Marketing Agreement, Food Safety and Contract Design

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Abstract

Recent outbreaks of food-borne illness related to fruit and vegetables have led to increased concerns about the safety of produce. In response, the industry has adopted marketing agreements to ensure consistency of product safety. Contracts now are widely used between processors and growers to specify product safety attributes. This paper uses a principal-agent model to examine how the inclusion of a marketing agreement influences the behavior of growers and processors under processor-grower contracts. We conclude that: (1) the processor offers a contract with a higher premium and a lower base payment under the contract with a marketing agreement (2) contract parameters change in similar manner under the two contracts (3) under a contract with a marketing agreement the processor earns less profit. The individual contract scenarios are discussed in detail.

Keywords: contract, food safety, principal-agent, marketing agreement, GAPs, on-farm inspection

Background

Recent outbreaks of food-borne illness related to fruit and vegetables have led to increased concerns about food safety and its effect on human health. Changes in consumer expectations in terms of food safety have led suppliers to improve supply practices in the fruit and vegetables sectors. Voluntary marketing programs such as marketing agreements that cover food safety related practices have been adopted to ensure consistency of food safety. Good Agricultural Practices (GAPs) act as guidelines to the growers and processors who participate in the agreement for adopting critical production steps to reduce contamination that leads to food safety failures. For example, in response to the spinach outbreak in September 2006, the Western Growers initiated the California Marketing Agreement that requires all signatory leafy greens handlers to purchase only product from growers who adhere to the newly developed Leafy Greens Good Agricultural Practices. In consequence, direct relationships with growers are being established on the basis of compliance with production practices and have enabled processors to become much more involved than before in the production practices.

The fruit and vegetables industry is extensively vertically coordinated in U.S. and 56.5 % of fruit production and 30% of vegetable production is under marketing contract (MacDonald et al, 2004). Control of product quality and safety usually plays an important role in the contract. Processors require a steady supply of safe products in order to reduce transaction costs associated with recall and tracking product. Growers seek income stability, market security as well as access to capital and technology. Contracts are used for coordinated exchanges in the production process and they provide the contracting parties with a degree of control and risk sharing. Provisions in a basic processing fruit and vegetables production contract that relate to food safety include provisions on the pricing mechanism, safety standards, and inspection plans, as well as provisions for sharing the cost of food safety failures. Of course, supply chain contracts include many other provisions in addition to those that influence safety.

Growers who accept a contract are expected to comply with all of the contract provisions. However, food safety is difficult to measure and product properties cannot be directly observed by processors at the time of delivery. Consequently, compliance can be difficult to establish. Food risks may be caused by poor practices of growers who know that their production processes and resulting product quality cannot be directly observed by processors. The probability of use of poor practices increases with the profits that can be earned through opportunistic behavior. Moral hazard can occur when a grower promises to deliver safe product but does not do so even in the presence of the contract – due to the difficulty of detection or enforcement of the contract.

With the availability of a marketing agreement with enforcement mechanisms, the monitoring agency can carry out on-farm inspections on the growers who contract with signatory processors in order to guarantee implementation of the GAPs. If a grower fails an inspection, both the grower and the processor will face failure costs such as penalties and/or market loss. Growers have greater incentive to comply with the GAPs in their production process in order to diminish the possible losses. In contrast, it is likely to be easier for processors to obtain high quality products due to the potential liability incurred by growers in failing the inspection. Therefore, marketing agreements serve to overcome moral hazard problems associated with noncompliance with GAPs. Consideration of the marketing contract design should account for the impact of both the marketing agreement as well as the distribution of payoff between growers and processors.

The objective of the model proposed in this paper is to examine how a marketing agreement influences the behaviors of growers and processors with respect to food safety as well.

Such information can be used to design efficient incentive-compatible contracts in the context of the marketing agreement.

Our analysis is related to previous literature that addresses the economic implications of food certification programs. Costly, perfect certification of quality can suffice to replicate the first best market equilibria (Viscusi 1978); costly, imperfect certification, however, only partially overcomes adverse selection problems (De and Nabar 1991); further consideration concerns the effects and role of certification (Caswell and Mojduszka 1996, Crespi and Marette 2003). In contrast to these studies, our model allows for the existence of opportunistic behaviors. Monitoring effort plays an important role in detecting low-safety foods disguised as high safety ones, and its inclusion leads to rather different conclusions regarding market outcomes.

Lack of information or asymmetric information in markets is a major source of market failure. Since the pioneering work of Akerlof (1970) and Grossmann and Hart (1983), a bulk of the literature has considered the causes and remedies of market failures caused by asymmetric information on product quality and how moral hazard affects producers' behavior and choice of product. For instance, Fraser (2002, 2004) shows that agri-environmental policy reduces the moral hazard problem and finds a positive relationship between monitoring activities and the extent of fraudulent behaviors by participants. Other work considers the interaction between moral hazard and food safety as a result of systemic failure in the provision of safe food (Hennessy et al. 2003), game- theoretic approaches to address incomplete inspection and tracing food risks (Hirschauer and Musshoff 2007), and consequences of inspection policy on food safety and welfare (Starbird 2005).

Especially relevant to our study are those that address how the marketing contract between processors and growers affects agricultural production. Several studies have explored the effects of contracting using theoretical and empirical approaches. Olesen (2003) analyzes interaction between the theory and the practice of contracting with heterogeneous growers. Goodhue (2000) examines the impacts of input control and grower heterogeneity on efficient contract design by using a moral hazard-adverse selection approach. Weaver (2000) demonstrates the potential benefits of supply chain management strategies that use contracts to improve food quality of the supply chain. Hueth et al. (1999, 2002, 2004, and 2005) examine the relationship between the moral hazard problem and contract design within the context of fruit and vegetable industry. Wang and Jaenicke (2006) consider contracting through a market equilibrium approach.

Until now, however, no formal studies of agricultural contracts have examined how efficient incentive-compatible contracts should be designed in the case of marketing agreements. The contribution of this paper is twofold: First, the paper establishes the link between contract design and the marketing agreement. In particular, we analyze the grower's compliance to the GAPs and the effects of the marketing agreement on the contract price mechanism. Second, we consider food safety failure and the distributed share of failure costs in a moral hazard model setting when analyzing the interaction between contract design and the marketing agreement.

The main findings of the paper can be summarized as follows (1) the processor offers a contract with a higher premium and a lower base payment under the contract with a marketing agreement (2) contract parameters change in similar manner under the two contracts (3) under a contract with a marketing agreement the processor earns less profit. We discuss, the individual contract scenarios in detail.

