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On the co-existence of spot and contract markets:  
An analysis of quality

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The food sector is undergoing a fundamental transformation in response to changing consumer demand that is the shift away from the agricultural commodities with standard quality specifications to agricultural ingredients with non-standard specifications. Consequently, there is an increasing concern about acquiring quality inputs among processors. The use of contracts to respond to this increasing demand for quality among consumers has become common practice in many agricultural sectors (Cook and Chaddad, 2000). To solve the apparent quality measurement problems between processors and independent growers that universally plague these relationships, the majority of contracts use incentives schemes to incentive growers to produce quality.

In fact, many studies of incentive contracts have empirical support for the prevalence of incentive contracts to encourage growers to produce greater level of quality over the spot market. Among the existing studies, Curtis and McCluskey (2003) analyze a sample of production contracts between potato processors and growers in the Columbia Basin area of Washington and Oregon. The authors conclude that contracts are effective at increasing potato load quality over the spot market alternative. In a recent paper, Alexander, Goodhue and Rausser (2007) examine an unusual dataset 14 tomato growers over 4 years to analyze the effect of incentive contracts on behaviour. They find that the processor obtains higher quality tomatoes from contracting than from spot purchases because growers respond to price incentives for quality.

The previous contributions have provided empirical support for the prevalence of incentive contracts to encourage growers to produce greater level of quality over the no contract alternative, which raises questions about the viability of spot markets in the future. One of the earliest formulations of co-existence of spot and contract markets in agriculture can be found in Xia and Sexton (2004). In their model, they analyzed the

impact of “top-of-the-market” contract clauses on the intensity of competition in the market in a duopsony model. In related work, Carriquiry and Babcock (2004) analyzed the impact of many buyers and sellers on a market equilibrium characterized by co-existence. They concluded that co-existence of both markets only arose in presence of uncertainty. Finally, Hendrikse (2007) found co-existence in a model of endogenous contract formation and endogenous uncertainty. His results established that contracts arise due to the costs associated with a spot market, regardless of the heterogeneity of buyers and the uncertainty of supply.

While the previous contributions have considerably enhanced our understanding of co-existence, they suffer from an important limitation. Although there is an increasing demand for food quality, quality issues are not introduced in their models of coexistence. Taking into account that one of the determinants of contracts is quality (Goodhue *et al.*, 2003; Hueth and Ligon, 1999a, b, 2001, 2002), it cannot be presumed that conclusions of previous literature remain stable in differentiated product markets. Hence, a fully satisfactory theory is yet to be developed.

To fill this gap, the purpose of this paper is to examine theoretically whether the co-existence of incentive contracts and spot market can emerge as an equilibrium outcome in a differentiated market. By taking into account quality issues, we take a further step towards understanding the market settings when contracts and spot exchanges coexist.

Using a simulation exercise, we prove that co-existence of incentive contract and spot market is quite natural in differentiated markets. While such a conjecture is apparent in the intuitions underlying many earlier models, we prove it formally, as resulting from the optimizing behaviour on the part of the agents.

The paper is organized as follows. The following section outlines the basic framework. Then we characterize the static equilibrium structures using the Nash

equilibrium concept and discuss the various implications of the different structures with a simulation exercise. A summary and concluding remarks are in the final section.

### **The basic framework**

The proposed methodology for studying the contractual problems is based on the maximization problems of the primary producers and the processing industry, respectively. Various assumptions can be made with respect to the market and the organizational structure.

We consider a regional area in which  $M$  identical upstream producers or growers ( $k:1\dots M$ ) supply the essential input used by  $N$  identical processors ( $i:1\dots N$ ) in a regional area. We suppose that one unit of input is needed to produce one unit of output and there is no other input. Likewise, inputs from different producers will yield a final product whose quality is a weighted average of the quality of its inputs. That is, we assume for simplicity that the processor doesn't add value to the product and likewise that there are no processing costs.

