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Co-regulation and voluntarism in the provision of food safety: lessons from institutional economics

Salman Hussain

Abstract

Traditional regulation in the food safety domain has been in the form of mandatory, inflexible food safety controls that are applied to firms. There has been a trend away from this regulatory paradigm towards more co-regulation and self-regulation by industry. This paper investigates the potential for systemic failure in the provision of safe food that might arise as a consequence of this new regulatory paradigm. These systemic failures occur owing to the fact that the food safety outcome depends on the behaviour of the three sets of agents (firms, consumers and the regulator). These populations of agents have generally been treated in the literature as homogeneous in terms of their behaviour and strategies. Further, the actions taken by any one agent are assumed to be independent of those taken by others. The institutional economics model that is developed assumes heterogeneity and inter-agent strategic interactions. Given this (more realistic) depiction of behaviour, instances of potential regulatory inefficiencies arise . In particular, the model challenges the trend towards voluntarism and self-regulation.

Keywords

co-regulation; strategic behaviour; food safety; ex ante regulation; institutional economics.

Introduction

The regulatory *status quo* for the food industry around much of the developed world might be characterised as inflexible, mandatory, *ex ante* regulation of product safety for firms, including both food producers and distributors/handlers. There is a range within this regulatory type (which I term 'traditional regulation') from prior approval through to the designation of different standards, the latter being more flexible forms of regulatory intervention. Traditional regulation imposes significant compliance costs on firms.

The remit of regulatory bodies has evolved to include cost-benefit appraisal of regulatory intervention. This has in part stimulated the interest both in the academic literature (e.g. Fearne and Garcia Martinez, 2005; Unnevehr and Jensen, 1999; Roe, 2004) and in empirical public regulation of the potential to find more economically efficient alternatives. One strand of alternatives to traditional regulation is what has been termed 'co-regulation' wherein a greater reliance is made on self-regulation by firms and their associated industry bodies. In a similar vein, there is the potential to tap into consumers' self-interested behaviour on the demand side, i.e. consumers are expected to make a greater contribution to the food safety outcome through their behaviour.

The probability of a foodborne illness incident arising depends on the behaviour of three agents, i.e. the firm, the consumer and the regulator, and the institutional context for their decisions, e.g. the accessibility to and efficacy of the legal system, cultural norms and values and the types of food consumed. The 'firm' in this case is a string of agents in the supply chain. Firms can reduce risks in home-prepared food by reducing pathogen levels in raw inputs by screening, by stunting pathogen growth through altering product formulation (e.g. by changing pH) and by slowing pathogen growth by quality assurance in the handling and storage of food in the distribution chain (Roe, 2004). Consumers affect risk through their food storage, handling and cooking methods. Consumer awareness and concern with regard to foodborne illness has burgeoned over the past two decades owing to several high profile incidences of contaminations. Although consumers state that their awareness of appropriate food safety handling procedures has risen (Fein, 2001), Daniels *et al*. (2001) report that three-quarters of consumers continue to make critical food handling and preparation errors that increase the risk of a foodborne illness incident arising.

The standard economic principle of equi-marginal returns to effort (e.g. Edwards-Jones *et al*, 2000) provides a rationale for this shift from traditional regulation to co-regulatory alternatives. This principle states that, in order for an outcome to be economically efficient, the last unit of effort expended by each agent to increase food security should realise the same given reduction in food risk. The agents in this case are the populations of firms and consumers and the regulator. Firms voluntarily participating in a quality assurance scheme or consumers adapting their food handling procedures (owing to an awareness-raising campaign) might achieve a given reduction in food risk at a lower cost than traditional regulation.

Although this rationale for regulatory alternatives appears reasonable, I would argue that it does not sufficiently account for the fact that the achievement of food safety depends on strategic interactions. These interactions occur both *within* the populations of agents (e.g. firms' strategic responses with respect to the behaviour of other firms) and *across* these populations (e.g. consumers reactions to changes in the institutional framework set by the regulator). These interactions are all the more complex when the standard (and unrealistic, arbitrary) assumption that the populations of firms and consumers are homogeneous in their strategies and behaviour is no longer applied. The aim of this paper is to draw out these strategic interactions and to consider the resulting potential for systemic failure in food safety provision. In essence, this research questions whether the regulatory paradigm shift is economically efficient given what is known (and what can be inferred and drawn from) the strategic behavioural and institutional economics literatures.

In order to achieve this aim, the paper has the following structure. In the next section, I develop a diagrammatic schematic framework for the analysis of food safety vis-à-vis the strategic interactions between the population of agents. At this stage of the analysis, homogeneity is assumed across the population of agents. This assumption is relaxed in the section that follows where the subsets of the populations are described and the interaction between these subsets is modelled. This model adapts the typology of systemic risk in Hennessy *et al*. (2003) to account for interactions between sub-populations. The final section then provides a synthesis of these theoretical discussions and a policy summary.