The remainder of this paper is organized as follows: Section 2 constructs a benchmark model in which a marketing agreement is absent and develops some analytical results. In Section 3, the contact design with a marketing agreement available is examined. Section 4 provides results from a numerical example. And finally, Section 5 includes conclusions and summary discussion.

Model Setting

Spot and contract markets

Our analysis is based on a monopsonistic market framework which consists of multiple growers and one processor with a single food product. In the fruit and vegetables industry, growers may sell their crop on the spot market without any special requirements placed on production practices. But the price on the spot market tends to fluctuate from one year to another due to a number of factors such as weather conditions, supply factors, import levels and foodborne illness outbreaks. Growers may select to contract with the processor to reduce the probability of bad outcomes and safety failures and to stabilize revenues. If the grower selects the contract market, the grower will likely face requirements to invest some effort in using GAPs. Growers select the market to sell in by comparing expected profits of the contacted market to spot market. Consequently, growers wishing to reduce potential risk will contract with the processor as long as the expected utility exceeds that of the spot market. The goal of the contract is to encourage growers to apply good agricultural practices thus to deliver safer products.

The timing of events is as follows: The grower decides whether to sell product in the contract or spot market. If the grower chooses the spot market, he/she does not have much incentive to improve food safety and gets reservation utility. Growers who select the contract market move into the next stage where they determine production takes place and invest on good agricultural practices. This is because the payment from the processor is based on the product quality level which is positively related to the production practices.

Each grower’s effort level is private information. When marketing agreements are available, the contracted growers are inspected on farm by the enforcement agency for GAP compliance. Hence, in this case, growers are induced to invest more on the GAPs in order to reduce losses in market share due to failing inspection. If the grower fails the inspection, all product is rejected by the processor and will be sold on the spot market; if the grower passes inspection, the grower ships the product to the processor and receives the compensation outlined in the contract. Then, processing takes place and the processor sells product to a downstream user and earns a processed good price. Because of high testing costs, the inspection procedure is imperfect at both the farm and processing level. Thus an illness outbreak related the product may happen even if the product passes the safety inspection. We assume even food safety failure can be traced back to the responsible growers and the failure costs will be allocated to both growers and the processor. The following subsections outline the grower and processor's problems under the contracts with a marketing agreement and without a marketing agreement, respectively. Note, we refer to a marketing agreement as one with stipulations designed to insure safe product.

The grower's problem

Without a marketing agreement

We assume the growers are risk neutral and homogenous. They maximize expected utility given a payment and compliance costs. In this model, we simplify the quality to be one dimensional and only reflect the safety level. In order to induce growers to select the contract market, the processor offers premiums above the spot market price. Let $s(\pi) = P_0 + \alpha + \beta\pi$ denote the grower's linear payment schedule under contract. The payment is determined by the spot market price P_0 , a base payment α ,a premium β , and quality level π at delivery. We interpret the quality level π is the quality grade as an indicator of the quality in terms of the downstream price as characterized by Hueth (1999), and hence that downstream price P is a signal of quality.

Obviously, quality level is dependent on the safety effort e . However, the downstream price is an imperfect quality signal because despite compliance efforts during production, many fruit and vegetables products are subject to random changes in quality such as stochastic deterioration during the time between shipment and delivery because of their perishable attributes. This makes it possible for the farm quality to differ from delivered quality. In addition, the downstream price is also dependent on marketing conditions and other factors. Thus, the quality level is a random variable and each grower faces a quality distribution which is based on a normal CDF $F\left(P \mid e\right)$. Differ to the standard choice of effort level, we restrict the effort levels to be binary choices, which means only two effort levels, e_h and e_l, for high and low effort respectively, are considered.

As we mentioned above, a food safety failure such as an illness outbreak related to the product may happen due to poor production practices and other random reasons. We assume the incident can be traced back to the responsible growers of the unsafe product with 100% probability. Cost associated with outbreaks traced to unsafe product include recall costs, costs of compensating victims, lost income as well as losses of goodwill. Food safety failures do not occur often, so the probability is usually very small. We denote q_h and q_l as failure probabilities associated with a unit of high quality product and of low quality product, respectively. Obviously, higher quality means lower probability of failure occurrence, i.e., $q_h < q_l$. We denote ε_1 as the share of the food safety failure costs that is allocated to the processor responsible for the incident. Then, $\varepsilon_2 = 1 - \varepsilon_1$ is the share of cost allocated to the grower. Let's denote Q as the failure cost, thus the failure cost allocated to the grower is $\varepsilon_2 Rq = R_2 q$, where $R_2 = \varepsilon_2 R$.

It is reasonable to assume that it becomes increasing difficult for the growers to adopt GAPs. We specify compliance costs for GAPs to have a simple quadratic form as $c\left(e\right) = be^2 / 2$, where b is cost parameter. For the grower to enter into a contract with the processor, the grower faces higher compliance costs which include investments in harvesting and storage equipment, energy and waste management or investments to improve farmer worker safety, etc.. In addition, we assume the production costs are homogenous across all growers and normalize the production costs to be zero. (In extensions, this assumption can be relaxed to account for effects of size in production costs.) Obviously, the grower has no incentive to invest in high safety level when he chooses spot market.

Thus, with the absence of a marketing agreement's, the grower's profit in the contract market can be expressed as $w = s(\pi) - R_2 q - c(e)$.Each grower's utility function is assumed to have the property of constant absolute risk aversion (CARA), $U(w) = 1 - \exp(-\rho w)$,where ρ is the Arrow-Pratt coefficient of absolute risk aversion and the expected utility $E(U(w))$ is tantamount to

$$E(w) - \rho\,\mathrm{var}(w)/2 \quad (1)$$

The grower chooses the contract as long as the expected utility from the contract exceeds that of the spot market (reservation utility).

