector produces mostly maize and other basic grains mainly for local exchange and consumption, livestock, and some cash crops (coffee and sugar cane); they rely on low-input production technologies, maintain simple post-harvest management practices, and family labour may be partly involved in off-farm activities. Both of the above groups differ with respect to typical farm-household characteristics (age, education, family size, and dependency rate), production scale, resource endowments, spatial location (access to infrastructure) and market characteristics (access to inputs and information) (Sáenz-Segura, 2006).

The 19 smallholders selected from El Roble can be considered as traditional low-income producers. They devote on average 0.92 ha to pepper; that is, 2.5% of their available land (Table 2). The start-up costs are partially financed for beginners by means of an interlocked contract (seedlings are provided by the processor in exchange for a promise of the farmer to supply pepper to that firm). However, most producers cope with the expensive start-up costs by using intensive individual care such as manually removing infected plants and soil maintenance measures reducing start-up and maintenance costs of the crop, instead of the recommended technical packages. Further increases in the area of pepper depend on labour availability, investment capital and the farmers' confidence in the market conditions. At the time the data were collected, El Roble farmers expressed that they would be very willing to expand their pepper plots in the near future, but they

also reported a higher proportion of defaults in contracts (Sáenz-Segura, 2006). These producers have additional income sources aside from pepper, such as animal husbandry and non-agricultural activities. For example, 11 of the 19 producers in El Roble (58%) reported that less than 40% of their income came from pepper.

Pepper is an attractive diversification crop for smallholders, since its production is highly labour intensive and does not require complex technologies or machinery. After the second year, the crop produces continually throughout the year and can reach high and fairly stable yields per hectare. Although the land devoted to pepper by farmers in the sample differs, this variability did not influence the present model directly because pepper production is for the group of farmers as a whole. Therefore, the farmers' average data were used.

As indicated above, a maximum of 60,000 kg of fresh pepper can be produced each season by the 19 farmers together and traded in either individual or group contracts. In El Roble the contracts between farmers and the processor consist mainly of verbal agreements that are renewed every season. These verbal contracts can be considered as resource-providing contracts, focusing on seedling provision and technical assistance, but without any other variable production inputs (i.e., fertilisers and pesticides). The cost of seedlings is not included in the model because all 19 producers had mature plantations at the time of this research. Technical assistance is included as part of the processor's variable production costs. For individual contracts, the processing firm organises the collection and transport of the pepper at a specific location inside the settlement. The processor is also responsible for quality control and will reject pepper if it does not fulfil its requirements. These services are assumed by the firm as part of its variable production costs.

In the case of group contracts, the group of farmers organises the collection of the fresh pepper. This pepper is then graded so that pepper of a quality acceptable to the processor can be transported to its plant. As a reward for supplying better-quality pepper (which lowers production costs for the firm), the farmers receive a premium per kg pepper transported. However, farmers must pay a membership fee (fixed yearly) for the organisation of the group contract, governance costs, and transport and supervision costs (per kg of fresh pepper supplied). Procurement prices are fixed twice a year by the processor (near the beginning of each supply season). However, these amounts are fixed differently with ups and downs across seasons, from year to year. This mechanism causes price uncertainty among farmers, who in turn respond by acting opportunistically and defaulting on contracts.

4.2. Contract choice and income distribution at different combinations of procurement price and level of bargaining power

We simulated the effect of different fresh pepper prices on the distribution of incomes between the contracting parties and the adopted governance structure at three levels of bargaining power, as outlined in Section 3.2. We identified the combination of prices for the low-and high-supply seasons, with which the firm can induce group contracts, given a certain level of bargaining power w.

Table 3 shows the distribution of incomes between the processing firm (Panel A) and all farmers (Panel B), at different combinations of prices for both seasons, when the firm has all the bargaining power in the case of individual and group contracts alike, and when a monopsonistic market condition thus prevails $[w(k) = 1]$. The income of both parties is determined by the combination of two prices during the year and the adopted contractual arrangement for each possible combination of prices. A group contract implies a better delivery of produce in terms of quantity and quality, while redistributing the related costs of organisation, supervision and transport.

Table 2
Descriptives of pepper production of farmers in the Apropisa group (n = 19).

	Mean per farmer (std. deviation)	Total
Total farm area (ha)	36.95 (50.89)	702.14
Area with pepper production (ha)	0.92 (0.61)	16.59
Total income (US$)	7528.98 (4903.62)	143,050.57
Income from pepper (US$)	2744.95 (2159.69)	46,664.10
Share of pepper in total income (%)	36.93 (25.17)	
Production of pepper (kg)	3734.84 (3172.31)	70,962.00
Rejection rate (%)	11.94 (2.42)	
Price of pepper (US$/kg)	0.96 (0.03)	

Note: All monetary values were given initially in Costa Rican Colones and later converted to US Dollars.