The processors, risk-neutral, are quantity-setting (Cournot) competitors, producing a differentiated product. The differentiation can be vertical and horizontal. In general, market prices are higher for high-quality than for lower quality goods. Likewise, prices and yields appear to be inversely related in the aggregate market (see for example Beard and Thompson, 2003). Although some of our analysis can be carried out by using a general functional form for the price, the exposition is significantly improved if a specific functional form is used. To improve the exposition, we assume that the inverse demand function for processor  $i$ 's product is assumed to be linear<sup>1</sup>:

$$P_i = b_1 S_i - b_2 Q_i - b_3 \sum_{\substack{j=1 \\ j \neq i}}^N Q_j \quad i=1..N$$

Where  $P_i$  is the price of the output,  $Q_i$  is the quantity and  $S_i$  denotes the quality of the output of processor  $i$ . Likewise,  $b_1$ ,  $b_2$  and  $b_3$  represent, respectively, the own market specific quality effects, and the own and each rival market specific supply effects with  $b_h > 0$   $h=1 \dots 2$ .

Following Carriquiry and Babcock (2004), it is assumed that producers are risk-neutral<sup>2</sup>. Each producer decides his level of quantity,  $q$ , and quality,  $s$ . As is traditionally the case in models of this kind (see, e.g. Champsaur and Rochet, 1989; Giraud-Héraud, Soler and Tanguy, 1999), we assume constant marginal production costs regardless of volume and that the cost varies quadratically in line with the level of quality as follows:  $C(q, s) = \frac{c}{2}qs^2$ , with  $c > 0$ .

Each processor can acquire his input in the spot market or by offering an incentive contract to a grower. We assume that the incentive contract is exclusive, that is, a processor can only contract with a producer and vice versa. Moreover, if a producer accepts the incentive contract, he can not supply his input at the spot market<sup>3</sup>. Following the previous literature in agency theory (for example, Stiglitz, 1974; Holmström and Milgrom, 1979, 1987) and guided by empirical evidence, we consider that the structure of the incentive contract is linear in the observed processor's revenue. This implies a two-part compensation scheme consisting of (i) a fixed payment,  $\alpha$ , that is independent of the observed revenue, and (ii) an incentive payment that amounts to a positive share,  $\beta$ , of the observed revenue.

We do not consider the optimal allocation of land ownership between the grower who works with land directly and his intermediary who processes and sells the growers' output in some downstream market because it does not affect the total joint certainty equivalent.

Our formulation of the models<sup>4</sup> implicitly recognizes the law of supply and demand for both raw material and finished product, that is, the volume demanded will be equivalent to the volume supplied in the regional area.

### **The structure of the game**

As we mentioned earlier, the main objective of this paper is to determine the equilibrium governance mechanism in the vertical relationship. To this end, we consider a two-stage game. In the first stage, the processors, simultaneously, decide whether to offer an incentive contract or to remain at the spot market. Following to Hendrikse (2007), processors in contracts are not allowed to trade on the spot market. They take their decisions based on the anticipated expected profits resulting from the second stage. In the second stage, the processor's problem depends on the governance mechanism structure which results from the first stage.

There are three possible structures of governance forms in this second stage. In the first, denoted by *non incentive contract structure*, both growers and processors operate independently at the spot market. Producers set a price for the input, which processors buy at the spot market, transform it into output and compete in quantities in the downstream market. The growers, simultaneously, decide on their effort to produce quality input and quantity input. In doing so, they face the derived demand for the input derived from the decisions of the processors. In the downstream stage, the processors simultaneously decide on the quantity of the output, taking as given the price of the input and the consumer demand for the output.

In the second structure, denoted by *asymmetric incentive structure*, some pairs processor-grower remain at the spot market and other pairs set an incentive contract. In each incentive contract, the processor delegates the quantity and quality decisions to his

contracting grower and determines the compensation scheme:  $w = \alpha + \beta y$ , where  $\alpha$  and  $\beta$  are constant,  $\beta \geq 0$ , and  $y$  is the processor's revenue. The processor selects  $\alpha$  so that the grower gets only his reservation utility. We assume that the grower accepts any incentive contract that gives him a payoff at least as great as what he would get in his best alternative, that is, what he would obtain if he remained in the spot market.

Finally, in the third structure, denoted by symmetric incentive structure, each processor sets an incentive contract with a grower. The continuation game proceeds in the same way that in the incentive contract of the previous structure.