Under a marketing agreement

With a marketing agreement available, the monitoring agency will carry out costly on-farm inspections on the growers who contract with processors to guarantee implementation of the GAPs. If a grower passes the on-farm inspection, his output will be delivered to the processor; otherwise his product will be sold on the spot market. Because testing is costly, the monitoring agency takes the form of random inspections with intensity θ. We assume that safety control is not error-free. Specifically, if a farm is tested, its level of safety effort is only partly observable in the farm's results. Let γ denote the fixed detection rate of not meeting safety standards. It can be viewed as the conditional probability of detection given that a monitoring event occurs, or alternatively the difficulty of detecting fraudulent output. Higher γ means easier detection. We treat γ as common knowledge. Moreover, probability of detecting a safety failure is assumed to have a linear, negative relationship with the safety effort that the farm has exerted. Therefore, $\theta\gamma(1-e)$ is the true probability of passing the farm inspection. This expression accounts for the fact that incomplete inspection increases the profitability of opportunistic behavior. If a grower fails the inspection tests, he will face costs of reimbursement to processor, which are denoted by F. Therefore, the expected utility for the grower in the context of the marketing agreement is $E(U(\omega))$, which is tantamount to

$$\begin{aligned} &E(w)\left(1-\theta\gamma(1-e)\right)+EP_0\left(\theta\gamma(1-e)\right)-\rho\,\text{var}(w)/2 \\ &q\in[q_h,q_l],\ e\in[e_h,e_l] \end{aligned} \quad (2)$$

The processor's problem

Consider a risk neutral processor who procures product from a group of growers who use agricultural practices by way of a marketing contract. The processor sets the terms and the structure of the contract. The processor gets a processing (downstream) price P for each unit of processed product. We assume that each processed unit results in one unit output in this analysis. We also assume that the processor is aware of the grower's utility function and the distribution of his effort level. Recall ε_1 is the share of failure cost allocated to the processor. Thus, the value of his failure cost is $\varepsilon_1 Rq = R_1 q$, where $R_1 = \varepsilon_1 R$. This provides the processor with the following profit function $\pi_p = P - R_1 q - (P_0 + \alpha + \beta P)$. If a marketing agreement is absent in the market, the processor's expected utility, $E\left(U\left(\pi_p\right)\right)$, is equal to the returns from processing less the cost of the food failure and payment to growers and can be written as

(3) $$E\left(P - R_1 q - \left(P_0 + \alpha + \beta P\right)\right)$$

Similarly, the processor's expected utility under the contract with a marketing agreement can be expressed as

(4) $$E\left(P - R_1 q - \left(P_0 + \alpha + \beta P\right)\right)\left(1 - \theta\gamma\left(1-e\right)\right) + F\theta\gamma\left(1-e\right)$$

Benchmark Model- without a Marketing Agreement

In order to better understand the implications of the model, we construct a benchmark model in which the marketing agreement is absent. The processor maximizes expected utility by choosing the payment scheme, subject to the grower's decision rule. Given the above assumptions, the processor must solve the following problem.

(5) $$\max_{\alpha,\beta} E\left(U\left(\pi_p\right)\right) = \int \left(P - R_1 q - \left(P_0 + \alpha + \beta P\right)\right) dF\left(P \mid e_h\right)$$

subject to

(6) $$\int E\left(U\left(w\right)\right) dF\left(P \mid e_h\right) - c\left(e_h\right) \geq E\left(U\left(P_0\right)\right) - c\left(e_l\right)$$

(7) $$\int E\left(U\left(w\right)\right) dF\left(P \mid e_h\right) - c\left(e_h\right) \geq E\left(U\left(P_0\right)\right) - c\left(e_l\right) \quad e \in \left[e_h, e_l\right]$$

The participation constraint (6) requires that the expected utility of each grower who sells product in the contract market should be no less than that in the spot market. The incentive compatibility constraint (7) ensures that under the payment scheme, the grower's optimal effort is e_h. The processor is assumed to design contracts by choosing contract parameter α and β to induce growers to invest more effort in adopting GAPs. Note that the failure cost allocation ratio, ε_1 and ε_2 , includes two important parameters and determines directly the distribution of payoff between the growers and the processor.

Given the assumptions and analysis above, the processor's expected utility $E\left(U\left(\pi_p\right)\right)$ can be rewritten as

(8) $$EP_h - R_1 q - \left(EP_0 + \alpha + \beta EP_h\right)$$

With risk adverse growers both constraints must be binding because, otherwise, the price offered by the processor can always be reduced until both of the constraints become equalities. Thus, condition (6) is equivalent to

(9) $$\left(EP_0 + \alpha + \beta EP_h\right) - R_2 q - be_h^2 / 2 - \rho \,\mathrm{var}(P_0) / 2 \geq EP_0 - be_l^2 / 2 - \rho \,\mathrm{var}(P_0) / 2$$

And similarly, condition (7) becomes

(10) $$e \in \arg\max \left(EP_0 + \alpha + \beta EP_h\right) - R_2 q - be^2 / 2 - \rho \,\mathrm{var}(P_0) / 2 \qquad e \in \left[e_h, e_l\right] \; .$$

Using the model, the solution to the processor's problem $\left(\alpha, \beta\right)$ satisfies the following first order conditions

(11) $$\beta = \frac{b\left(e_h^2 - e_l^2\right) / 2 + R_2\left(q_h - q_l\right)}{P_h - P_l}$$

(12) $$\alpha = b\left(e_h^2 - e_l^2\right) / 2 + R_2 q_h - \beta P_h$$

(13) $$s = \alpha + \beta P = b\left(e_h^2 - e_l^2\right) / 2 + R_2 q_h$$

Several aspects of the design are incorporated in the contract parameters. First, the optimal premium increases with the spread of high effort over low effort, $e_h^2 - e_l^2$, and increases with the spread of failure probability under the two effort levels, $q_h - q_l$. The intuition behind this result is that by offering a higher premium, the processor is able to encourage the growers to participate in the contract market and invest more in their efforts. Second, the optimal premium decreases with a larger spread in the downstream prices. That is, the processor has less incentive to induce more effort if the difference in the downstream prices between high quality product and low quality product is small. Finally, the total payment does not depend on the spread of downstream prices. (As defined here, the total payment includes only the base payment and the premium payment.)

In the absence of a marketing agreement, the products delivered by the grower will not face a problem of being rejected by the processor and the grower can always get a base payment no matter how much effort he exerts.

Contract with a Marketing Agreement

The benchmark model above is extended here to include the marketing agreement. In this context, the enforcement agency monitors the program through on-farm audits. The processor will not accept product produced by the growers who cannot pass the inspection will not be accepted by the processor. Thus, the optimal contract provided by the processor should account for this potential effect and adjust the payment schedule accordingly.

