Incentive payments, food safety and moral hazard in the supply chain

By Rob Fraser*^ and Mohamud Hussein^^

^School of Economics, University of Kent

^^ Food and Environment Research Agency, York

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*Rob Fraser, School of Economics, University of Kent, Canterbury CT2 7NZ; r.w.fraser@kent.ac.uk

Abstract

This paper analyses an incentive payment-based approach to improving food safety in the supply chain. It develops a principal-agent model of the food supply chain in which the principal offers heterogeneous agents a payment to implement costly additional practices to improve food safety. It is shown that the presence or absence of the moral hazard problem affects the balance of benefits and costs from broadening the scope of the system from just lower cost larger agents to include higher cost smaller agents, thereby affecting the optimal design of the system. In particular, broadening the scope of the system to include smaller agents by increasing the size of the incentive payment can ameliorate the moral hazard problem among larger agents to the extent that this more costly approach is socially optimal.

Keywords: incentive payments, moral hazard, food safety, supply chain

JEL codes: D82, L51, Q18

Introduction

In the context of agriculture and the environment, moral hazard analysis has been used to evaluate agri-environmental policy design in situations where agents (ie farmers) have primary control over the provision of (public) goods and/or services desired by the principal (i.e government). In such analyses the agents are typically incentivised with a payment to provide the goods and/or services desired by the principal, and the principal operates a system of monitoring and penalties which is designed to encourage compliance behaviour by the agents, so as to cost-effectively deliver on the principal's objectives (eg Fraser, 2002).[1]

In the context of food quality, a recent survey of the literature by Goodhue has shown that principals generally choose one of two alternative approaches to encouraging improvements in food quality by agents: "financial incentives…(or)…the specification of required production practices" (Goodhue, 2011, p.132). However, in the specific context of food safety, only the latter approach seems to have been the subject of moral hazard analysis (eg Starbird, 2005). Moreover, this approach implies that agents would only have the negative incentive of avoiding penalties to provide improved food safety.[2] But given the inherent uncertainty of detecting pathogens such as Campylobacter and Salmonella affecting food in the supply chain, this approach would seem to neglect the opportunity to improve food safety by positively incentivising improvements in food safety with an appropriate payment system, (EFSA, 2012). Note that such an approach has already been identified in the literature as "Management-based regulation", but as yet has not been the subject of moral hazard analysis (see Coglianese and Lazer, 2003).

As a consequence, the aim of this paper is to analyse an incentive payment-based approach to improving food safety along the lines of which is common in the agri-environmental policy design literature. More specifically, this paper analyses a situation where the principal's objective is to improve food safety by offering agents an incentive payment to implement costly additional practices, and then operating a system of monitoring and penalties to encourage compliance behaviour by agents.

The structure of the paper is as follows. Section 1 develops the principal-agent model of incentive payments to improve food safety, which features heterogeneous agents and considers both the presence and absence of the moral hazard problem in determining the socially optimal policy design. Section 2 provides a numerical analysis of this model, which evaluates the role of key parameters in also determining the socially optimal policy design.

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[1] Note that this incentive payment-based system is in addition to a requirement-based approach which relates to farmers having to keep their land in "good agricultural and environmental condition". See Quillerou and Fraser, 2010.

[2] Although note that compliance behaviour in relation to food safety may also be influenced by broader factors such as social responsibility and market reputation.

The paper ends with a brief Conclusion, which summarises the paper's contribution, including outlining two hypotheses on which to base subsequent empirical research.

Section 1: The Model

In this model the agents (eg "abattoirs") have primary control over delivering food safety in the supply chain. In the initial situation these agents have been subject only to regulation by the principal ("government") in terms of "the specification of required production practices" (Goodhue, 2011, p.132), in association with a monitoring and penalties system.[3]

In what follows, it is assumed that this initial regulatory system delivers a specified probability (p_1) of a "good" food safety experience from each unit of throughput. However, in an attempt to improve food safety, the principal is considering introducing an incentive payment (x) per unit of throughput for firms to adopt (costly) additional practices which will increase the probability of a "good" food safety experience from each unit of throughput to p_2 (where $p_2 > p_1$).

One complication to introducing such a system is that agents are assumed to be heterogeneous both in size of throughput (Z_i) and in the cost of implementing these additional practices per unit of throughput (c_i), with larger throughput agents having the benefit of economies of scale which result in a lower implementation cost per unit of throughput.[4] Therefore, with the incentive payment being based on each unit of throughput, it follows that the size of incentive payment required to encourage smaller agents to implement the additional practices is higher than for larger agents. As a consequence, the principal is faced with a choice of the scope of adoption of such an incentive payment system, knowing that broadening the scope of adoption from the relatively low-cost larger throughput agents will increase the associated benefits by incorporating smaller throughput agents, but in so doing will require a higher per unit of throughput incentive payment to be paid to all participating agents.