Table 3
The effect of different procurement prices on the income distribution between the contracting parties, and the governance structure. A monopsony market condition prevails $w(k) = 1$.

Price (low-supply season)	Price (high-supply season)										
	0.632	0.675	0.718	0.761	0.804	0.847	0.890	0.933	0.976	1.019	1.062
	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC
Panel A: processor's income ('000 US$)											
0.681	98	95	93	91	88	85	83	80	78	75	73
0.710	97	94	92	89	87	84	81	79	76	74	71
	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC
0.738	107	104	101	98	96	94	91	89	86	84	81
0.767	105	102	100	97	95	92	90	87	84	82	79
0.795	103	100	98	96	93	90	88	85	83	80	78
0.824	101	98	96	94	91	89	86	84	81	79	76
0.853	100	97	95	92	90	87	84	82	79	77	74
0.881	98	95	93	90	88	85	83	80	78	75	73
0.910	96	94	91	89	86	84	81	79	76	73	71
0.938	94	92	89	87	84	82	79	77	74	72	69
0.967	93	90	88	86	83	80	78	75	73	70	67
Panel B: Farmers' income ('000 US$)											
0.681	46	49	52	54	58	59	62	64	67	69	72
0.710	48	50	53	55	58	61	63	66	68	71	73
	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC
0.738	47	50	52	55	57	60	62	65	67	70	72
0.767	49	51	54	56	59	61	64	66	69	71	74
0.795	50	53	55	58	61	63	66	68	71	73	76
0.824	52	55	57	60	62	65	67	70	72	75	78
0.853	54	56	59	61	64	66	69	72	74	77	79
0.881	55	58	60	63	66	68	71	73	76	78	81
0.910	57	60	62	65	67	70	73	75	78	80	83
0.938	59	61	64	66	69	71	74	77	79	82	84
0.967	60	63	65	68	71	73	76	78	81	84	86

Note: IC, individual contracts; GC, group contracts.

In general, the processor's income decreases with increasing prices in the high-supply season, combined with any possible price in low-supply season. The opposite obviously happens with the farmers' income. This is an expected outcome since the higher the procurement price paid by the firm during the peak season, the higher its input costs, and at the same time, the higher the farmers' income. Nevertheless, this does not apply for prices in the low-supply season because the income of both parties also depends on the type of contract with which pepper is traded as this influences the cost structure of each party.

One would expect that the processor would have the highest income at the lowest price combination, which is US$0.681/kg in the low-supply season and US$0.632/kg in the high-supply season. Yet at that price combination and even exerting full market power, pepper is traded in individual contracts in the low-supply season and in group contracts during the high-supply season. A similar effect can be observed at the next lowest price in the low-supply season, combined with any possible price in high-supply season. We assumed that $w(GC) = 1$, which means that the processor's expected income determines the objective function, but this income is negatively influenced by the probability of farmers behaving opportunistically. The model uses the expected net incomes of the parties as arguments in the objective function, and each party's expected income is corrected by the probability of the other party's behaving opportunistically.

At such low prices the processor's income is maximised in the low-supply season by individual contracts (not by group contracts), implying not only the farmers' high opportunistic behaviour and thus high costs for the processor, but also large rejection rates and therefore a smaller quantity of fresh pepper with an acceptable quality. The preference for individual contracts at low prices in the low-supply season is due to the constraint of a minimal income to be reached by the farmers. At these prices the farmers cannot cover the higher costs of a group contract in this season, as this would cause their income to fall below the pre-defined minimum income level. Group contracts are more expensive

to organise for the farmers in the low-supply season in terms of governance costs, which are lower in the high-supply season. Stated otherwise, the procurement price paid during the low-supply season has a more important effect on contract choice and the farmers' possibility of forming a group than the price paid during the high-supply season. This is a plausible outcome, since the price paid in the low-supply season is the price that farmers would receive most of the year (nine months).

If the processor increases the low-supply season price of fresh pepper to US$0.738/kg, while maintaining a price of US$0.632/kg for high-supply seasons, the processing firm maximises its income and achieves group contracts for both supply seasons (US$106,590). Conversely, the farmers' income is maximised (US$86,173) at the combination of the highest prices (US$0.967/kg and US$1.062/kg). This is, of course, also the price combination that yields the lowest processor's income (US$67,458). However, the processor does not need to offer a combination of prices beyond US$0.738/kg and US$0.632/kg, since at that point group contracts are already achieved.