As for the benchmark model, the processor solves the following problem:

(13) $$\max_{\alpha,\beta} \int \left(P - R_1 q - \left(P_0 + \alpha + \beta P \right) \right) dF\left(P \mid e_h \right) \left(1 - \rho\left(1 - e \right) \right)$$

subject to

(14) $$\int E\left(U\left(w\right)\right) dF\left(P \mid e_h\right)\left(1-\rho\left(1-e_h\right)\right) + E\left(U\left(P_0\right)\right)\left(\rho\left(1-e_h\right)\right) - c\left(e_h\right) \geq E\left(U\left(P_0\right)\right) - c\left(e_l\right)$$

$$e \in \arg\max \int E\left(U\left(w\right)\right) dF\left(P \mid \tilde{e}\right)\left(1-\rho\left(1-\tilde{e}\right)\right) + E\left(U\left(P_0\right)\right)\left(\rho\left(1-\tilde{e}\right)\right) - c\left(\tilde{e}\right) \qquad (15)$$

The processor's expected utility $E\left(U\left(V\right)\right)$ can be rewritten as

$$\left(EP_h - R_1 q - \left(EP_0 + \alpha + \beta EP_h\right)\right)\left(1-\theta\gamma\left(1-e_h\right)\right) + F\theta\gamma\left(1-e_h\right) \qquad (16)$$

The participation constraint (14) equals

$$\left(\left(EP_0 + \alpha + \beta EP_h\right) - R_2 q\right)\left(1-\theta\gamma\left(1-e_h\right)\right) - F\theta\gamma\left(1-e_h\right) - be_h^2/2 - \rho\,\mathrm{var}(P_0)/2 = EP_0 - be_l^2/2 - \rho\,\mathrm{var}(P_0)/2 \qquad (17)$$

The incentive compatibility constraint (15) equals to

$$e \in \arg\max \left(\left(EP_0 + \alpha + \beta EP_h\right) - R_2 q\right)\left(1-\theta\gamma\left(1-e\right)\right) - F\theta\gamma\left(1-e\right) - be^2/2 - \rho\,\mathrm{var}(P_0)/2 \qquad e \in \left[e_h, e_l\right] \qquad (18)$$

$$s^{with} = \alpha + \beta P = \frac{e_h^2 - e_l^2}{2\left(1-\rho\left(1-e\right)\right)} + R_2 q_h \qquad (19)$$

From the above equations, we can obtain the optimal contract parameters. In order to save space, we omit the complex derivation and arithmetic expressions here. The total payment is expressed by equation (19), the grower under a contract with a marketing agreement gets payment determined by the monitoring intensity.

Simulation Analysis

We now construct a simulation model to illustrate our comparative statics results for the fresh strawberry market in California. We choose California as an example because it supplies more than 85 percent of the total market for fresh strawberries. The main objective is to examine how the simulation results of efficient marketing contracts are affected by exogenous variables under the contracts with and without a marketing agreement. The grower's price for fresh strawberry in California in the year 2000~2006 was equal to 73 cents per pound. We assume that the price range of high safety product is from 70 to 80 cents per pound and the price range of low safety product is from 62 to 67 cents per pound. The cost of five main GAPs that the farmer may adopt is between 0.5~1 cent per pound according to the empirical data. We assume that the compliance cost parameter is between 2 to 3 cents per pound. In addition, we assume that the high effort level is 0. 8 and the lower effort level is 0.2 in our model. In addition, the penalty rate is assumed to be zero in this analysis.

To start, we list the values of parameters in table 1. Given these parameters, table 2 through 8 show the optimal contract parameters from the numerical examples where exogenous variables are varied for the different scenarios.

Table 1. Parameters Used in the Numerical Example

Parameter	Value
E_1	0-100
E_2	100-0
b	2.0-3.0
P_h	70-80
P_l	62-67
q_h	0-0.005
q_l	0.002-0.007
θ	0-1.0
γ	1.0
F	0
e_h	0.8
e_l	0.2

The solution to the processor's profit maximization problem is solved under quality uncertainty.

Tables 1-7 report the optimal contract terms for both contracts. Note that the contents which are highlighted with grey are the results under the contract with the marketing agreement.

Before examining results for individual contract scenarios, we make several general observations pertain to the results. First, the processor offers a contract with a higher premium and a lower base payment under a contract with a marketing agreement. This is because the introduction of the marketing agreement induces the processor to pay more for a higher quality level This reflects the fact that the marketing agreement changes the conditional payoff probabilities and decreases the profitability of noncompliant behavior.

Second, the contract parameters (α and β) change in a similar manner under the two contracts. The marketing agreement does not change the basic effects of the contract but can make small improvements.

Third, under the contract with a marketing agreement the processor earns less profit. To recover profits, the processor may set an underage penalty on growers who contract and fail the on-farm inspection. Of course, this results in fewer growers accepting the contract, as grower profits are reduced when there is a penalty related to on-farm inspection. More specific results are presented below.

Case (1), monitoring intensity: The results in Table 2 and Figure 1 show that the premium increases as θ increases.. This is because the grower faces higher risk of losing all his product in the contract market if he fails the on-farm inspection. The strength of the grower's incentive to invest in GAPs is highly dependent on the ability of the monitoring and enforcement agency to separate GAP and non-GAP produce. The importance of the incentive increases as monitoring rate becomes larger because of the direct relationship between monitoring intensity and the detection rate of noncompliance. When monitoring rate is zero, the case is reduced to the contract without a marketing agreement. At the other extreme, when monitoring rate is 1, the detection rate is the highest and the grower has the least chance of passing the inspection. Correspondingly, the base payment which is not related to quality declines in order to satisfy the participation constraint. Thus, the total contract payment goes up with increased monitoring and the processor' profit goes down.

Case (2), allocation of costs of food failure: Table 3 and figure 2 illustrate the effects of the allocation of food failure costs on efficient contract design and show that the premium earned by the grower increases as the cost allocated to the processor increases. This is because the grower will face lower expected failure costs, and in order to compensate the processor for the higher expected failure costs, a higher proportion of the payment related to quality risk will be allocated to the grower. This effectively shifts the higher proportion of quality risk to the growers. The base payment decreases due to the participation constraint, which means the processor needn't pay more than the reservation utility on the spot market. At a result, the processor's profit does not change at all, which means that the processor can transfer the risk related to safety to the grower.

Case (3), compliance cost: In this case, results of Table 4 and Figure 3 show that when compliance costs become higher, the grower reduces his effort level to maximize expected profit. The processor contracts with growers through increasing the premium to an optimal level and thus is able to attract the growers to select contract. Again, the results show the decline in base payment earned by the growers through contracting as the cost of compliance increases. Consequently, the total payment increases and the processor's profit declines.