More specifically, to incentivise "large" agents (with throughput Z_L) to implement the additional practices, the incentive payment must be set at least equal to their cost of implementation (c_L):

$$x \geq c_L \tag{1}$$

But to incentivise "small agents" (with throughput Z_S) to implement the additional practices, the incentive payment must be set at least equal to their cost of implementation (c_S):

$$x \geq c_S > c_L \tag{2}$$

Therefore, the minimum social cost of adoption just for the "n" large agents is given by:

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[3] This is consistent with the current HACCP approach which "has become a widely-accepted regulatory strategy for addressing food safety" (Coglianese and Lazer, 2003, p.6).

[4] This is consistent with the specification in Fraser and Souza Monteiro (2009).

$$\text{Social Cost (Large Agents)} = nc_L Z_L \quad (3)$$

Whereas the minimum social cost of adoption for both the "n" large agents and the "k" small agents is given by:

$$\text{Social Cost (Large + Small Agents)} = nc_S Z_L + kc_S Z_S \quad (4)$$

Which means that the minimum social cost has increased not just by the associated cost of incorporating small agents into the system, but also by the increased size of payment to large agents:

$$nc_S Z_L > nc_L Z_L \quad (5)$$

Moreover, this increasing cost characteristic of broadening the scope of the system is in contrast to the associated impact on the social benefits from broadening its scope. Specifically, setting the social benefit of a "good" food safety experience per unit of throughput at "a", and the social benefit of a "bad" food safety experience at "b" (where a > b), it follows that the social benefit of adoption just by large agents (and assuming full compliance) is given by:

$$\text{Social Benefit (Large Agents)} = n(a-b)(p_2-p_1)Z_L \quad (6)$$

While the social benefit of adoption by both large and small agents (again assuming full compliance) is given by:

$$\text{Social Benefit (Large + Small Agents)} = n(a-b)(p_2-p_1)Z_L + k(a-b)(p_2-p_1)Z_S \quad (7)$$

In this case a comparison of (6) and (7) shows that the only increase in social benefit is that associated with the incorporation of small agents into the system (ie the second term on the right-hand-side of (7)).

An additional complication is that introduced by recognition of the moral hazard problem. In particular, the above analysis of social benefits has been based on an assumption of full compliance – ie all agents who accept the incentive payment then proceed to incur the cost of implementing the additional practices. But such a system may instead exhibit the moral hazard problem in that some agents may choose to accept the payment, but also choose not to incur the costs of implementation. More specifically, if an agent behaves truthfully, then the benefit of participation per unit of throughput (B_t) is given by:

$$B_t = (x - c_i) \quad (8)$$

But if the agent instead chooses to cheat and not incur the costs of implementation, then the associated benefit (B_c) is uncertain and given by:

$$B_c = x \text{ if not caught}$$

$$B_c = x - xt \text{ if caught} \quad (9)$$

Where: t = penalty parameter if caught cheating.

Specifying the probability of not being caught as "q", it follows that the expected benefit from cheating ($E(B_c)$) is given by:

$$E(B_c) = (1-q)(x-xt) + qx \quad (10)$$

And simplifying by setting t = 1 implies:

$$E(B_c) = qx \quad (11)$$

Therefore, if a (risk neutral) agent is to have no incentive to cheat then the benefit of behaving truthfully per unit of throughput must exceed the expected benefit from cheating:

$$(x - c_i) > qx \quad (12)$$

Or alternatively:

$$x(1-q) > c_i \quad (13)$$

Which in words states that the expected benefits from compliance must exceed the cost of compliance per unit of throughput.

Acknowledging the moral hazard problem has two consequences for evaluating the benefits from introducing such a system:

(i) Setting the incentive payment at the minimum level necessary to cover the costs of implementation (ie $x = c_i$) means that unless the probability of being caught cheating is 100% (ie q = 0) then those agents who are subject to moral hazard may cheat and not implement the additional practices. As a consequence, the expected benefits of adoption of the system are likely to be different than as specified in equations (6) and (7).

(ii) Expanding the scope of the system to incorporate small agents may mean that for some large agents the incentive to cheat is removed, so that the additional expected benefits of incorporating small agents are not just derived from their implementation of the additional practices (ie as in equation (7)), but also from some large agents now choosing to implement the additional practices who were previously not doing so.