A schematic representation of food safety

Consider Figure 1. I begin with the assumption that there are homogeneous populations of firms and consumers that affect the safety of one particular sample of a given commercially marketed food product. Note that these are discreet subsets of the entire populations of firms and consumers. Further, these discreet subsets may only contain one element, e.g. one consumer. Each firm in the (food safety) chain is assumed to be a profit-maximiser and each consumer a utility-maximiser. These agents take actions that are contained within activity sets. For the population of firms, these activity sets are as follows: raw material selection; processing; storage; handling; distribution. For the population of consumers, they are as follows: food storage; handling; preparation. Each activity set can contain actions carried out by more than one agent in the respective populations (e.g. two different firms take actions in the 'handling' activity). Further, one agent can be responsible for multiple actions within one activity (e.g. two areas within the production process of the same firm that affect 'handling').

Figure 1 A schematic representation of food security

It is assumed in the first instance that the activities are independent, i.e. one firm's procedures in terms of, say, food handling neither affect nor are affected by any other agent's behaviour. Further, it is assumed that the regulator sets the institutional and legal context for the actions taken by firms and consumers. The regulator affects food safety outcomes through its role in influencing the expected private payoffs to the competing options made by these agents.

In Figure 1, the sets *F* and *C* respectively represent 'safe processes'. P_{FSI} represents the overall probability of a foodborne safety incident arising at the point of consumption, i.e. after all the actions have been taken by the populations of firms and consumers. Note that P_{FSI} depends not only on the activities of the agents but also on the susceptibility of the consumer to illness. For instance, the likelihood of a contaminated food sample causing an illness incident is higher *ceteris paribus* if this sample is consumed by an elderly person with a weak immune system as compared with consumption by a younger, healthier individual.

If any action has an associated P_{FSI}:P_{FSI}>0 then this action is outside the 'safe processes' sets. The further this element is from F, C the higher is probability P_{FSI}. Thus the P_{FSI} associated with F_{S2} is larger than that associated with F_{S1}. Note that Figure 1 pertains to one hypothetical food sample and as such both food storage activities F_{S1} and F_{S2} occur simultaneously, the source being either the same firm or different firms in the food safety chain.

As well as the possibility of one or more non-safe activities from the same activity set (F_{S1} and F_{S2}) there can be one or more other non-safe elements across different activities. For instance F_{S1} and C_{H1} may both apply. Clearly, the greater the number of elements that fall outside 'safe processes', the higher is P_{FSI}. However P_{FSI} is unlikely to rise in a linear fashion as 'non-safe' elements are added. In comparing P_{FSI} for F_{S1} in isolation versus the P_{FSI} for both $F_{S1}$and C_{H1} occurring concurrently, the latter P_{FSI} is by definition larger but the increase in probability depends on the *systematic interactions* between the elements. This is analysed further below when the simplifying (and unrealistic) assumptions that we apply of homogeneity in the populations of agents and the non-interdependence across activities are removed.

The schematic framework in Figure 1 can be adapted to allow the determination of standard theoretical efficiency conditions, i.e. the equalisation of marginal social cost and marginal social benefit. Society should select food safety provision up to some level where the incremental social costs of achieving a higher level are bigger than incremental social benefits. The social benefit of any form of regulatory intervention is the expected avoided costs in terms of morbidity and/or mortality. (For a discussion of this literature see Moran *et al*., 2004). Thus this expected social benefit is conditioned by the impact that any activity has on P_{FSI}. A reduction in P_{FSI} is valuable in that it implies a reduced likelihood of an incident arising with the associated costs that must be borne by society. The social cost is the aggregate of the costs borne by the regulator, firms and consumers.

How does this analysis link with the trend towards co-regulation? Consider Figure 2. This schematic is a characterisation of traditional regulation. Note that whereas Figure 1 is a schematic for the *actual* activities that affect the food safety outcome for one sample of food, Figure 2 represents what *should* happen vis-à-vis the activities of firms under traditional regulation. The focus is very much on the behaviour of firms and the various activities are regulated accordingly. Regulatory impact assessment is applied so as to allow the designation of a safe minimum standard in these various firm activities. There are various reasons why this traditional regulatory framework is economically inefficient which, in part, explain the trend towards co-regulation.

Figure 2 Traditional e*x ante* regulation of firm activity

First, there are no activity points in *C* for the simple reason that the behaviour of consumers is unregulated. This is not an omission or oversight on the part of regulators. It is the consumer that suffers directly from the morbidity and/or mortality associated with foodborne illness. It is unlikely that consumers would have any incentive to willingly self-inflict such illnesses and studies consistently show positive willingness-to pay to avoid such illnesses (*ibid*.). Thus there is no discrepancy between the preferred outcomes of the state and the consumer, i.e. minimising the occurrence and impact of such incidents. There is thus no need for regulatory intervention, even though many of the costs of such incidents are externalised by the consumer to the state, e.g. free healthcare provision at point of delivery. The activities of consumers do however affect P_{FSI}. Thus alternative mechanisms such as funding of information provision and awareness raising campaigns may be economically justified in that they might achieve a given level of social benefit/reduction in P_{FSI} at a lower cost than, for instance, further tightening of *ex ante* regulation of the firm.

A second form of potential inefficiency is the reliance on inflexible command-and-control regulation. The co-regulation agenda promotes more flexible options such as the voluntary adoption of quality assurance schemes instigated by individual firms or industry bodies. It is a standard economic assumption (e.g. Edwards-Jones *et al*., 2000) that providing incentives for private agents to search for mechanisms to achieve performance enhancement has a lower associated aggregate social cost than achieving the same enhancement through command-and-control.