Case (4), downstream price of high quality products: The optimal contract parameters are reported in Table 5 and Figure 4 over a range of downstream prices of high quality products. The increase in the downstream price for high quality products means that the average quality level becomes higher and the processor has less incentive to encourage the grower to invest in safety effort; the resulting optimal contract is characterized by a lower premium and a higher base payment. As we discussed before, because the total payment is independent on the downstream prices, there is no change in the total payment. Consequently, the processor's profit increases due to the higher market price he receives.

Case (5), downstream price of low quality products: The optimal contract parameters are reported in Table 6 and Figure 5 with the changes of downstream price of low quality products. The premium increases with the increase of the price. This is because the smaller price spread will discourage growers from investing in food safety efforts. For example, when downstream price of low quality products is 62 cents per pound, the premium parameter the processor offers with the marketing agreement is 0.058. The premium under the same conditions is 0.156 when the downstream price of low quality products is 67 cents per pound. This effect is magnified as the downstream price of low quality products becomes higher. Additionally, an increased premium decreases the base payment to keep participation constant. The total payment and processor's profit will not change at all.

Case (6), probability of failure in the high quality product: Tables 7 and Figure 6 report the numerical results when failure probability with high quality product is increased. Increasing failure probability increases the risk related to the high quality product. The processor offers contracts with a higher premium in order to encourage the grower to invest more in food safety practices and to reduce the magnitude a probability of losses when the risk is high.

Case (7), the probability of failure in low quality product: When the probability of failure in the low quality product is increased the processor reduces the premium because it becomes easier to distinguish between high quality and low quality products. Table 8 and Figure 7 show that the total payment and the processor's profit do not change.

Conclusion

The rise of voluntary marketing programs on food safety in agriculture has received attention recently. In this paper, we use a principal-agent model to examine how a marketing agreement influences contract provisions as well as the behavior of growers with respect to practices that improve food safety. For each form of contract we discuss the payment scheme with and without marketing agreement as well as the extent to which a contract may overcome moral hazard problems. We provide a numerical example to compare the two forms of contract and discuss implications for marketing institutions and policies.

The primary contribution of our paper is that we incorporate the marketing agreement into the analysis of the contract design and offer guidance on understanding contractual relations to both suppliers and governing institutions. The main analytical results are that the optimal premium is higher and the base payment is lower under the contract with a marketing agreement. Furthermore, it is shown that the contract parameters change in similar manner under the tow contracts. Moreover, the processor earns less under the contract with a marketing agreement. In addition, the individual contract scenarios are discussed in detail.

The results of this paper are limited by a set of underlying assumptions which include one dimensional quality, binary safety efforts, zero penalty rates, and zero production as well as zero processing cost. Thus, there exist many possible extensions for further research.

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Appendix

Simulation Results

Table 2 Contract changes with respect to monitoring intensity

θ	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
α	-4.950	-5.109	-5.275	-5.448	-5.629	-5.817	-6.014	-6.220	-6.436	-6.662	-6.900
β	0.080	0.082	0.085	0.088	0.090	0.093	0.096	0.100	0.103	0.106	0.110
π	0.650	0.662	0.675	0.688	0.702	0.717	0.732	0.748	0.764	0.782	0.800
s	9.300	9.102	8.904	8.706	8.508	8.310	8.112	7.914	7.716	7.518	7.320

Table 3 Contract changes with respect to cost allocation ratio

E_1	0	10	20	30	40	50	60	70	80	90	100
E_2	100	90	80	70	60	50	40	30	20	10	0
α	-2.967	-3.537	-4.107	-4.677	-5.247	-5.817	-6.387	-6.957	-7.527	-8.097	-8.667
	-2.100	-2.670	-3.240	-3.810	-4.380	-4.950	-5.520	-6.090	-6.660	-7.230	-7.800
β	0.053	0.061	0.069	0.077	0.085	0.093	0.101	0.109	0.117	0.125	0.133
	0.040	0.048	0.056	0.064	0.072	0.080	0.088	0.096	0.104	0.112	0.120
π	0.767	0.757	0.747	0.737	0.727	0.717	0.707	0.697	0.687	0.677	0.667
	0.700	0.690	0.680	0.670	0.660	0.650	0.640	0.630	0.620	0.610	0.600
s	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310
	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300

Table 4 Contract changes with respect to compliance costs

b	2	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3
α	-5.817	-6.251	-6.683	-7.117	-7.551	-7.984	-8.417	-8.850	-9.283	-9.717	-10.150
	-4.950	-5.340	-5.730	-6.120	-6.510	-6.900	-7.290	-7.680	-8.070	-8.460	-8.850
β	0.093	0.100	0.107	0.113	0.120	0.127	0.133	0.140	0.147	0.153	0.160
	0.080	0.086	0.092	0.098	0.104	0.110	0.116	0.122	0.128	0.134	0.140
π	0.717	0.750	0.783	0.817	0.850	0.883	0.917	0.950	0.983	1.017	1.050
	0.650	0.680	0.710	0.740	0.770	0.800	0.830	0.860	0.890	0.920	0.950
s	8.310	8.280	8.250	8.220	8.190	8.160	8.130	8.100	8.070	8.040	8.010
	9.300	9.270	9.240	9.210	9.180	9.150	9.120	9.090	9.060	9.030	9.000

Table 5 Contract changes with respect to price of high quality product

p_h	70	71	72	73	74	75	76	77	78	79	80
α	-5.816	-4.806	-4.083	-3.541	-3.120	-2.783	-2.507	-2.278	-2.083	-1.917	-1.772
	-4.950	-4.083	-3.464	-3.000	-2.639	-2.350	-2.114	-1.917	-1.750	-1.607	-1.483
β	0.093	0.078	0.067	0.058	0.052	0.047	0.042	0.039	0.036	0.033	0.031
	0.080	0.067	0.057	0.050	0.044	0.040	0.036	0.033	0.031	0.029	0.027
π	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717
	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
s	8.310	9.210	10.110	11.010	11.910	12.810	13.710	14.610	15.510	16.410	17.310
	9.300	10.300	11.300	12.300	13.300	14.300	15.300	16.300	17.300	18.300	19.300

Table 6 Contract changes with respect to price of low quality product

p_l	62	62.5	63	63.5	64	64.5	65	65.5	66	66.5	67
α	-3.366	-3.639	-3.950	-4.309	-4.728	-5.223	-5.817	-6.543	-7.450	-8.617	-10.172
	-2.850	-3.083	-3.350	-3.658	-4.017	-4.441	-4.950	-5.572	-6.350	-7.350	-8.683
β	0.058	0.062	0.067	0.072	0.078	0.085	0.093	0.104	0.117	0.133	0.156
	0.050	0.053	0.057	0.062	0.067	0.073	0.080	0.089	0.100	0.114	0.133
π	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717
	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
s	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310
	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300