In conclusion, as a monopsonist, the firm can pay the lowest procurement price that still makes it worthwhile for farmers to supply pepper, and that makes it possible for the farmers to bear the costs of organising a group. Group contracts improve product coordination in terms of quality and quantity, thus influencing the shift of farmers' opportunistic behaviour; at the same time, marketing costs for the firm decrease while the quantity of fresh pepper with acceptable quality increases. The combination of higher quality pepper with lower costs explains why the firm is willing to pay a higher price for fresh pepper. This can also be understood by adding the incomes of the processor and the farmers. Starting at the lowest price combination (US$0.681/kg and US$0.632/kg) to the low season price of US$0.738, their combined incomes increased from US$144,693 to US$153,630. In other words, the total 'cake' has increased, permitting a larger share for each party. Finally, comparing this model outcome with prices observed, it is interesting to note that this higher low season price *l* is, according to our

model, lower in each season than the actual 2000 procurement price of fresh pepper of US$0.89 per kg.

Table 4 shows the results of the scenario where, in a group contract, the farmers' group would have all the market power and a monopoly market condition would prevail [$w(GC) = 0$], whereas in individual contracts, the market still is a monopsony with $w(IC) = 1$. In this scenario, the farmers' expected income entirely determines the objective function in the case of a group contract, and this income is also determined by the probability of the processor behaving opportunistically.

In this scenario, the processor maximises his income and achieves group contracts for both supply seasons at a slightly higher price in the low-supply season (US$0.795/kg), and at the same price in the high-supply season (0.632/kg), but with a slightly lower income (US$103,193; Table 4, Panel A) than in the previous scenario. The farmers' income is US$50,438 at that price combination (Table 4, Panel B), which enables them to assume organisation costs throughout the year. Prices above US$0.632/kg, but below US$0.847, in the high-supply season would lead to pepper being traded in individual contracts in both seasons or to group contracts during the low-supply season and individual contracts during the high-supply season. Increasing high-supply season prices further would again lead to group contracts in both seasons. As mentioned above, it is interesting to note that according to our model this higher price is lower in each season than the actual 2000 procurement price of fresh pepper (US$0.89 per kg). All in all, this combination of prices can result in a rather unstable governance structure, where opportunistic behaviour from both parties could influence the shift from one governance structure to another, in any supply season. As in the previous scenario, such behaviour also affects the sum of the incomes of the processor and farmers (not reported here). Thus the procurement prices for the high-supply season between US$0.675 and US$0.804 would only result in less income for both parties, thus making it unrealistic to offer such prices. As in the previous case, in this scenario the best prices from

the processor's point of view are those leading to a combination of higher quality pepper with lower costs. This explains why the firm is prepared to pay a higher price for fresh pepper. At the same time these prices induce farmers to form a group and permit them to bear the costs of organisation and assume part of the marketing costs, while still obtaining a better income than under individual contracts. Finally, the behaviour of both parties increases their combined incomes, allowing each to have a larger income.

Table 5 shows the in-between scenario in the case of group contracts under the market form of a bilateral monopoly, where the firm relaxes its market power and shares the bargaining power with farmers [$w(GC) = 0.5$]. In this scenario, the processor's and farmers' expected incomes are weighted equally in the objective function, while both incomes are determined by the probability of both parties behaving opportunistically. Once again, in the case of individual contracts, the market is still a monopsony with $w(IC) = 1$.

In this case the processor maximises his income (US$103,217) and achieves group contracts for both supply seasons at the price combination of US$0.795/kg and US$0.632/kg, for the low-and high-supply seasons, respectively. This is the same price combination as in the second scenario. The farmers' income amounts to US$50,438 at that price combination, where they can assume the costs of organisation throughout the year. Any previous combinations of prices (under US$0.795/kg and US$0.632/kg) would lead to pepper being traded in individual contracts during the low-supply season and in group contracts during the high-supply season. Again, the farmers' sensitivity regarding the price that they receive during most of the year is evident and becomes higher when they share the bargaining power with the processor. When it is shared, the farmers have more chances to increase their income by adopting opportunistic behaviour. Because the bargaining power is relaxed, the processor must move to a higher combination of prices than in the first scenario and receives less income (US$103,217), in order to foster group contracts in both seasons.

Table 4
The effect of different procurement prices on the income distribution between the contracting parties, and the governance structure. A monopoly market condition prevails $w(k) = 0$.