The schematic framework presented in this section is useful as it allows a global appraisal of optimality and therein supports the contention that conventional *ex ante* regulation is often less economically efficient than alternatives such as co-regulation. I have stated above that this analysis depends on two sets of conditions.

First, all activity points are independent. Second, the population of firms and consumers are homogeneous with well-defined and consistent objective functions in each case. In the next section these assumptions are relaxed.

Systemic risk in food safety provision

The food safety outcome, measured as changes in P_{FSI}, depends on the actions and interactions of several agents (both firms and consumers) in a *system*. The assumption in the previous section of non-interdependency between activity points was applied. Even under this assumption, if some activity falls outside the ‘safe processes’ regions (F, C) then the resultant impact on P_{FSI} depends on what else happens in the system. In the analysis that follows, the assumption of homogeneous populations of firms and consumers is no longer applied and thus the behavioural assumptions of the sub-populations are set out. The interactions between the strategies of these sub-populations then allow the development of a typology of systemic risk.

The designation of heterogeneity in the populations of firms and consumers

Consider firm behaviour first. Assume that, through some process failure, one of the firm’s activity points is outside F, i.e. $P_{FSI}>0$, and that the firm is aware of this. Consider a scenario where asymmetric information applies between this firm and all other agents in society. This asymmetric information takes the form of this firm knowing (with certainty) that there has been some breakdown in food safety within the production process, that firm not informing other societal agents, and those agents not being able to determine with certainty any food safety risk. These societal agents might include the regulator, the consumer and any affected firms, the latter including both those firms that might use the food stuff as an input to their own production and distributors/final retailers. Each agent forms some prior probabilistic assumption that $P_{FSI} = 0$ at the factory gate[1]. Assume that the choice of the firm that has produced the risky food is a dichotomous choice, i.e. either disposal of the risky batch or sale.

The firm's cost assessment of the 'sell it' alternative depends on two subjective evaluations: first, the probability of an outbreak resulting from the food safety breakdown; second, the probability of the cause of the outbreak being attributed to the firm. Assume that this subjective probability is termed α. Further, note that Calvin *et al*. (2004), in a USDA analysis of Hepatitis A outbreak arising from green onions imported into the US from Mexico, report that, until the outbreak occurred, food producers thought that the probability of an outbreak occurring was lower than was the case in reality.

The total private penalty to the firm arising from an outbreak occurring and being traced to that firm is the sum of three elements. First, there is the loss in sales revenue and associated profitability that arises from the shift in consumer confidence. Second, there are direct and indirect financial penalties applied by the regulator, an example of the latter being the mandatory adoption of a certified quality assurance scheme. Third, there may be legal expenses and claims arising from consumer applications of tort liability law and breach-of-contract applications by retailers/intermediate purchasers. All three elements are likely to be affected by the extent of the outbreak in terms of morbidity and mortality.

Three distinct sub-populations of firms are characterised based on the manner in which a particular firm evaluates this dichotomous choice. The first firm sub-population is termed FP_{CSR}. Corporate social responsibility [CSR] is the adoption of an ethical position on social/environmental matters such that the firm chooses strategies/options based on what it perceives it *ought* to do irrespective of the financial consequences (Hussain, 1999; Clarkson, 1991). In the case of food safety, a firm in FP_{CSR} never *knowingly* releases any potentially contaminated produce to market even if the source of the outbreak could never be traced back to the firm, i.e. even if the firm itself would bear no private costs from any outbreak. The second sub-population is termed FP_{LAW}. A firm in this sub-population maximises profits subject to legal constraints, i.e. it never knowingly contravenes regulations. However, it might choose to market the

[1] This prior probability is determined by a host of variables including the institutional/legal context, reputation-formation, signalling and food labelling *etc*. These variables and the effects that they have on asymmetric information (and the associated potential for market failure) form the core of the discussion that follows.

potentially contaminated batch if, say, it could *ex post* demonstrate due diligence in its actions[2]. The third population sub-set is termed FP_{CHEAT}. This constitutes firms that profit-maximise but, unlike those firms in FP_{LAW}, choose to abide by regulations if and only if there is sufficient incentive to do so. For a risk-neutral firm in FP_{CHEAT}, the expected cost is α multiplied by the *ex ante* estimate of total penalties, as discussed above. If this expected cost is lower than the benefit from selling the batch then the firm in FP_{CHEAT} markets the contaminated batch.

It is methodologically difficult to estimate the proportion of firms that fall within each of these three sub-populations. Firms regularly claim CSR credibility but such claims are often difficult to externally verify and no firm is likely to admit being in FP_{CHEAT}. Further, a firm might not consistently be in the same sub-population. For instance, if the firm perceives (correctly or incorrectly) that a specific regulation is merely a 'red tape' bureaucratic imposition, it might be tempted to 'cheat' whereas it might be responsive (or even adopt a CSR stance) in other food safety decision-making. This provides a rationale for stakeholder consultation in the designation of regulations. However, Henson and Caswell (1999) note that different stakeholders apply divergent criteria both when judging the need for food safety *ex ante* and the success or failure of regulation after implementation.