Table 7 Contract changes with respect to failure probability of high quality product

q_h	0	0.0005	0.001	0.0015	0.002	0.0025	0.003	0.0035	0.004	0.0045	0.005
α	-5.167	-5.492	-5.817	-6.142	-6.467	-6.792	-7.117	-7.442	-7.767	-8.092	-8.417
	-4.300	-4.625	-4.950	-5.275	-5.600	-5.925	-6.250	-6.575	-6.900	-7.225	-7.550
β	0.083	0.088	0.093	0.098	0.103	0.108	0.113	0.118	0.123	0.128	0.133
	0.070	0.075	0.080	0.085	0.090	0.095	0.100	0.105	0.110	0.115	0.120
π	0.667	0.692	0.717	0.742	0.767	0.792	0.817	0.842	0.867	0.892	0.917
	0.600	0.625	0.650	0.675	0.700	0.725	0.750	0.775	0.800	0.825	0.850
s	8.400	8.355	8.310	8.265	8.220	8.175	8.130	8.085	8.040	7.995	7.950
	9.400	9.350	9.300	9.250	9.200	9.150	9.100	9.050	9.000	8.950	8.900

Table 8 Contract changes with respect to failure cost of low quality product

q_h	0.002	0.0025	0.003	0.0035	0.004	0.0045	0.005	0.0055	0.006	0.0065	0.007
α	-7.917	-7.567	-7.217	-6.866	-6.517	-6.167	-5.817	-5.466	-5.117	-4.767	-4.417
	-7.050	-6.700	-6.350	-6.000	-5.650	-5.300	-4.950	-4.600	-4.250	-3.900	-3.550
β	0.123	0.118	0.113	0.108	0.103	0.098	0.093	0.088	0.083	0.078	0.073
	0.110	0.105	0.100	0.095	0.090	0.085	0.080	0.075	0.070	0.065	0.060
π	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.717
	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
s	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310	8.310
	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300	9.300