Price (low-supply season)	Price (high-supply season)										
	0.632	0.675	0.718	0.761	0.804	0.847	0.890	0.933	0.976	1.019	1.062
	IC/GC	IC	IC	IC	IC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC
Panel A: processor's income ('000 US$)											
0.681	98	84	82	79	77	85	83	80	78	75	73
0.710	97	82	80	78	75	84	81	79	76	74	71
0.738	95	81	78	76	74	82	80	77	75	72	70
0.767	94	80	77	75	73	81	78	76	73	71	68
	GC	GC/IC	GC/IC	GC/IC	GC/IC	GC	GC	GC	GC	GC	GC
0.795	103	89	86	84	82	90	88	85	83	80	78
0.824	101	87	85	83	80	89	86	84	81	79	76
0.853	100	85	83	81	79	87	84	82	79	77	74
0.881	98	84	81	79	77	85	83	80	78	75	73
0.910	96	82	80	78	75	84	81	79	76	73	71
0.938	94	80	78	76	74	82	79	77	74	72	69
0.967	93	78	76	74	72	80	78	75	73	70	67
Panel B: Farmers' income ('000 US$)											
0.681	46	47	49	51	53	59	62	64	67	69	72
0.710	48	49	51	53	55	61	63	66	68	71	73
0.738	49	50	52	54	57	62	65	67	70	72	75
0.767	51	51	54	56	58	64	66	69	71	74	76
	GC	GC/IC	GC/IC	GC/IC	GC/IC	GC	GC	GC	GC	GC	GC
0.795	50	51	53	55	58	63	66	68	71	73	76
0.824	52	53	55	57	59	65	67	70	72	75	78
0.853	54	54	57	59	61	67	69	72	74	77	79
0.881	55	56	58	60	63	68	71	73	76	78	81
0.910	57	58	60	62	64	70	73	75	78	80	83
0.938	59	60	61	64	66	71	74	77	79	82	84
0.967	60	61	63	65	68	73	76	78	81	84	86

Note: IC, individual contracts; GC, group contracts.

Table 5
The effect of different procurement prices on the income distribution between the contracting parties, and the governance structure. A bilateral monopoly market condition prevails $w(k) = 0.5$.

Price (low-supply season)	Price (high-supply season)										
	0.632	0.675	0.718	0.761	0.804	0.847	0.890	0.933	0.976	1.019	1.062
	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC	IC/GC
Panel A: processor's income ('000 US$)											
0.681	98	96	93	91	88	85	83	80	78	75	73
0.710	97	94	92	89	87	84	81	79	76	74	71
0.738	95	93	90	88	85	82	80	77	75	72	70
0.767	94	91	89	86	84	81	78	76	73	71	68
	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC
0.795	103	101	98	96	93	90	88	85	83	80	78
0.824	101	99	96	94	91	89	86	84	81	79	76
0.853	100	97	95	92	90	87	84	82	79	77	74
0.881	98	95	93	90	88	85	83	80	78	75	73
0.910	96	94	91	89	86	84	81	79	76	73	71
0.938	95	92	90	87	84	82	79	77	74	72	69
0.967	93	90	88	85	83	80	78	75	73	70	67
Panel B: Farmers' income ('000 US$)											
0.681	46	49	52	54	57	59	62	64	67	69	72
0.710	48	50	53	56	58	61	63	66	68	71	73
0.738	49	52	54	57	60	62	65	67	70	72	75
0.767	51	53	56	58	61	64	66	69	71	73	76
	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC	GC
0.795	50	53	55	58	61	63	66	68	71	73	76
0.824	52	55	57	60	62	65	67	70	72	75	78
0.853	54	56	59	61	64	66	69	72	74	77	79
0.881	55	58	61	63	66	68	71	73	76	79	81
0.910	57	60	62	65	67	70	73	75	78	80	83
0.938	59	61	64	67	69	72	74	77	79	82	84
0.967	61	63	66	68	71	73	76	79	81	84	86

Note: IC, individual contracts; GC, group contracts.

5. Discussion

The firm seeks the best governance structure to ensure a stable trade relationship with pepper producers in El Roble. This structure should be a hybrid, where the procurement price plays an important role as an incentive (Williamson, 1991), but also its members' cooperation and commitment are required (Slangen et al., 2008). For the processor, the best level of procurement prices should ensure a maximum supply of fresh pepper, of an acceptable quality and at the lowest possible costs. Such prices induce and permit farmers to form a group, bearing the costs of organisation and assuming part of the marketing costs, while still obtaining a better income than under individual contracts. A stable and larger flow of better-quality pepper, plus a redistribution of marketing costs can explain why the processor is able to pay a combination of higher prices for both seasons.

Nonetheless, based on theoretical considerations, we would not expect a processor to behave entirely as a monopsonist. According to Key and Runsten (1999), a monopsonistic firm exerting all its bargaining power for its own benefit might face uncertainty regarding the farmers' response, which is costly to monitor. Although farmers tend to be loyal to the processor and their negotiating power is limited, they might be forced out of pepper production if the price is too low. They would earn a better living in alternative activities. This would be critical for the firm as it requires a stable, continuous flow to operate and remit its investments.