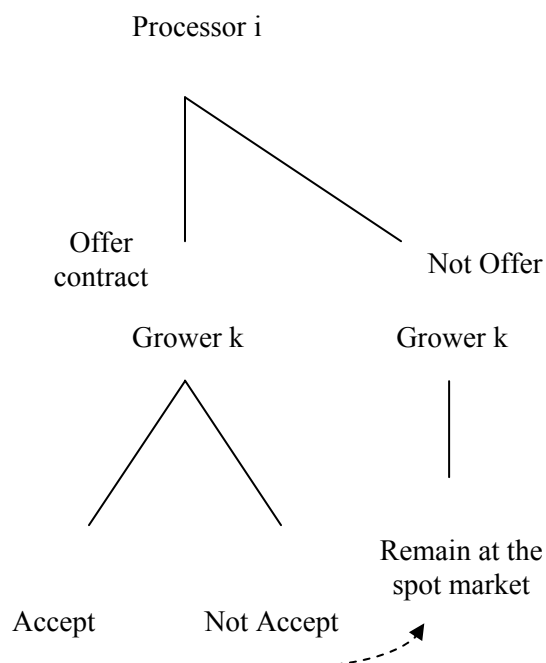


FIGURE 1: The basic structure of the game

### The expected profits of the structures

We are interested in characterizing the subgame-perfect Nash-equilibria. As usual, we solve the game by backward induction.



Following Hendrikse (2007), we have taken the number of processors to be equal to the number of growers, that is,  $N=M$ . This assumption is made for the purpose of allowing each processor to have possibility to set an incentive contract with a grower.

Case (i): *Non-incentive contract structure*

We solve first the structure where all processors acquire their input at the spot market prices. The analysis is symmetrical for all processors. We denote by  $q_{ij}$  the quantity of input acquired by processor  $i$  from the grower  $k$ ,  $i=1 \dots N$ ,  $k=1 \dots M$ . We solve the subgame by backward induction. Then, we start from second stage 2, in which given the input prices,  $p_k$ , processor  $i$  choose his quantity to maximize his profits,  $\pi_i^M$ . A processor's profit is the revenue generated minus the total cost paid:

$$(1) \quad \text{Max}_{Q_i} \pi_i^M = Q_i P_i - \sum_{k=1}^M q_{ik} p_k$$

$$(2) \quad \text{Max}_{Q_i} \pi_i^M = Q_i \left( b_1 S_i - b_2 Q_i - b_3 \sum_{\substack{j=1 \\ j \neq i}}^N Q_j \right) - \sum_{k=1}^M q_{ik} p_k$$

$$\text{Where } Q_i = \sum_{k=1}^M q_{ik} \quad \text{and} \quad S_i = \sum_{k=1}^M s_k q_{ik} / \sum_{k=1}^M q_{ik}$$

Taking the first-order necessary condition for a maximum in (2) yields:

$$(3) \quad p_k = b_1 s_k - 2b_2 \sum_{k=1}^N q_{ik} - b_3 \sum_{\substack{j=1 \\ j \neq i}}^N \sum_{k=1}^M q_{jk}$$

Aggregation of (3) across the demands for producer  $k$  from the processors yields:

$$(4) \quad p_k = b_1 s_k - \frac{2b_2 + b_3(N-1)}{N} \sum_{k=1}^M q_k$$

The grower  $k$ 's problem for the derived demand (4) is to choose this effort in quality and quantity to maximize his profit  $\pi_k^M$ :

$$(5) \quad \underset{q_k, s_k}{\text{Max}} \pi_k^M = q_k p_k - \frac{c}{2} q_k s_k^2$$

Upon expanding the above expression, the following is obtained:

$$(6) \quad \underset{q_k, s_k}{\text{Max}} \pi_k^M = q_k \left( b_1 s_k - \frac{2b_2 + b_3(N-1)}{N} \sum_{k=1}^M q_k \right) - \frac{c}{2} q_k s_k^2$$

Maximizing (6) with respect to  $q_k$  and  $s_k$ , a system of two equations with two unknowns is obtained:

$$(7a) \quad \frac{\partial \pi_k^M}{\partial q_k} = b_1 s_k - \frac{(2b_2 + b_3(N-1)) \left( \sum_{k=1}^M q_k + q_k \right)}{N} - \frac{c}{2} s_k^2 = 0$$

$$(7b) \quad \frac{\partial \pi_k^M}{\partial s_k} = q_k b_1 - c q_k s_k = 0$$

Since processors and growers face common equations, without loss of generality, in what follows we omit the subscripts  $i$  and  $k$  in the variables. From the first order conditions of this problem, we get the equilibrium values<sup>5</sup> of the input,  $s^*$  and  $q^*$ .