Turning to the demand side, three sub-populations for consumers are categorised. $CP_{\text{PROACTIVE}}$ is the subset of consumers that are proactive in seeking food product information. They always follow food safety instructions and warnings and feel that food safety is in significant part their personal responsibility. CP_{REACTIVE} is the sub-population of consumers that react to food safety instructions and warnings that are clearly labelled on the product itself but do not search for further information. They feel that food safety provision is the responsibility of the firm and the regulator. The consumers in $CP_{\text{NEGLIGENT}}$ neglect or disregard food safety instructions or warnings, relying on (potentially risky) cultural norms and traditions in their food handling, storage and preparation. A similar caveat applies to the consumer populations as to those of firms, i.e. this characterisation is a generalisation and individuals may not be coherent and consistent in their decision-making vis-à-vis food safety.

[2] Note that the legal context of what is permissible firm behaviour varies across OECD nations. Due diligence may be a necessary but insufficient condition to avoid prosecution.

This typology of the populations allows an investigation of the theoretical possibilities of systemic failure arising owing to this heterogeneity in the populations. Hennessy *et al*. (2003) provides a useful typology of systematic risk for food safety. The authors refer to four types (A-D) of failures and I follow this designation. I thus use this typology as a starting point but modify it to account for the effect of having heterogeneous sub-populations of firms and consumers and I then introduce other potential sources of systemic market failure that might warrant regulatory intervention.

Systemic failure: system typology and interconnectedness

Failures in Type A occur as a consequence of interconnectedness in the system wherein consequences are known (e.g. an outbreak of *Salmonella* poisoning) but the cause is not isolated. The strategic responses of the sub-populations are summarised in Table 1. Each firm sub-population applies a different strategy to the institutional scenario. FP_{CSR} applies every feasible (and reasonable) effort to ensure that its activities are not the source of any such outbreak. However, the strategies of FP_{LAW} and FP_{CHEAT} are driven by the fact that, if traceability is not achieved, then the private cost borne by the offending firm is low relative to the aggregate cost to the industry in general and society at large. Each agent has some *ex ante* subjective probabilistic estimate of whether or not the source of the outbreak will the isolated *ex post*. A profit maximising firm chooses to externalise the costs associated with the food safety risk if it can do so. Since the offending firm is part of the food production sector that is responsible for the outbreak, it suffers a financial penalty from the outbreak as consumers lose confidence and switch consumption patterns. However, these costs are *shared* across the entire food sector whereas prevention costs are privately borne by the firm. This is a case of market failure. The difference between the strategies of FP_{LAW} and FP_{CHEAT} is that the former chooses to always abide by regulation whereas the latter only does so if there is sufficient incentive, i.e. the probability and/or the penalty are sufficiently high.

Table 1 Strategic responses to System Failure Type A

In type A system failure, only $CP_{\text{PROACTIVE}}$ might look for certification to reduce the probability of suffering the private economic costs of consuming contaminated food. Owing to mixing and the fact that certified alternatives are not available in all food sectors that constitute the basket of commodities consumed by $CP_{\text{PROACTIVE}}$, there is uncertainty.

In Type A system failure then there is an economic rationale for regulatory intervention. This is the case for the mandatory application of Hazard Analysis Critical Control Point (HACCP) regulations in the US for industries that sell raw, unbranded seafood, meat, poultry, along with some fruits and vegetables (Unnevehr and Jensen, 1999; Antle, 1998; Caswell and Hooker, 1996). A Critical Control Point is "any point in the chain of food production from raw materials to finished product where the loss of control could result in unacceptable food safety risk" (Pierson and Corlett, 1992). This is an example of flexible (and therein more efficient, cost-effective) legislation in that the food safety agency provides general requirements in terms of food safety outcomes. It relies on measurable indicators as opposed to the more costly traditional options such as product sampling and testing (Unnevehr and Jensen, 1999). For these food product categories, traceability is limited, i.e. it may not be feasible to determine the source producer responsible for a foodborne illness incident. Given this, the level of food safety provision selected by FP_{LAW} and FP_{CHEAT} may be below the social optimum owing to the assumed objective of profit-maximisation.

Calvin *et al*. (2004) analyses an incident in the US arising from the consumption of green onions sourced from Mexico. This is an example of the Type A failure in that the incident was traced to one food product type from a defined geographical region but not to a particular producer. The resultant decline in consumer confidence and sales is likely to have affected *all* producers of that product. The private cost borne by the offending firm is a small fraction of the total shared across all Mexican producers of green onions, i.e. an instance of market failure in the form of an externality. This situation is akin to a common property resource problem as described in the seminal analysis of Hardin (1968). The common property resource in this case is the 'consumer perception of food security of (say) Mexican green onions'. Although each and every Mexican producer of green onions might see that this common property resource as valuable, no individual private producer has an economic incentive to unilaterally increase the food security of its own produce. Hardin (1968) suggests a solution to this in "mutual coercion mutually agreed upon" with an associated penalty mechanism and there is an extensive literature on common property resource management (e.g. Ostrom *et al*., 1994). Such management is however difficult to implement, monitor and enforce on a voluntary basis. This in turn implies that regulatory intervention may be economically efficient.