Figure 1 Monitoring intensity changes

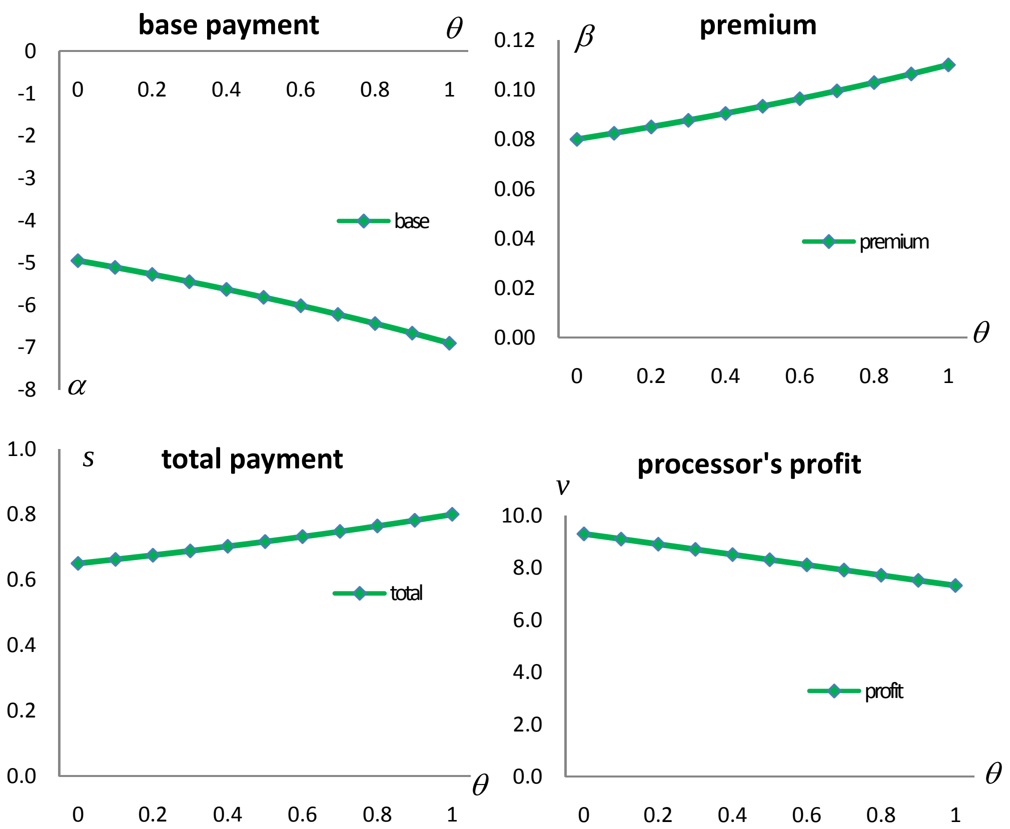

Figure 2. Failure allocation changes

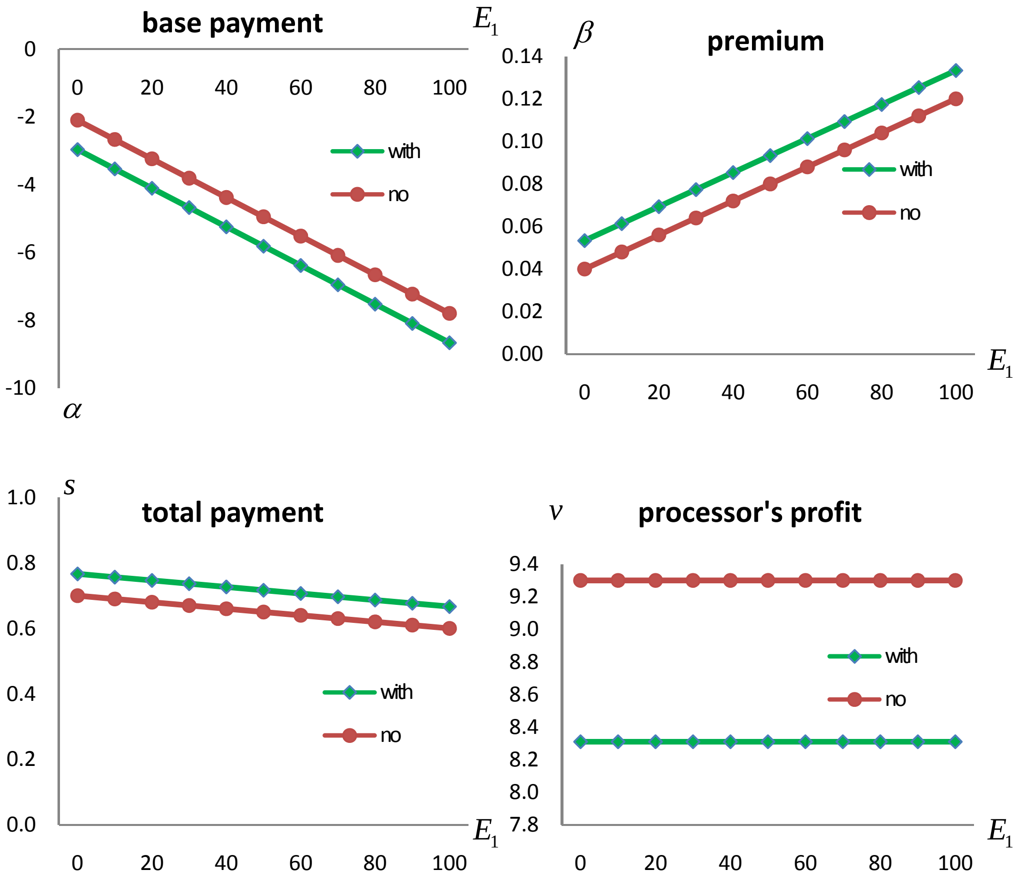

Figure 3 Compliance cost changes

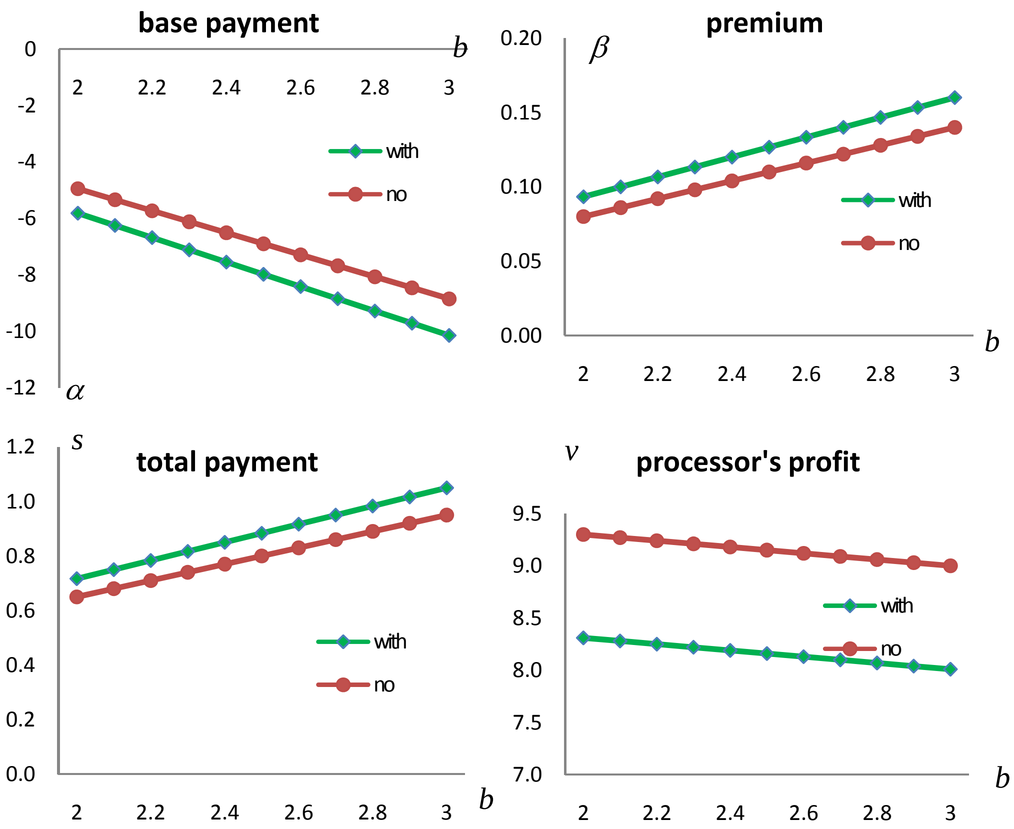

Figure 4 Price of high quality product changes