More specifically, since for $x = c_L$ (and q > 0) it follows that:

$$x(1-q) < c_L \quad (14)$$

those large agents subject to moral hazard will choose to cheat and not implement the additional practices, but if the scope of the system is broadened to include small agents (so that $x = c_S$), the potential now exists for:

$$x(1-q) > c_L \tag{15}$$

and so large agents who previously were cheating, so choose to behave truthfully.

As a consequence, the balance of benefits and costs from broadening the scope of adoption is likely to differ in the presence of moral hazard from that in its absence.

In the following section this theoretical model of an incentive payment-based system to improve food safety is further formalised into a numerical analysis. This will enable the consequences of acknowledging the moral hazard problem for the socially optimal design of such a system to be more clearly illustrated. In addition, it will enable the role of various parameters in the model in determining the socially optimal policy design to be evaluated.

Section 2: Numerical Analysis

For the purpose of this numerical analysis the theoretical model developed in Section 1 is further formalised by assuming that there are three types of agents (k small, j medium and n large) which differ both in terms of their throughput (Z_i) such that:

$$Z_L > Z_M > Z_S \qquad (16)$$

And in terms of their cost per unit of throughput of implementing the additional food safety-improving practices:

$$c_S > c_M > c_L \qquad (17)$$

On this basis, consider the specification of the principal's decision problem in terms of the socially optimal scope of adoption of its incentive payment system.

Given there are three types of agents, the principal has to evaluate the social benefits and costs of four alternatives:

a) Zero adoption (ie the status quo)

b) Adoption by large agents only

c) Adoption by large and medium agents only

d) Adoption by all three types of agents.

The cost of each of these alternatives is given by:

a) Zero

b) nc_LZ_L

c) $(nZ_L + jZ_M)c_M$

d) $(nZ_L + jZ_M + kZ_S)c_S$

It is clear from a comparison of these costs that broadening the scope of adoption from case (a) to case (b) to case (c) to case (d) increases the cost each time, both by increasing the number of participating agents and by increasing the size of the incentive payment per unit of throughput.

Consider next the social benefits associated with each alternative. If it is assumed that there is no moral hazard problem, then the benefits in each case are as follows:

a) Zero

b) $(a-b)(p_2-p_1)nZ_L$

c) $(a-b)(p_2-p_1)(nZ_L + jZ_M)$

d) $(a-b)(p_2-p_1)(nZ_L + jZ_M + kZ_S)$

However, in the presence of the moral hazard problem the potential arises for some agents to cheat and accept the incentive payment but not deliver the social benefits of improved food safety. To illustrate the consequences of this problem for the levels of benefits associated with broadening the scope of adoption it is assumed in what follows that half the agents of each type will cheat if offered their per unit cost of implementation of the additional practices, while half will not. But also, if the scope of adoption is broadened, the associated increase in the size of the incentive payment will be sufficient to deter those agents previously cheating from now doing so. For example, if x is increased from c_L to c_M, then those large agents previously cheating will stop doing so (this is equivalent to equation (13) being satisfied, which is called the agent's "compliance constraint").[5] As a consequence, the pattern of benefits from broadening the scope of adoption is as follows:

a) Zero

b) $(a-b)(p_2-p_1)0.5nZ_L$

c) $(a-b)(p_2-p_1)(nZ_L + 0.5jZ_M)$

d) $(a-b)(p_2-p_1)(nZ_L + jZ_M + 0.5kZ_S)$

A comparison of the two sets of benefits shows that, as suggested in Section 1, the benefits from adopting the system only for large agents are reduced in the presence of moral hazard. However, in considering an expansion of the system to include medium agents (ie case (b) to case (c)), there is an additional benefit in this situation from the removal of non-compliance by large agents (and similarly for case (c) to case (d) for medium agents). This difference raises the possibility that, in the presence of moral hazard, while the net social benefit of adopting the lower cost option of incorporating only large agents is not worthwhile, one of the higher cost options may be of net social benefit.

This possibility is illustrated in Table 1.

[INSERT TABLE 1 HERE]

In particular, Table 1 shows that, in the presence of moral hazard, adoption of the lower cost option of only incorporating large agents into the system delivers a net social loss. However, adoption of the higher cost option of incorporating both large and medium agents

[5] Note that if it was assumed that agents were risk averse, then compliance behaviour may be achieved for lower levels of x because of the (unattractive) riskiness of cheating. See Fraser (2013).

delivers a net social benefit. As suggested previously, this result follows from the additional social benefit delivered by the removal of non-compliance by those large agents previously cheating with the lower level of incentive payment. Note in contrast to this result, that in the absence of moral hazard it is the lowest cost option which maximises the net increase in social welfare from adopting the incentive payment system. It follows that, because of its impact on the level of expected benefits, the extent of the moral hazard problem can be an important determinant of the socially optimal design of such a system, with the associated amelioration of the moral hazard problem being a potential rationale for broadening the scope of availability of an incentive payment-based system for improving food safety.