There is a parallel here also with co-regulation and voluntarism in the food sector. There may be an adverse selection issue in that those firms that choose voluntarily to improve food safety provision are likely to be those that are members of FP_{CSR} or FP_{LAW} but these are not the firms that have the greatest impact (all else being equal) on P_{FSI}. If a firm in its activities is close to the frontier of 'safe processes' (F), the private cost of its adopting some industry standard for a safe minimum standard is likely to be higher than that of a firm with established protocols and procedures. Under voluntarism, the former firm is less likely to adopt the standard but it is more likely than the latter to be the source of a foodborne illness incident. There is then an economic rationale for regulatory intervention and compulsion.

Improvements in both traceability technologies and their applications potentially offer an alternative avenue to internalise the externality and therefore correct the market failure. However, one issue to be borne in mind here is the nature of the food sector in terms of market concentration and restrictions on legal liability. If the source of the outbreak is a small producer and/or the source has limited insurance liability cover then it might not be possible to fully internalise the social costs of an outbreak. Further, individuals may not be able or choose to take the issue to court. *Ex post* remediation then only has limited effectiveness. If this is the case then the externality persists even under conditions of perfect traceability.

Systemic failure: mistrust in communication

The second type of systemic risk in the Hennessy *et al*. (2003) typology is termed 'mistrust in communication' by the authors. Mistrust of the sender is linked to asymmetric information. This is discussed in Hussain (2000) for eco-labelling and this has direct parallels for food safety given the heterogeneity in populations. Any of the three firm types might choose to send a 'signal' to potential consumers vis-à-vis the food safety of their products. This signal might be, for instance, the marketing of some quality assurance scheme that the product is accredited under, or the designation of a particular food processing technology that has been applied. The act of sending this signal necessarily incurs some private costs to the firm (regardless of the firm type) and thus the firm sends this signal if and only if it the expected returns are sufficient to counter-balance these costs[3]. Table 2 summarises the strategies of the agents in the sub-populations.

Table 2 Strategic responses to System Failure Type B: mistrust of the sender

The Lancaster-Rosen model of rational consumer decision-making suggests that a consumer forms some subjective estimation of the attributes of a product with respect to his/her preferences and then allocates his/her budget accordingly (Lancaster, 1966; Lancaster, 1971). $CP_{\mathrm{PROACTIVE}}$ and CP_{REACTIVE} may value the product attribute of 'level of food safety'. If the market functions efficiently, such consumers can signal that they value this attribute by making their product selection based in part on their preference for this attribute. The price mechanism then functions in that this signal sent by the consumers stimulates the provision of such products by suppliers. However, note that all three firm subsets are willing to send a signal in an attempt to capture this segment of the market. In the case of FP_{CSR}, any signal sent is never *intentionally* misleading. (Owing to controversies and incompleteness in the scientific understanding of food safety provision, such signals might be found to be inappropriate *ex post*.) For FP_{LAW}, a signal is sent if it is profitable to do so and the signal/marketing claim is scientifically defensible. Given the aforementioned incomplete and imperfect nature of food science, there is then scope (and an associated economic incentive) for FP_{LAW} to send a signal that is misleading but not categorically scientifically incorrect. FP_{CHEAT} only applies the profit analysis within which is captured an expected penalty from an indefensible signal being challenged.

The potential for a market failure arises in the co-existence of genuine and misleading signals in the context of asymmetric information. Consider a scenario where self-certification labeling coexists in the market

[3] We refer here to the marketing costs alone. The extent of other private costs incurred depends on both the nature of the signal being sent and also on the sub-population that the sender is a member of.

with externally accredited labeling. Assume that, with self-certified labels, the consumer cannot perfectly discriminate between legitimate and illegitimate food safety labels. This seems to be a plausible assumption in that the science underpinning such labeling claims can be both complicated and equivocal. The consumer must then attribute probabilities that a signal received has been sent by FP_{CSR}, FP_{LAW} or FP_{CHEAT}. Assume for exposition that a consumer in $CP_{\mathrm{PROACTIVE}}$ assigns a prior probability of 0.6 that the signal is legitimate and 0.4 that it is not. If he or she is willing to pay, say, a £1.00 premium for this attribute then, assuming risk neutrality and rationality, this consumer would apply a 'mixing' strategy and now only pay £0.60 for a product that is signaled as having this attribute.

There is a potential vicious cycle that might occur, as discussed originally in Akerlof (1970) and in Hussain (2000). It is likely that legitimate increases in the food safety attribute are more costly then illegitimate ones. Assume that the cost to a FP_{CSR} firm of providing the incremental increase in the food safety attribute is £0.80 per unit. Owing to the rational adoption of a mixing strategy by $CP_{\mathrm{PROACTIVE}}$ the premium paid is only £0.60. In this case FP_{CSR} decides not to provide this attribute. Since this is the case, this means that a greater proportion of the remaining signals in the market are illegitimate. If consumers update their beliefs vis-à-vis the legitimacy of signals (as they become aware of the fact that FP_{CSR} is no longer sending signals), this in turn *lowers* the premium that $C_{\mathrm{PROACTIVE}}$ is willing to pay (to say £0.45) given the updated mixing strategy. Those firms that could legitimately offer the attribute at £0.55 now withdraw from the market.