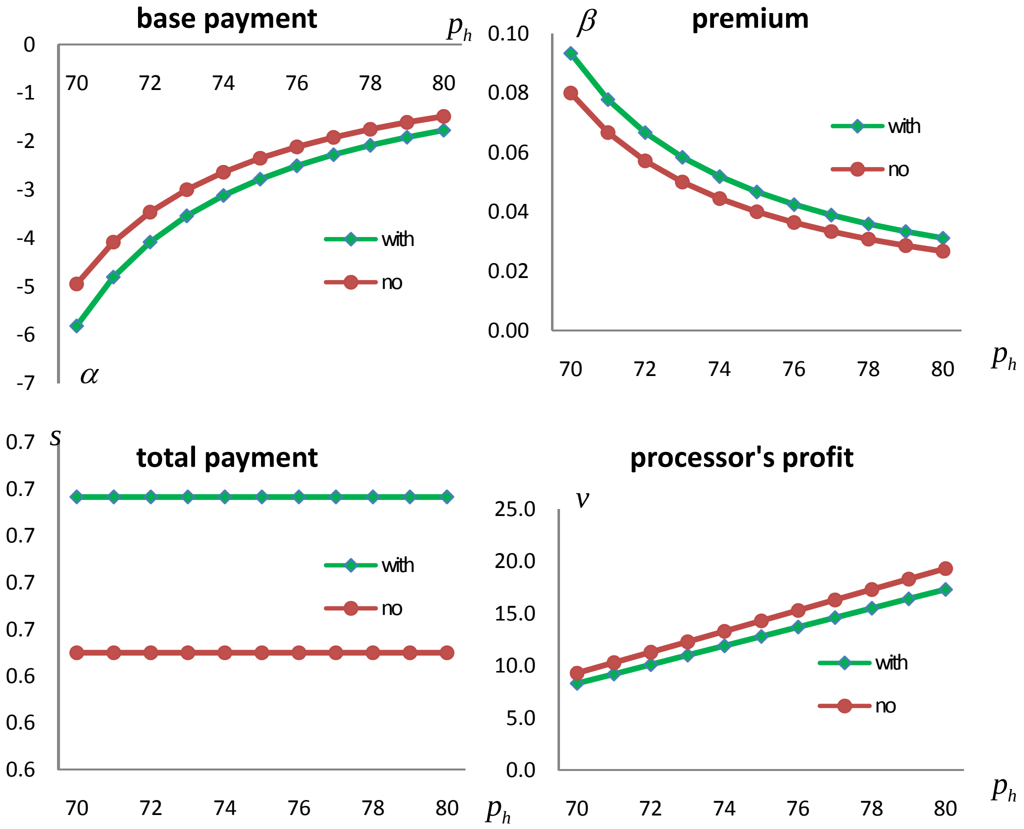

Figure 5 Price of low quality product changes

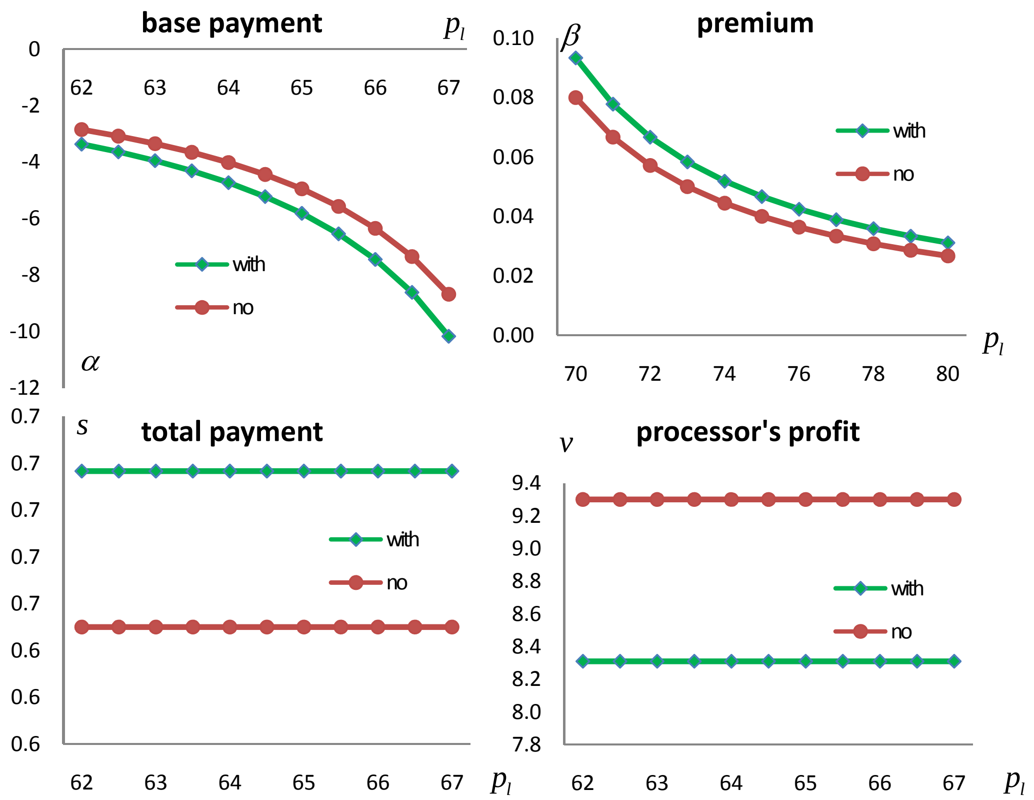

Figure 6 Failure probabilities of high quality product changes

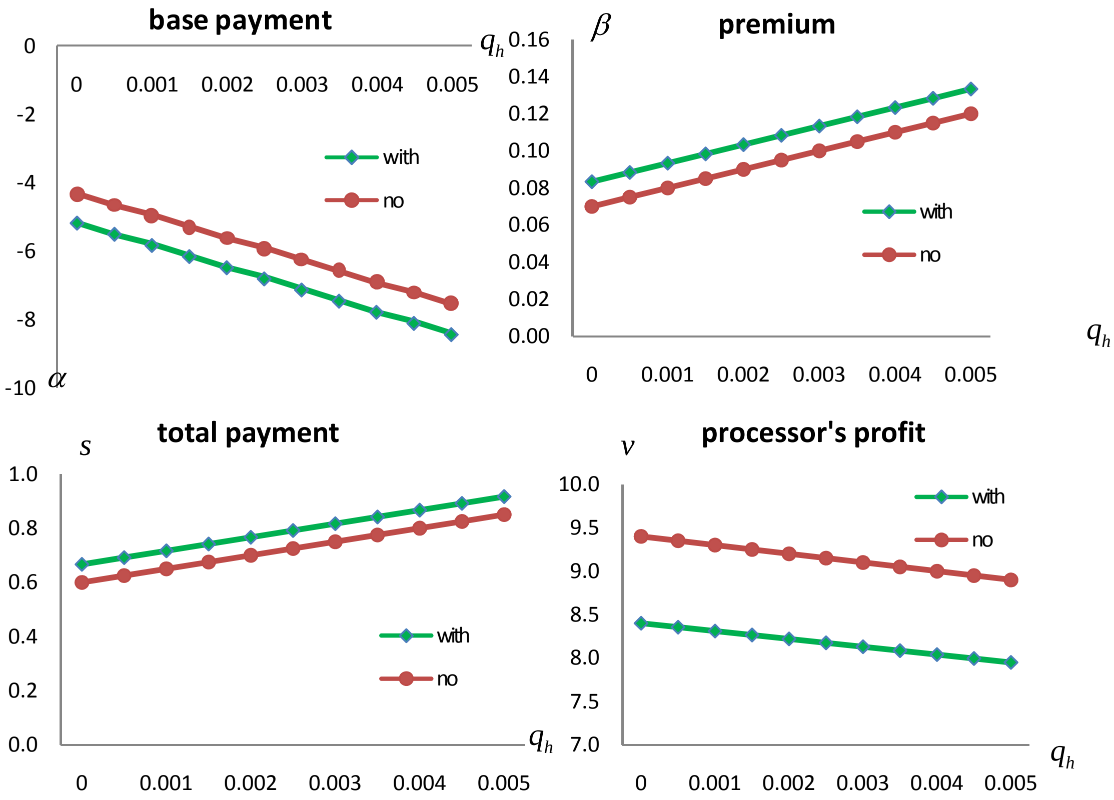

Figure 7 Failure probabilities of low quality product changes