Case (ii): *Asymmetric incentive contract structure*

We assume that  $n$  pairs of processors ( $i: 1 \dots n$ ) and growers ( $k: 1 \dots n$ ) decide to offer an incentive contract and  $N-n$  processors ( $i: n+1 \dots N$ ) and growers ( $k: n+1 \dots M$ ) remain at the spot market.

To determine the profits of each processor, we must simultaneously consider the processors' problems in the incentive contract and in the spot market to solve the reaction functions.

In the incentive contract, the processor  $i$  chooses the parameters of the incentive scheme,  $\alpha_i$  and  $\beta_i$ , to maximize his profit subject to the constraints that the grower chooses his efforts in quantity and quality to maximize his utility (incentive restriction) and that the grower attains at least his reservation utility (participation restriction), i.e.,

$$(8) \quad \underset{\alpha_i, \beta_i}{\text{Max}} \pi_i^{IC} = Q_i P_i - w_i$$

Subject to

$$(9) \quad \underset{q_k, s_k}{\text{Max}} \pi_k^{IC} = w_k - \frac{c}{2} q_k s_k^2$$

$$(10) \quad w_k - \frac{c}{2} q_k s_k^2 \geq U_k^{\min}$$

The grower's reservation utility in the previous structure is the profit that he would obtain in the spot market with N-n+1 participants (upstream and downstream) and the rest of participants setting incentive contracts.

The optimization problem in equations (8)-(10) can be solved sequentially. First, the optimal solutions to the grower's decision on efforts in quantity and quality in equation (9) are obtained:

$$(11) \quad \underset{q_k, s_k}{\text{Max}} \pi_k^{IC} = \alpha_i + \beta_i Q_i^{IC} \left( b_1 S_i^{IC} - b_2 Q_i^{IC} - b_3 \sum_{\substack{j=1 \\ j \neq i}}^n Q_j^{IC} - b_3 \sum_{i=n+1}^N Q_i^M \right) - \frac{c}{2} q_k^{IC} (s_k^{IC})^2$$

Since processor i (i:1...n) only contracts with a grower, grower k (k:1...n), it is obvious that  $Q_i = q_k$  and  $S_i = s_k$ . Making these substitutions it is obtained that,

$$(12) \quad \underset{q_k, s_k}{\text{Max}} \pi_k^{IC} = \alpha_i + \beta_i q_k^{IC} \left( b_1 s_k^{IC} - b_2 q_k^{IC} - b_3 \sum_{\substack{j=1 \\ j \neq k}}^n q_j^{IC} - b_3 \sum_{k=n+1}^M q_k^M \right) - \frac{c}{2} q_k^{IC} (s_k^{IC})^2$$

Optimizing, we obtain:

$$(13a) \quad \frac{\partial \pi_k^{IC}}{\partial q_k} = \beta_i \left( b_1 s_k^{IC} - 2b_2 q_k^{IC} - b_3 \sum_{\substack{j=1 \\ j \neq i}}^n q_j^{IC} - b_3 \sum_{k=n+1}^M q_k^M \right) - \frac{c}{2} (s_k^{IC})^2 = 0$$

$$(13b) \quad \frac{\partial \pi_k^{IC}}{\partial s_k} = \beta_i q_k^{IC} b_1 - c q_k^{IC} s_k^{IC} = 0$$

Parellally, in the spot market we proceed in the same manner as in the previous case.

Proceeding through backward induction, the processor i solves the following problem:

$$(14) \quad \text{Max}_{Q_i^M} \pi_i^M = Q_i^M P_i^M - \sum_{k=n+1}^M q_{ik}^M p_k$$

which, after substitutions, gives

$$(15) \quad \text{Max}_{Q_i^M} \pi_i^M = Q_i^M \left( b_1 S_i^M - b_2 Q_i^M - b_3 \sum_{\substack{j=n+1 \\ j \neq i}}^N Q_j^M - b_3 \sum_{i=1}^n Q_i^{IC} \right) - \sum_{k=n+1}^M q_{ik}^M p_k$$

$$\text{Where } Q_i^M = \sum_{k=n+1}^M q_{ik}^M \quad \text{and} \quad S_i^M = \sum_{k=n+1}^M s_k^M q_{ik}^M / \sum_{k=n+1}^M q_{ik}^M$$