What this analysis implies is that there can be an economically valid case for intervention to monitor self-certification in the food safety domain or indeed to apply more stringent *ex ante* legislation such as requiring that all such claims be externally certified. If the latter applies then $CP_{\mathrm{PROACTIVE}}$ no longer need apply a mixing strategy. Although such intervention upon initial inspection might appear to be overly interventionist and non-market in nature, it might in fact be necessary to allow market operations and the price mechanism to operate efficiently. In essence this is again an argument against voluntarism, i.e. allowing firms do decide whether or not to legitimate food safety claims through third party verification.

Such intervention will not be appropriate in all cases however. Both proposed measures have implied transactions costs. If the scale of the inefficiency that arises from asymmetric information and the need for consumers to apply a mixing strategy is small then regulatory change might not be justified in economic terms.

One feature of the food sector in the UK is the relative dominance of supermarket chains own brand sales in food provision (Henson and Traill, 1993). In terms of food safety signals, a common denominator for all three subsets of the population of firms is that expected profitability from signaling would need to be positive. There are two features of supermarkets that imply that illegitimate signals are unlikely to be sent. First, the scale of these organisations implies that corporate liability in the event of *ex post* scientific proof that food safety claims were inappropriate is potentially enormous. Second, consumers are likely to associate food safety failures with not just one particular product in the supermarket's own label brand but the entire *brand* itself. This knock-on effect serves as a countervailing force against the tendency in FP_{LAW} and FP_{CHEAT} profit-maximising firms to send illegitimate signals. Reputation formation is cited by Buzby and Frenzen (1999) as a possible reason why large franchises are more likely than most other defendants to settle any legal challenges out of court and therefore away from public scrutiny.

Systemic failure: asymmetric information leading to co-ordination failure and distorted incentives

Whereas Type B systemic failures occur owing to information asymmetries across populations (firm/consumer), Type C failures in the Hennessy *et al*. (2003) typology refer systemic to *inter-firm* asymmetries. For exposition, assume that there are two firms, Firm *A* and Firm *B*, which are participants in the production of a particular food commodity for sale to the consumer. Firm *A* is 'upstream' of Firm *B*, i.e. the former provides an input to the latter. Assume further that Firm *B* is considering the implementation of a food safety measure (which incurs a private cost to Firm *B*) but that the effectiveness of this measure depends not only on its activity points (handling, processing *etc*.) but also those of Firm *A*. Firm *B* does not know with certainty which population sub-set (i.e. FP_{CSR}; FP_{LAW}; FP_{CHEAT}) Firm *A* is a member of. Similarly to the Type B failure, Firm *B* plays a mixing strategy with the associated potential economic inefficiencies that are implied. In a similar fashion to Type B failure, adverse selection issues can imply that voluntarism leads to an economically inefficient outcome.

A form of regulatory intervention to address Type C failure is external accreditation, but whether or not it is economically efficient to enforce accreditation depends on the appraisal of costs and benefits. This type of systemic failure is perhaps less of an empirical issue in that Firm *B* has an incentive to preserve the credibility of its brand and to avoid the liability/penalties arising from any food safety incident that might arise. There is a strong private incentive to instigate 'supplier challenges' to make the demonstration of food safety compliance a necessary condition of being a supplier.

Systemic failure: Failure to develop state-conditioned technologies

Type D in the Hennessy *et al*. (2003) typology does not arise as a consequence of the structure of the system or incentives therein. It arises owing to the fact the food safety technologies might not be able to adapt to deal with all potential 'states of nature' or outcomes. Although the link is not drawn out in Hennessy *et al*. (2003), there are parallels with the economics of 'network externalities' discussed for environmental technologies Hussain (2003). Conventional economic theory suggests that, if the market is functioning efficiently, firms have an incentive to search for technological improvements that increase private profitability. In the realm of food safety, this implies that, were a technique or technology to lead to efficiency gains then the market would stimulate its development and application. The evolutionary economic models of Nelson-Winter (e.g. Nelson and Winter, 1977; Nelson and Winter, 1982) suggest that the technology trajectory is 'path dependent'. If firms have had a history of searching for and selecting technologies in a certain domain then they are likely to choose to pursue R&D options close to this trajectory. However, it is quite possible that this implies that certain technologies remain underdeveloped as a consequence, technologies that might actually be more efficient than those that are developed: this is where the network externality arises from. There may then be the need to stimulate not just incremental technological steps in the R&D of food safety but fundamental paradigm shifts.

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Systemic failure: dependence between activity points

I would suggest the addition of a further potential source of systemic failure that arises either owing to inappropriate *ex ante* assumptions with respect to how the behaviour of one agent affects that of another, or cases where no inter-dependence is assumed but actually occurs in practice. There is evidence from the literature on the economics of risk that such inter-dependence can lead to sub-optimal outcomes. Further, I would suggest that this might apply in the food safety domain as well.

Analysis by Peltzman (1975) demonstrates that the introduction of seatbelts as a safety feature to reduce the risk of morbidity/mortality arising from a car accident resulted in a shift in consumer behaviour in that drivers took more risks *ex post*. Similarly, Viscusi (1984) considers the mandatory application of child-resistant bottle caps on medicine bottles. This research shows that the number of incidents of accidents in the home arising from children consuming medication without parental awareness/consent actually increased *ex post*. Viscusi suggests that this occurred because parents adopted a more risky strategy than they had prior to the regulation, i.e. some no longer took the caution of keeping the medication out of the reach of their children.