Our first scenario shows that under low levels of procurement prices (the prices paid during the low-supply season in particular), farmers adopt an opportunistic type of behaviour and trade their pepper under individual contracts. The firm invested significantly in specific assets – specifically in a processing plant and personnel – and it is dependent on the farmers' loyalty to provide a constant flow of fresh pepper. In the low production season and under individual contracts, however, the delivery of fresh pepper is more

irregular (every 2–3 weeks instead of weekly, as during the high season). In this case the firm may not want to run the risk of farmers refusing to harvest pepper and turning to other activities. Farmers have some room for negotiation, yet it may not be enough to convince them to form an association and bulk their production, as this is too expensive at low prices. Transaction costs are high due to the less frequent deliveries in the low season, thus encouraging the farmers to behave opportunistically. The reduction of these transaction costs that would result from a group contract is not sufficient to lead to collective action.

Conversely, the processor, as a monopsonist, can define a hybrid governance structure that always permits group contracts with the farmers. This governance structure can be characterised by a combination of at least two groups of coordination mechanisms, namely the 'invisible hand' and the 'handshake' (Slangen et al., 2008). In the first, price plays an important role as an *autonomous adaptation*, while in the second the adjustment also comes from mutual agreement between two parties working together for a certain purpose (producing and selling pepper). This mechanism is usually categorised as adaptation by non-price coordination (Slangen et al., 2008).

According to Williamson (1991), price as a coordination mechanism is not as strong under a hybrid governance structure as under a market governance structure. This is because price is neo-classically interpreted as an outcome of changes in the demand or supply of goods, under which the agents just adapt or react to each changing situation (Hayek, 1945, quoted by Williamson, 1991). Williamson referred to this type of reaction an 'autonomous adaptation' (Slangen et al., 2008). In our case study, however, price is not an outcome of changes in the supply or demand of fresh pepper between farmers and the processing firm; it is intended to be the incentive for increasing the pepper supply, with a regular flow, at an acceptable level of quality. Therefore, we suggest that the hybrid governance structure between both parties should also have characteristics of the 'handshake' mechanism, where the price

definition is more an outcome of negotiation. Under the particular role of the procurement, the price (to increase and stabilise the flow of fresh pepper of an acceptable quality) plus the elements of negotiation from the non-price adaptation, should yield a governance structure where the price becomes an important coordination mechanism.

This is in line with Sivramkrishna and Jyotishi (2008), who state that the nature of negotiation between the processing firm and the farmers' association should entail a negotiated minimum price for the association, while the processor is ensured a minimum supply. A negotiated price like this cannot be identified *a priori*, but is more an outcome of trial and error and negotiation. In this particular case study, we provided a first estimation of the magnitude of a negotiated price.

Under a hybrid governance structure such as this one, we expect stable and more frequent transactions between both parties. Transaction frequency increases, and the risk of opportunistic behaviour decreases (Hobbs, 1996). Stable relationships are more easily maintained with oft-repeated transactions, where agents are able to build up a reputation, loyalty and confidence; in other words, it is worthwhile for the firm to enter into a group contract in order to economise on transaction costs.

6. Conclusion

The results have shown that contract preference changes at different prices; however, such behaviour is also related to the different bargaining power attributed to the firm and to the smallholders. This is important for agricultural policy making. If pepper is to be considered to be a viable non-traditional export crop for farmers to invest in, and if processing firms are to survive and expand, an institutional environment conducive to pepper production should be created to stabilise contract choice. This will secure the raw material flow for the processor and supplement the family income flow for the farmers. Policies can improve farmers' bargaining power by promoting a fully-recognised co-operative structure which could serve to provide the necessary inputs and information, and also support fair price negotiations (see also World Bank, 2007).

For the future development of pepper production, there is a need to maintain an attractive market environment which would preferably also lead to an increase in productivity and the stabilisation of production throughout the year. This would increase (and stabilise) transaction frequency, improve trust between actors and encourage low opportunistic behaviour, thereby strengthening vertical integration between both parties. The terms of the contracts must be clear for the farmers and their rights should be better secured. In absence of trust between farmers and producers, both parties could benefit from better contract enforcement. It should be possible for a third party to control the contracts and take measures when one of the parties does not obey the terms of the contract.

The results of the simulations show that group contracts are beneficial if the farmers gain enough to cover the costs of organising the group's activities. As mentioned in the introduction, farmers' associations may improve access to the market for the farmers, but the costs of managing the association should not be underestimated. This is also discussed in the World Development Report as one of the challenges for collective action (World Bank, 2007); collective action among farmers requires social capital and builds on social inclusion and solidarity. The associations are therefore expected to 'cross-subsidise poorer-performing members at the expense of better performers' (World Bank, 2007, p. 155), although this may reduce the overall strength of the group. The larger the size and the heterogeneity of the group, the more effort it will re-

quire to manage the individual performances, and enforce agreements between the organisation and the farmers and secure the contract. The size of the group and its heterogeneity were not accounted for in our model, but these are interesting aspects for future work.