Optimization of this equation yields:

$$(16) \quad p_k = b_1 s_k^M - 2b_2 \sum_{k=n+1}^N q_{ik}^M - b_3 \sum_{\substack{j=n+1 \\ j \neq i}}^M \sum_{k=n+1}^M q_{jk}^M - b_3 \sum_{k=1}^n q_k^{IC}$$

Aggregation of (16) across the demands for grower k from the processors in the spot market yields:

$$(17) \quad p_k = b_1 s_k^M - \frac{2b_2 + b_3(N-n-1)}{N-n} \sum_{k=n+1}^M q_k^M - b_3 \sum_{k=1}^n q_k^{IC}$$

The grower k's problem in the spot market for the derived demand (17) is to choose his effort in quality and quantity to maximize his profit  $\pi_k^M$ :

$$(18) \quad \text{Max}_{q_k^M, s_k^M} \pi_k^M = q_k^M p_k - \frac{c}{2} q_k^M (s_k^M)^2$$

Upon expanding the above expression, the following is obtained:

$$(19) \quad \text{Max}_{q_k^M, s_k^M} \pi_k^M = q_k^M \left( b_1 s_k^M - \frac{2b_2 + b_3(N-n-1)}{N-n} \sum_{k=n+1}^M q_k^M - b_3 \sum_{k=1}^n q_k^{IC} \right) - \frac{c}{2} q_k^M (s_k^M)^2$$

Maximizing (19) with respect to  $q_k^M$  and  $s_k^M$ , a system of two equations with two unknowns is obtained:

$$(20a) \quad \frac{\partial \pi_k^M}{\partial q_k^M} = b_1 s_k^M - \frac{2b_2 + b_3(N-n-1)}{N-n} \left( \sum_{k=n+1}^M q_k^M + q_k^M \right) - b_3 \sum_{k=1}^n q_k^{IC} - \frac{c}{2} (s_k^M)^2 = 0$$

$$(20b) \quad \frac{\partial \pi_k^M}{\partial s_k^M} = q_k^M b_1 - c q_k^M s_k^M = 0$$

By symmetry we omit the subscripts  $i$  and  $k$  in equations 12a, 12b, 20a, 20b and resolve these equations obtaining the following expressions:  $s^M, q^M=f(\beta), s^{IC}=f(\beta)$  and  $q^{IC}=f(\beta)$ . Then, we substitute these values into equation (8) and (10) and maximizing with respect to  $\beta$  the optimal incentive is obtained. Finally, we calculate  $s^{M*}, q^{M*}, q^{IC*}$ , and  $s^{IC*}$  and substitute them into equation (10) to obtain the optimal fixed rent  $\alpha^*$ .

Case (iii): Symmetric *incentive structure*

Consider now the case when all processors offer an incentive contract, that is processor  $i, i=1\dots N$  offers an incentive contract to grower  $k, k=1\dots M$ . We first determine the grower  $k$ 's reservation utility, which is the profit from the grower at the spot market with successive monopoly.

We proceed in the same manner as in the incentive contract of the case (ii). First, we solve the incentive rationality of the grower  $k$ :

$$(21) \quad \underset{q_k, s_k}{\text{Max}} \pi_k^{IC} = \alpha_i + \beta_i Q_i \left( b_1 S_i - b_2 Q_i - b_3 \sum_{\substack{j=1 \\ j \neq i}}^N Q_j \right) - \frac{c}{2} q_k (s_k)^2$$

which, after substitutions, gives

$$(22) \quad \underset{q_k, s_k}{\text{Max}} \pi_k^{IC} = \alpha_i + \beta_i q_k \left( b_1 s_k - b_2 q_k - b_3 \sum_{\substack{j=1 \\ j \neq k}}^M q_j \right) - \frac{c}{2} q_k (s_k)^2$$

The optimal solutions to this problem are:

$$(23a) \quad \frac{\partial \pi_k^{IC}}{\partial q_k} = \beta_i \left( b_1 s_k - 2b_2 q_k - b_3 \sum_{\substack{j=1 \\ j \neq k}}^M q_j \right) - \frac{c}{2} (s_k)^2 = 0$$

$$(23b) \quad \frac{\partial \pi_k^{IC}}{\partial s_k} = \beta_i q_k b_1 - c q_k s_k = 0$$