Both these cases are examples of bilateral damage control wherein one agent's effort affects the marginal effectiveness of the other agent's effort. Roe (2004) argues that, for most foodborne illness occurring in the home, consumers can alter the damage outcome by altering the preventative effort taken in response to information concerning the industry's level of preventative effort. Shogren and Crocker (1999) refer to this as endogenous risk.

Figure 3 Endogenous risk

Endogenous risk can be conceptualised using the schematic framework that was developed above. Consider Figure 3. Assume that there is a regulatory change that requires that the product packaging for uncooked poultry be changed so as reduce the risk of raw meat juices leaking from the packaging and therein cross-contaminating other cooked produce. This mandatory change reduces the likelihood of food contamination in storage and distribution and thus the relevant activity points shift from F_{S1} to F_{S2} and F_{D1} to F_{D2}. Such a shift might be expected to realise no change in the activity points of the consumer. However, in the same vein as consumers' reactions to 'safer' paracetamol packaging (Viscusi, 1984), some proportion of consumers of poultry (in CP_{REACT} and $CP_{NEGLIGENT}$) might adapt their behaviour and therein cause an outward shift in the storage activity from C_{S1} to C_{S2} and in handling from C_{H1} to C_{H2}. Although C_{S2} and C_{H2} are depicted in Figure 3 as being safe, i.e. in C and F respectively, there may be cases where this does not apply. The conceivable net effect of the regulation might be an increase in P_{FSI}., and therefore of course be inefficient in that there is likely to be a positive marginal cost associated with the 'safer' packaging.

Summary and policy recommendations: a screening procedure

Consumers and firms are often treated as agents that respond consistently and rationally to regulatory interventions. In the designation of optimal regulation, it is often assumed that firms aim to maximise private profitability within the confines of the law and consumers to maximise private utility subject to the constraints of the market. Under the typology developed, the assumption then is that firms are all FP_{LAW} and consumers are all $CP_{REACTIVE}$. The analysis presented is based on the premises that the populations of firms and consumers are in fact heterogeneous and that there is strategic interaction between the agents. Other subsets of the firm and consumer populations have been defined, *viz*. FP_{CSR}, FP_{CHEAT}, $CP_{PROACTIVE}$, and $CP_{NEGLIGENT}$.

The food safety outcome then depends not only on the behaviour of each agent in isolation but on the actions and strategies of a group of agents. This group comprises firms and consumers that select activities that affect food safety. These activities can be grouped as raw material selection, processing, storage, handling, distribution, storage and preparation. If any activity is located outside the region termed 'safe processes' then the probability P_{FSI} that a food safety arises is strictly positive. The assumed global objective function of the regulator is to determine the economically efficient level of P_{FSI}. This is achieved by counter-balancing at the margin the expected costs of an incident occurring (in terms of the value of morbidity and/or mortality) and the prevention costs.

There are many different mechanisms for reducing the incidence of unsafe processes, i.e. of reducing probability P_{FSI}. Each of the aforementioned activities that affect the food safety outcome has an associated likelihood of falling out with ‘safe processes’ owing to stochastic or systematic breakdowns in food safety procedures. In turn, there is some cost associated with reducing this likelihood for each activity. A necessary condition for economic efficiency is probability P_{FSI} is reduced at least cost by surveying and appraising options vis-à-vis these activities. This is perhaps the rationale for co-regulation. I accept the argument that the traditional regulatory focus on rigid, inflexible legislation targeting only firm activities is unlikely to be efficient. But I also argue that a shift towards voluntarism should be tempered by an appraisal of the strategic interactions between agents. There are various types of systemic market failure that may occur.

The first occurs when the consequences of the actions of the various agents that determine the food safety outcome are known but the cause is not isolated to one agent, or similarly when the cause is known but mixing occurs. There can be an incentive for FP_{CHEAT} to ‘externalise’ the costs of food safety if the probability of being caught and the associated penalty are insufficiently high. Forms of regulatory intervention include increasing traceability and/or making compliance with food safety systems mandatory, and providing a sufficient incentive for FP_{CHEAT} to comply.

A second potential market failure occurs if there is potential for mistrust of a firm sending a food safety message as the recipient cannot determine with certainty the legitimacy of otherwise of the message received. Forms of regulatory intervention include expending greater resources on monitoring self-certified signals or requiring that all signals be externally accredited. An alternative might be to change the institutional context of firm decision-making by adapting tort and liability laws.

A third failure is a potential ‘network externality’ effect. This arises as the private ‘searches’ carried out by agents to find improvements in food safety technologies and techniques might be incremental in nature. This process of ‘searching’ and ‘selecting’ innovation options might preclude a more fundamental paradigm shift in behaviour that might lead to a more globally efficient solution. Such a paradigm shift may need to be identified and stimulated through state intervention.

If there is the potential for market failure, this does not mean that the aforementioned forms of regulatory intervention as corrective measures are necessarily economically efficient. In each case, the marginal social costs and marginal social benefits would need to be determined. What I contend however is that the argument that voluntarism and co-regulation are inherently efficient alternatives may be flawed.