In follow-up research, the model could be expanded by considering each individual farmer in order to analyse the factors that may influence the farmers' actions. Some may benefit more from the group contract, while others may show non-cooperative behaviour and/or breach the group contract. Furthermore, fine-tuning the costs of managing the group and the cost effectiveness of increasing the group size would require an in-depth analysis of the structure, operation and negotiation procedures of the group contracts. The sensitivity of the model could be tested by adapting it to evaluate contracts in other types of agricultural products. Finally, this methodology may be helpful for policy makers, in order to identify: (1) scenarios where the market environment between the firm and producers can be improved; and (2) conditions that stimulate collective action among farmers and how to support them.

Appendix A

A.1. Model specifications

The aim of the model is to determine the optimal volume of fresh pepper traded between seller (farmers) and buyer (processor), which is the result of the quantity of fresh pepper produced, X_{kjs}, the central choice variable of model, and that part of the production not refused, $(1 - ref_{kjs})$, with ref_{kjs} the refusal rate, under each set of conditions. In the present paper, we look in particular at the influence of the price of fresh pepper in each season, f_s. In the model, we consider two market conditions, low-and high-supply seasons (s); two contract arrangements (k), individual and group contracts (IC and GC, respectively); and that parties may display a low or high opportunistic behaviour (j) (low-opp and high-opp, respectively); see Tables 6–8 list the variables and coefficients of the model, respectively.

Table 6
Sets.

Symbol	Elements in set	Explanation
k		Contractual arrangement
	IC	Contract between individual farmer and processor
	GC	Contract between farmer group and processor
j		Behaviour
	High-opp	High opportunistic behaviour
	Low-opp	Low opportunistic behaviour
s		Market season
	Low-supply	Low-supply season (March to November)
	High-supply	High-supply season (December to February)

Table 7
Variables (with units) used in the model.

Symbol	Explanation	Units
A	Objective variable to be maximised	US$
B_{kjs}	Expected income of buyer (processor)	US$
S_{kjs}	Expected income of seller (farmer)	US$
X_{kjs}	Volume of traded fresh pepper	kg
F_{kjs}	Price of fresh pepper	US$/kg
Zb^-_{kjs}	Sum of buyer's income deviations from target income	US$
Zs^-_{kjs}	Sum of seller's income deviations from target income	US$
Y_{kjs}	Binary marketing choice variable	

Table 8
Coefficients used in the model with units.

Symbol	Explanation	Units
w_{kj}	Market power	
Indy	Industrial yield of white pepper from fresh pepper	kg/kg
Frp	White pepper price	US$/kg
f_s	Fresh pepper price per season	US$/kg
ref_{kjs}	Rejection rate of fresh pepper	
$prem_k$	Premium for high quality pepper	US$/kg
bc_{kjs}	Buyer's (processor's) variable cost of production per kg of fresh pepper	US$/kg
bf_{ks}	Processor fixed costs per year	US$
sc_{kjs}	Seller's (farmer's) variable cost of production per kg of fresh pepper	US$/kg
sf_{ks}	Farmer's fixed costs per year	US$
rib_s	Reservation income buyer (processor) per season	US$
ris_s	Reservation income seller (farmer) per season	US$
prb_{kjs}	Probability for buyer of farmer behaviour	
prs_{kjs}	Probability for seller of processor behaviour	
λ^{buyer}	Acceptable weighted sum of deviations below processor's target income	US$
λ^{seller}	Acceptable weighted sum of deviations below farmers' target income	US$
tib_s	Target income buyers (processor)	US$
tis_s	Target income sellers (farmer)	US$
pqs_s	Processing capacity per season	kg
m	Artificial large number to force binary solution	

The model specifications are as follows: Objective function (US$):

$$\text{Max } A = \sum_{kjs} w_k B_{kjs} prb_{kjs} + \sum_{kjs} (1 - w_k) S_{kjs} prs_{kjs} \tag{1}$$

Net income calculations (US$):

$$B_{kjs} = X_{kjs}((1 - ref_{kjs})/indy)frp \\ - X_{kjs}(1 - ref_{kjs})(f_s + prem_k + bc_{kjs}) - bf_{ks}, \quad \forall k, j, s \tag{2}$$

$$S_{kjs} = X_{kjs}(1 - ref_{kjs})(f_s + prem_k) - X_{kjs}sc_{kjs} - sf_{ks}, \quad \forall k, j, s \tag{3}$$