Next consider the role of various parameters in the model in determining the socially optimal policy design. First, see the results in Table 2, which illustrate the effect of increasing and decreasing the size of expected social benefits from improved food safety (given by $(a-b)(p_2-p_1)$). Note initially that such expected benefit differences could be due to changes in either or both of: i) the divergence in "good" and "bad" food safety experiences (ie a-b); ii) the impact of the additional practices on the probability of a "good" food safety experience (ie p_2-p_1).

[INSERT TABLE 2 HERE]

The results in Table 2 show that for lower levels of expected social benefit from improved food safety (ie $(a-b)(p_2-p_1) = 1$) it is socially optimal for the principal not to introduce the system in any form, and regardless of the presence or absence of the moral hazard problem. In contrast, for higher levels of expected social benefit from improved food safety (ie $(a-b)(p_2-p_1) = 4$), it is socially optimal to introduce the system in its broadest form, and again regardless of the presence or absence of the moral hazard problem (as specified in this illustration). In particular, these results suggest that if improved food safety is sufficiently an important objective, then even the moral hazard problem should not be a barrier to its pursuit. Moreover, the results in Table 2 suggest that if such a system is introduced in its broadest form, then while the largest agents can be expected to be receiving considerable economic "rents" from its adoption, they are also the least likely to jeopardise these rents by non-compliance. Hence, in this situation monitoring resources should be targeted towards the smallest agents who are (relatively) more likely to be non-compliant.

Finally in this section, consider the roles of agent numbers, agent size and agent implementation costs in determining the socially optimal policy design. The results in Table 3 show the impact of changing these various parameter values on the optimal policy design, but only for the situation where the moral hazard problem is present.

[INSERT TABLE 3 HERE]

In particular, the first column shows the impact of an increase in the number of large agents on net social welfare. Compared with the Base Case results in Table 1, these results show an increase both in the net social loss associated with only incorporating large agents into the system, and an increase in the net social benefit from broadening the scope of the system to include medium agents. So much so, that there is also a positive effect on social welfare from broadening the system to incorporate the small agents, albeit not as large a positive impact as with the initial broadening to incorporate medium agents.

Nevertheless, this finding suggests that for an industry dominated by large agents, in the presence of the moral hazard problem broadening the scope of an incentive payment-based system to incorporate smaller agents may be a relatively low cost solution to encouraging compliance behaviour among larger agents.[6]

In addition, the second column in Table 3 shows the impact of an increase in the size of medium agents on social welfare. Compared to the Base Case results in Table 1, this change both increases the cost of broadening the scope of the system to incorporate medium agents, and increases the benefits of further broadening the scope of the system to incorporate small agents by increasing the benefits associated with inducing compliance behaviour among medium agents. Hence, as shown by the results in Table 3, the socially optimal policy design in the presence of the moral hazard problem becomes to broaden the scope of the system to incorporate not just large and medium agents, but also small agents. So once again, ameliorating the moral hazard problem can be seen as a rationale for broadening the scope of an incentive payment-based system for improving food safety.

Finally in relation to Table 3, the results in column (3) support the suggestion in Table 2 that not just diminishing the benefits, but also increasing the costs of delivering improved food safety, undermine the justification for introducing such an incentive payment system.

[6] Note this finding is in contrast to the impact of this parameter change on the socially optimal policy design in the absence of the moral hazard problem, which remains as restricting availability of the system only to large agents.

Conclusion

This paper has analysed an incentive payment-based approach to improving food safety in the supply chain. As is already the case in the context of agri-environmental policy, such an approach would augment the existing requirements-based approach with the objective of incentivising food processors to implement (costly) additional practices which further improve food safety.

Specifically, Section 1 developed a principal-agent model of the food supply chain, whereby the principal (eg "government") has an objective of improving food safety beyond pre-existing levels, and in order to do so offers agents (eg "abattoirs") a payment in order to implement additional food safety-enhancing practices. In this model agents are heterogeneous in terms of both size of throughput and cost per unit of throughput of implementing the additional practices. This heterogeneity means that the principal is faced with a choice of scope of adoption of such a system, knowing that broadening the scope of adoption from the relatively low-cost larger throughput agents will increase the associated benefits by incorporating smaller throughput agents into the system, but in so doing require a higher per unit of throughput incentive payment to be paid to all participating agents. Given this situation, it is shown that the presence or absence of the moral hazard problem affects the balance of benefits and costs from broadening the scope of adoption to incorporate smaller agents.