Since processors and growers face common equations, without loss of generality, in what follows we omit the subscripts  $k$  and  $j$  in the variables. Substituting the values of  $q$  and  $s$  obtained in (23a) and (23b) in processor's problem and in grower's compatibility constraint, and maximizing with respect to  $\beta$  the optimal incentive is obtained. It is easy to check<sup>6</sup> that  $\beta=1$ , which is consistent with the prediction made by the standard principal-agent model when the agent is risk-neutral. Finally, we calculate  $q^{IC*}$ , and  $s^{IC*}$  and substitute them into grower's participation restriction to obtain the optimal fixed rent  $\alpha^*$ .

### **Equilibrium industry structure**

Having determined the processor's expected profits in each structure, we proceed now to find their equilibrium strategies. So far, we analyzed competitive behaviour in a two-stage game with  $N$  processors and  $M$  growers. We assume all firms make their entry decision simultaneously; although this clearly raises some questions about the exact nature of the entry process, the identification of viable supply-chain structures and characterization of Nash equilibria that it allows is useful.

The strategy space for processor  $i$  at first stage is given by  $\varphi_i = \{0,1\}$ , where the strategy  $s_i=1$  if and only if the processor sets an incentive contract. We do not care exactly which processor sets an incentive contract, only how many do so, as they are symmetric. Therefore, we can focus on the number of processors with incentive contract,  $n = \sum_{i=1}^n s_i$  and the number of processors in the spot market,  $N-n$ . Any pair  $(n, N-n)$  that corresponds to a Nash equilibrium is an equilibrium structure.

Let  $\pi_i^{IC}(n, N-n)$  the profit obtained by processor  $i$  in the incentive contract in a structure with  $n$  pairs of processor-grower in the Incentive Contract and the rest in the

Spot Market. Similarly,  $\pi_i^M(n, N-n)$  define the profit obtained by processor  $i$  in the spot market in the previous structure.

Our solution concept is the (Nash) equilibrium of the above game. A structure integrated by  $n$  processors with incentive contract and  $N-n$  in the spot market,  $(n, N-n)$ , is an *equilibrium* such that for all  $i$ ,

$$\pi_i^{IC}(n, N-n) \geq \pi_i^M(n-1, N-n+1)$$

$$\pi_i^M(n, N-n) \geq \pi_i^{IC}(n+1, N-n-1)$$

No processor could be strictly better off by unilaterally reversing his decision whether or not to set an incentive contract in an equilibrium structure.

In the next subsection we characterize the equilibrium structures of the industry for different number of processors and growers.

### **Characterization of the static equilibrium**

Here, we carry out a simulation exercise to calculate the equilibrium structure industry for a wide range of number of growers and processors in an attempt to investigate whether the co-existence of incentive contract and spot market is an equilibrium structure under diverse conditions.

In order to undertake the simulation exercise, we consider the following initial values:  $b_1=1$ ,  $b_2=0.00001$ ,  $b_3=0.0001$  and  $c=0.4$ . It should be noted that these initial values are used for convenience and has no special significance here and that simulation results do not change substantially if different values for  $b_1$ ,  $b_2$ ,  $b_3$  and  $c$  are used.

This analysis is used to provide explanations for several contractual structure related issues, such as the co-existence of incentive contracts and spot market. However, before proceeding, we should note the caveat that this simulation exercise uses restrictive assumptions about the shapes of price and cost functions. Although these seem highly

plausible to us for most situations, there may be situations which are not covered by our simulations.

Then, we have two free parameters in our model: the number of growers,  $M$ , and the number of processors,  $N$ . It may be worth noting here that an unmatched pair is not a player. Hence, we directly consider an identical number of processors and growers, varying from 1 to 50, in steps of 1.

Figure 1 graphically depicts the equilibrium structure  $(n, N-n)$  for each value of  $N$ . The horizontal axis corresponds to the number of participants in the sector,  $N$ . The vertical axis corresponds to the number of participants in incentive contract,  $n$ , and the number of them at the spot market,  $N-n$ , that would result in an equilibrium structure using the equilibrium concept defined above.