Minimum income requirements per season (US$):

$$\sum_{kj} B_{kjs} prb_{kjs} \geqslant rib_s, \quad \forall s \tag{4}$$

$$\sum_{kj} S_{kjs} prs_{kjs} \geqslant ris_s, \quad \forall s \tag{5}$$

Target MOTAD part (US$), with negative income deviations of buyer and seller, respectively, and the expected weighted sum of deviations below target income of both buyer and seller, respectively:

$$\sum_{s} (B_{kjs} + Zb_{kjs}^-) \geqslant tib_s, \quad \forall k, j \tag{6}$$

$$\sum_{s} (S_{kjs} + Zs_{kjs}^-) \geqslant tis_s, \quad \forall k, j \tag{7}$$

$$\sum_{kjs} prb_{kjs} Zb_{kjs}^- = \lambda^{buyer} \tag{8}$$

$$\sum_{kjs} prs_{kjs} Zs_{kjs}^- = \lambda^{seller} \tag{9}$$

Capacity restriction (kg):

$$\sum_{kj} X_{kjs} \leqslant pqs_s, \quad \forall s \tag{10}$$

Binary part of the model:

$$X_{kjs} \leqslant m * Y_{kjs}, \quad \forall k, j, s \tag{11}$$

$$\sum_{kj} Y_{kjs} \leqslant 1, \quad \forall s \tag{12}$$

In the objective function (1), the sum of the net incomes of both processor and farmers (A) is maximised. This is expressed as the expected net incomes of processor (B) and farmers (S) multiplied by their bargaining power (w_k). For IC, we have considered that w_k = 1 in all cases. However, we distinguish different market conditions in the case of GC. The most important are: monopoly (w_k = 0), monopsony (w_k = 1) and joint profit maximisation (w_k = 0.5). The coefficients prb_{kjs} and prs_{kjs} indicate the probability for a given party (processor or farmers) of another party's opportunistic behaviour (j), under contractual arrangement (k) and market condition (s). Probabilities sum to one for each market condition (s). The probability of farmers behaving opportunistically is higher when the processor chooses individual contracts and lower when group contracts are chosen. The probability of the processor behaving opportunistically is higher when farmers choose individual contracts and lower when they choose group contracts.

Eqs. (2) and (3) show the endogenously determined net incomes of the processor and farmers, respectively, by buying and selling, respectively, X_{kjs}, the volume of traded fresh pepper, the central choice variable in the model, under contractual arrangement (k), opportunistic behaviour (j) and season (s).

The volume of traded fresh pepper, X_{kjs}, is influenced by the following factors:

ref_{kjs}	rejection rate, which is defined at four levels as follows: 9% (IC and low-opp), 15% (IC and high-opp), 1% (GC and low-opp), and 5% (GC and high-opp)
indy	the industrial yield, defined by the processor as 4.20 kg of fresh pepper to produce 1 kg of processed white pepper
frp	the processor's price for white pepper (US$8/kg). This is the highest selling price reported by the processor in 2000. Selling prices may vary every semester, according to negotiations with the processor's main client (an American food processor based in Costa Rica). This niche-oriented market arrangement is relatively isolated from the world pepper market
f_s	the purchase price of fresh pepper for processor and farmers. It is fixed as a coefficient, albeit at different levels to reflect the influence of this price on the traded volume, the contractual arrangement and the (opportunistic) behaviour
$prem_k$	a quality premium paid as an incentive for good-quality pepper in the group contract
bc_{kjs}	the buyer (processor) variable production costs per kg of fresh pepper. It includes processing, organisation and transport costs
sc_{kjs}	the seller's (farmer's) production costs per kg of fresh pepper. It includes farm production costs and transports, as well as organisation costs, transport supervision costs, and membership fee in the case of group contracts
bf_{ks}	processor's fixed costs. For the processor, we consider half of the monthly administrative costs for management in processing pepper
sf_{ks}	farmers' fixed costs. For farmers, this is the minimal cost of delivering and referring to the value of working time and the time needed for delivery at the collection point

Eqs. (4) and (5) indicate that the expected net income of the processor and the farmers should be larger than a reservation income which is equal to what they could have earned in an alternative activity in both seasons of the year. For the processor (rib), this is defined as half of the target income, namely US$19,400, equally divided over each season. For the farmers (ris), it is defined as the average income obtained from other agricultural activities (commercial crops, livestock production and off-farm employment) amounting to US$17,570, divided over the two seasons.

The variables Zb_{kjs}^- and Zs_{kjs}^- in Eqs. (6) and (7) determine the value of the deviation of the net income below the target income un-

der each condition. In Eqs. (8) and (9), the expected shortfall from the target over all conditions is calculated and set equal to a satisfactory level of shortfall from the target as given by λ^{buyer} and λ^{seller}, for the processor and the farmers, respectively. The coefficients λ^{buyer} and λ^{seller} indicate an acceptable level of shortfall, thus accounting for the risk behaviour of the processor and the farmers, respectively. For the processor, the target income (*tib*) is set at US$38,000 in the base run, which refers to the annual fixed costs of operating the pepper processing plant. For the farmers' group, the target income (*tis*) is the lowest income which they reported to be willing to accept before they would quit producing pepper; it was calculated at US$27,412 per year from survey data.