In Section 2 this theoretical model was further formalised and then subjected to a numerical analysis. This numerical analysis demonstrated that the presence of the moral hazard problem creates the possibility that, while the net social welfare from adopting the lower cost option of only incorporating larger agents is negative, one of the higher cost options may be have positive net social welfare because in offering a higher incentive payment to incorporate smaller agents into the system, this payment also induces compliance behaviour among larger agents who were not complying at the lower level of incentive payment. The numerical analysis also considered the role of various parameters in the model in determining the socially optimal design of the incentive payment system to improve food safety. In this context it was shown that, again because of its ameliorating effect on the moral hazard problem, broadening the scope of the system to incorporate smaller agents is more worthwhile the more dominant are larger agents in the food supply chain.

It follows that the main policy implication of this analysis is that the presence of the moral hazard problem is an important factor influencing the socially optimal design of an incentive payment-based system aimed at improving food safety, with the nature of this influence being to encourage the adoption of a system which is more broadly-based across heterogeneously-sized food processors, rather than one which just focuses on the larger food processors, as is more likely to be socially optimal in the absence of the moral hazard problem. In addition, this analysis has identified two hypotheses which would be suitable for testing with empirical research: (i) that larger food processors would extract more "economic rent" from such a system that smaller food processors; but (ii) that because of this, larger food processors are more likely to exhibit compliance behaviour than smaller food processors.

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Table 1: Base Case Evaluation[1]

	No Moral Hazard	With Moral Hazard
Case (a) to Case (b) (Large Agents Only)		
Increased Social Benefit	1000	500
Increased Social Cost	750	750
Net Increase in Social Welfare	250	-250
Case (a) to Case (c) (Large and Medium Agents)		
Increased Social Benefit	1400	1200
Increased Social Cost	1190	1190
Net Increase in Social Welfare	210	10
Case (a) to Case (d) (Large, Medium and Small Agents)		
Increased Social Benefit	1560	1480
Increased Social Cost	1482	1482
Net Increase in Social Welfare	78	-2

Note 1: $Z_L = 250$; $Z_M = 100$; $Z_S = 40$; $c_L = 1.5$; $c_M = 1.7$; $c_S = 1.9$; $n = k = j = 2$

$(a-b)(p_2-p_1) = 2$

Case (a) to Case (b): $x = 1.5$; Case (a) to Case (c): $x = 1.7$; Case (a) to Case (d): $x = 1.9$

Table 2: Differences in Expected Social Benefits[1]

	$(a-b)(p_2-p_1) = 1$		$(a-b)(p_2-p_1) = 4$	
	No Moral Hazard	**With Moral Hazard**	**No Moral Hazard**	**With Moral Hazard**
<u>Case (a) to Case (b)</u>				
Increased Social Benefit	500	250	2000	1000
Increased Social Cost	750	750	750	750
Net Increase in Social Welfare	-250	-500	1250	250
<u>Case (a) to Case (c)</u>				
Increased Social Benefit	700	600	2800	2400
Increased Social Cost	1190	1190	1190	1190
Net Increase in Social Welfare	-490	-590	1610	1210
<u>Case (a) to Case (d)</u>				
Increased Social Benefit	780	740	3120	2960
Increased Social Cost	1482	1482	1482	1482
Net Increase in Social Welfare	-702	-742	1638	1478

Note 1: All other Base Case parameter values apply

Table 3: Differences in Agent Numbers, Agent Size and Agent Implementation Costs: With Moral Hazard Only[1]

	(1) Increased Agent Numbers[2]	(2) Increased Agent Size[3]	(3) Increased Agent Implementation Costs[4]
Case (a) to Case (b)			
Increased Social Benefit	1000	500	500
Increased Social Cost	1500	750	750
Net Increase in Social Welfare	-500	-250	-250
Case (a) to Case (c)			
Increased Social Benefit	2200	1240	1200
Increased Social Cost	1940	1258	1260
Net Increase in Social Welfare	260	-18	-60
Case (a) to Case (d)			
Increased Social Benefit	2480	1520	1480
Increased Social Cost	2232	1490	1638
Net Increase in Social Welfare	248	30	-158

Notes: 1: All other Base Case parameter values apply

2: n increased from 2 to 4

3: Z_M increased from 100 to 120

4: c_M increased from 1.7 to 1.8; c_S increased from 1.9 to 2.1