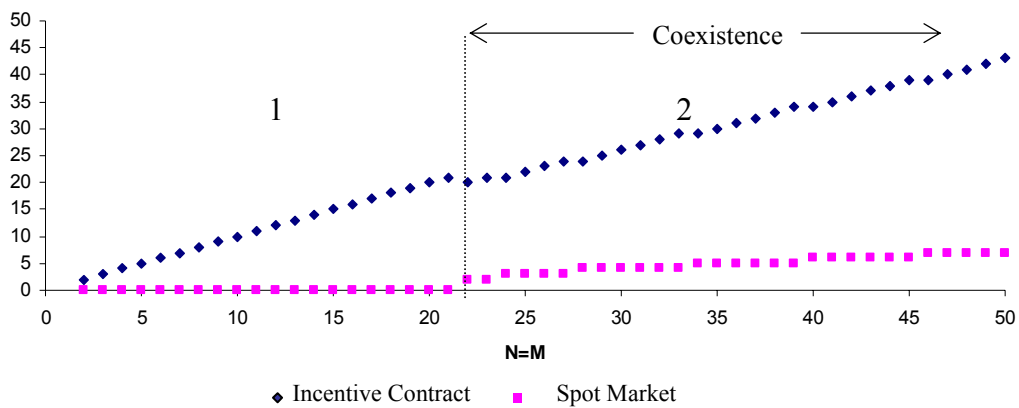


Figure 1: Equilibrium structures with  $N$  processors and  $M$  Growers ( $N=M$ )

Figure 1 shows that for each case of  $N$  used in the simulation, there is a unique equilibrium<sup>7</sup> structure. That is, for a given size of the market, there is a unique structure in which no processor has an incentive to unilaterally reverse his decision whether or not to set a contract. We discuss the types of equilibrium structures by dividing the graph into two areas. Each region is marked with a number. In the region 1, which represents the cases in which  $N < 22$ , each processor has an incentive to set a contract (the dominant strategy for each processor is to set a contract) and as a result a



completely incentive contract structure emerges as an equilibrium structure. When the number of participants increases, the degree of competitiveness changes and it may offer an advantage to remain at the spot market. In particular, when the number of participants in the upstream and downstream stage is larger than 21, then asymmetric incentive contract structures are the unique equilibrium structures. Basically, in these cases the majority of processors choose the incentive contract and a minority remains at the spot market. This result would demonstrate numerically the possibility of co-existence of both vertical structures.

This finding is consistent with previous literature that has demonstrated that the co-existence of spot and contract markets is quite natural. But there are also some differences. Unlike the result found by Carriquiry and Babcock (2002), who concluded that uncertainty had to be explicitly accounted for in any modeling situation in which contracts and spot markets co-exist and production outcomes are subject to randomness, we find that co-existence can emerge regardless of the uncertainty.

It is worth emphasizing, that our model assumes that all the market participants, growers and processors, are risk-neutral. Hence, the equilibrium outcomes are the results of purely financial considerations (Xia and Sexton, 2004).

For completeness, we now evaluate if the equilibrium structure is the optimal structure considering the total profit.

Figure 2 shows the structure  $(n, N-n)$  that would optimize the total profit for each value of  $N$ . Similar to the figure 1, the horizontal axis represents the number of participants in the sector,  $N$ . The vertical axis corresponds to the number of participants in incentive contract,  $n$ , and the number of them at the spot market,  $N-n$ , that would result in the optimal structure considering the total profit.

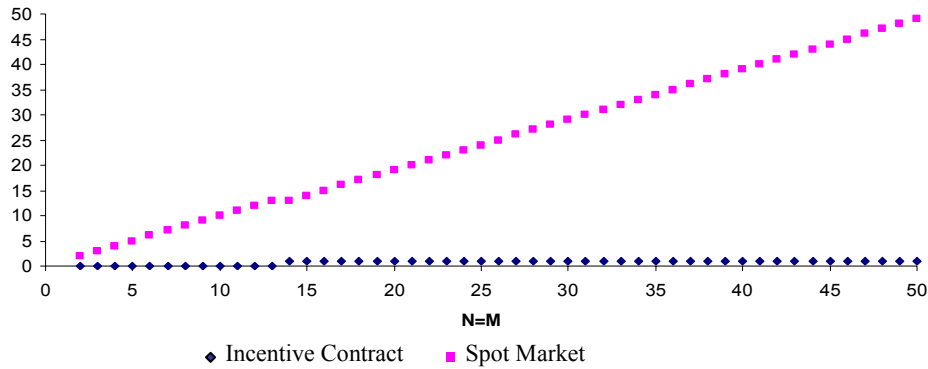


Figure 2: Optimal structures with  $N$  processors and  $M$  Growers ( $N=M$ )

In all cases analyzed in this simulation exercise, the equilibrium structure does not coincide with the optimal structure. In fact, the results suggest that they are antagonistic. While the equilibrium structures are characterized by incentive contracts majoritarily (see figure 1), the optimal structures are formed by spot market essentially (see figure 2).