Eq. (10) refers to production limitations, namely that the amount of fresh pepper traded in any season should be lower than the maximum that can be produced per season (60,000 kg, twice the production in 2000). Finally, constraints (11) and (12) are added to make the model integer, so that only one contractual arrangement per season is selected. This set of equations was programmed in the General Algebraic Modelling System (GAMS).

References

Babbie, E., 1992. The Practice of Social Research. Wadsworth, Belmont, CA.
Cook, M.L., 1995. The future of US agricultural cooperatives: A neo-institutional approach. Am. J. Agric. Econ. 77 (5), 1153–1159.
D'Haese, M., Verbeke, W., Van Huylenbroeck, G., Kirsten, J., D'Haese, L., 2005. New institutional arrangements for rural development: The case of local woolgrowers' associations in the Transkei Area, South Africa. J. Dev. Stud. 41 (8), 1444–1466.
Dirección General de Aduanas (DGA), 2003. Base de datos sobre exportaciones e importaciones de pimiento sin triturar/sin procesar y triturada/procesada, por empresa, por destino, y por año. Periodo 1996, 2003.
Dorward, A., 2001. The effects of transaction costs, power and risk on contractual arrangements: a conceptual framework for quantitative analysis. J. Agric. Econ. 52 (2), 59–73.
Fafchamps, M., 2004. Market Institutions in Sub-Saharan Africa. Theory and Evidence. MIT Press, Cambridge, MA.
Glover, D.J., 1984. Contract farming and smallholder outgrower schemes in less-developed countries. World Dev. 12 (11–12), 1143–1157.
Glover, D.J., 1987. Increasing the benefits to smallholders from contract farming: problems for farmers' organizations and policy makers. World Dev. 15 (4), 441–448.
Hazel, P., Norton, R., 1986. Mathematical Programming for Economic Analysis in Agriculture. Collier Macmillian Publishers, New York.
Henderson, J.M., Quandt, R.E., 1980. Microeconomic Theory: A Mathematical Approach. McGraw-Hill, New York.
Hobbs, J.E., 1996. A transaction cost approach to supply chain management. Supply Chain Manage. 1 (2), 15–27.
Key, N., Runsten, D., 1999. Contract farming, smallholders and rural development in Latin America: the organisation of agroprocessing firms and the scale of outgrower production. World Dev. 27 (2), 381–401.
Knoeber, C.R., 1983. An alternative mechanism to assure contractual reliability. J. Leg. Stud. 12 (2), 333–343.
McDormick, D., 1999. African enterprise clusters and industrialization: theory and reality. World Dev. 27 (9), 1531–1551.
Ménard, C., 2005. A new institutional approach to organisation. In: Ménard, C., Shirley, M.M. (Eds.), Handbook of New Institutional Economics. Springer, Dordrecht, pp. 281–318.
Rojas-Zuñiga, I., 1994. Cultivo de la pimienta (*Piper nigrum* L.). In: Cortés, G. (Ed.), Atlas Agropecuario de Costa Rica. EUNED, San José, Costa Rica.
Sáenz-Segura, F., 2006. Contract Farming in Costa Rica: Opportunities for Smallholders? PhD Thesis, Wageningen University, The Netherlands.
Simmons, P., Winters, P., Patrick, I., 2005. An analysis of contract farming in East Java, Bali, and Lombok. Indonesia Agric. Econ. 33, 513–525.
Simon, H., 1961. Administrative Behavior, second ed. Macmillan, New York, NY.
Singh, S., 2002. Contracting out solutions: political economy of contract farming in the India Punjab. World Dev. 30 (9), 1621–1638.
Sivramkrishna, S., Jyotishi, A., 2008. Monopsonistic exploitation in contract farming: articulating a strategy for grower cooperation. J. Int. Dev. 20, 280–296.
Slangen, L.H.G., Loucks, L.A., Slangen, A.H.L., 2008. Institutional Economics and Economic Organisation Theory. An Integrated Approach. Wageningen Academic Publishers, Wageningen, The Netherlands.
Tauer, L.W., 1983. Target MOTAD. Am. J. Agric. Econ. 65, 606–610.
Wadley, R.L., Mertz, O., 2005. Pepper in a time of crisis: smallholder buffering strategies in Sarawak, Malaysia and West Kalimantan, Indonesia. In: Mertz, O.M., Wadley, R.L., Egelund Christensen, A. (Eds.), Local Land Use Strategies in a Globalizing World: Subsistence Farming, Cash Crops and Income Diversification. Agric. Syst. 85(3), pp. 286–305.
Williamson, O.E., 1991. Comparative economic organizations: the analysis of discrete structural alternatives. Adm. Sci. Q. 36, 269–296.
World Bank, 2007. World Development Report 2008: Agriculture for Development. The World Bank, Washington, DC.