## Conclusions

Agricultural economists have been active in examining the rationale for the increasing use of contracts between growers and processors and in identifying the implications of this mechanism. Little attention, however, has been paid to the co-existence of spot and contract markets, a common feature in many agricultural markets.

In particular, the possible co-existence of structures that can emerge in the presence of quality issues with a number of growers and processors in each stage is something that has largely remained an open question in the literature. This paper is an attempt to fill this void.

In this study we consider a quality-differentiated agrarian sector in which there are two potentially separable levels of production: primary production by growers and secondary production by processors. In this setting, how is the equilibrium structure

determined? To answer this question, we use a straightforward two-stage Cournot oligopoly model with specific demand and cost functions. In the first stage, processors decide simultaneously whether or not to set an incentive contract. The second stage is the stage in which growers choose their levels of quantity and quality based on the industry structure developed in the first stage. With the help of numerical simulations we conducted the study of the equilibrium structures. Our results suggest that for a wide range of number of participants in both markets, participation in both markets constitutes a Nash equilibrium for the model. This result would indicate that the fact that a growing proportion of agricultural inputs are transacted by contracts does not necessarily imply that spot markets for these sectors will disappear altogether.

This paper provides an interesting implication from an agricultural policy perspective. Our results suggest that the equilibrium structure does not mean optimality considering the total profit. Therefore, policy makers could consider some measures to lead participants to choose the optimal structure.

On balance, this paper suggests that, under successive oligopoly, the co-existence of both markets is quite natural in differentiated markets. This result is consistent with the empirical evidence. However, the generality of this basic insight requires a few comments.

First, all processors and growers are assumed identical. On the basis of previous work, for example Hendrikse (2007), it seems reasonable to conjecture that the possibility of including heterogeneous participants would not influence our qualitative results. However, the analytical difficulties associated with this issue would increase considerably. A similar remark holds for relaxing the assumption that growers are risk-neutral.

Second, our results depend on the way we model the market interaction between the processors with incentive contract and the processors at the spot market. We must emphasize that the possibility of processors with an incentive contract buying at the spot market is not considered in this paper. However, processors might choose to purchase their inputs from independent upstream producers for strategic reasons, for example, to raise the rivals' input cost. Then, an interesting topic for future research could be to allow processors with an incentive contract to freely trade with independent upstream producers and analyse if the raising-rivals' costs strategy influences the nature of incentive contract equilibria.

Agricultural markets exhibit a rich variety of governance structures, such as vertical integration or cooperatives (Hendrikse, 2007). Then, a different direction in which this research could be extended is to explore whether co-existence also attains for other contractual arrangements.

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<sup>1</sup> Linear demand systems have been used extensively in models of oligopolies, see (Coughlan, 1985; McGuire and Staelin, 1983; Jaumandreu & Lorences, 2002).

<sup>2</sup> The similar socioeconomic background and demographic features of growers and processors in a regional area would be inconsistent with a model that posits dichotomous preferences and risk sharing (Allen and Lueck, 1999). Given risk-neutral preferences, we can omit the presence of uncertainty in agriculture because it does not affect the results.

<sup>3</sup> The assumption that growers elect to sell in either the contract or the spot market, but not both, is consistent with practice (Xia and Sexton, 2004).

<sup>4</sup> From now on, the superscripts M and IC will indicate the mechanism associated, that is, spot market and incentive contract respectively.

<sup>5</sup> Let the Nash equilibrium values be denoted as  $*$ .

<sup>6</sup> Proof is available upon request.

<sup>7</sup> It is worth mentioning that in this simulation exercise not only are the equilibrium structures stable, but also they are viable. That is, in each structure all processors earn nonnegative net profits.