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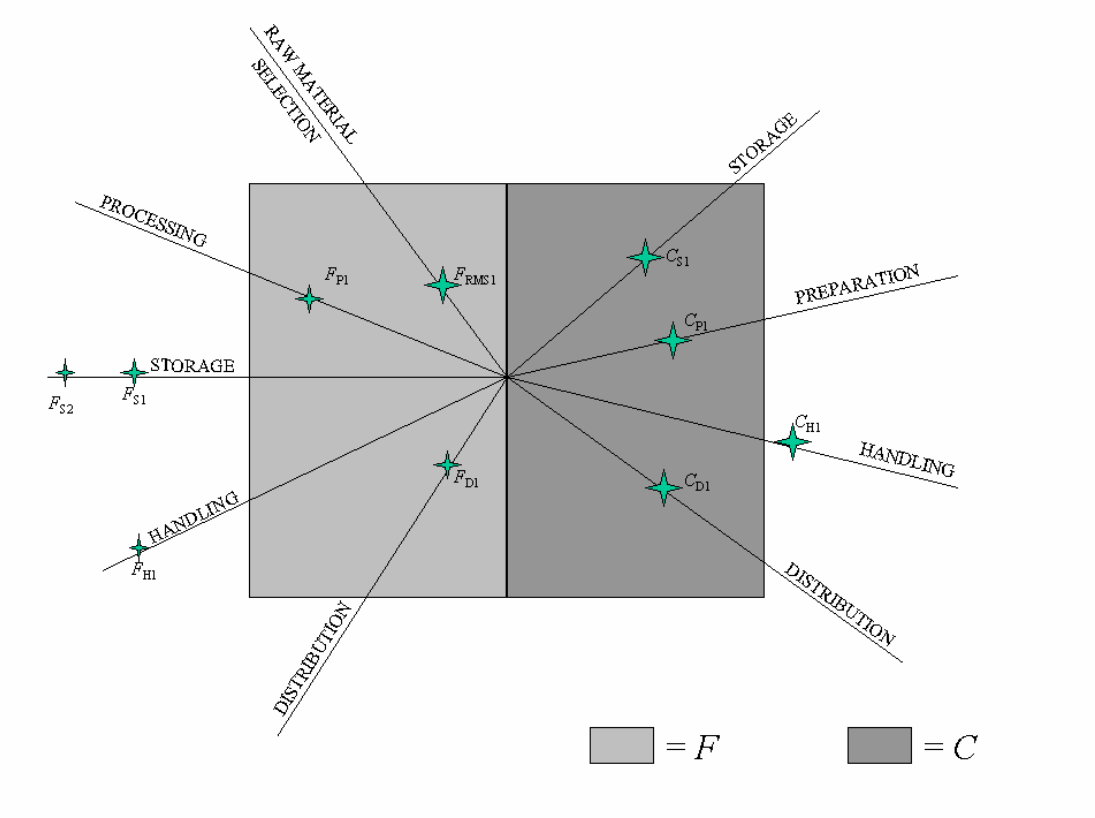


Figure 1 A schematic representation of food security

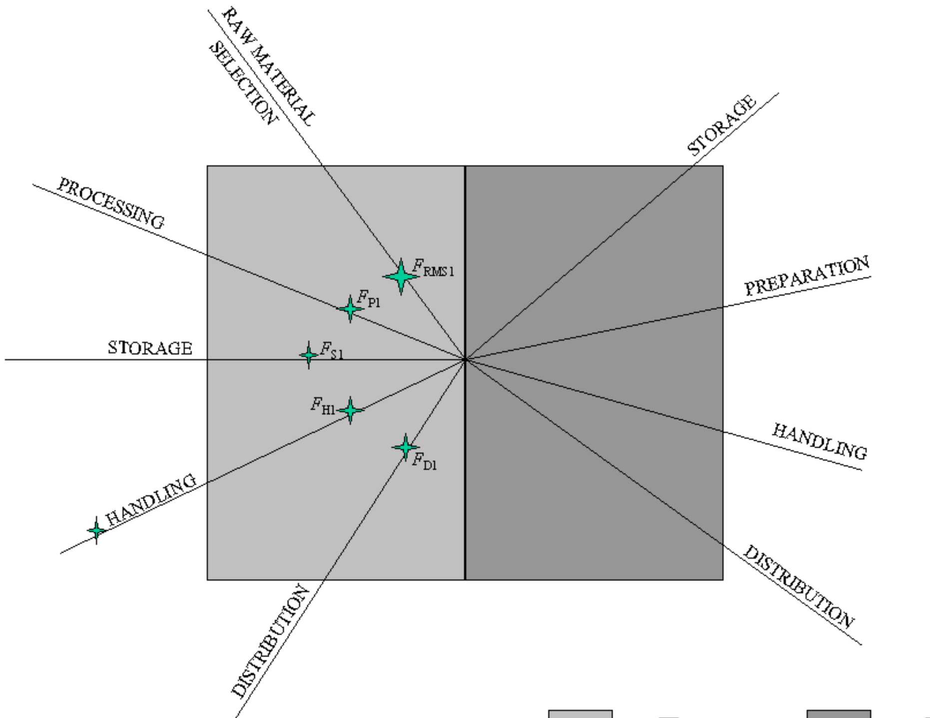
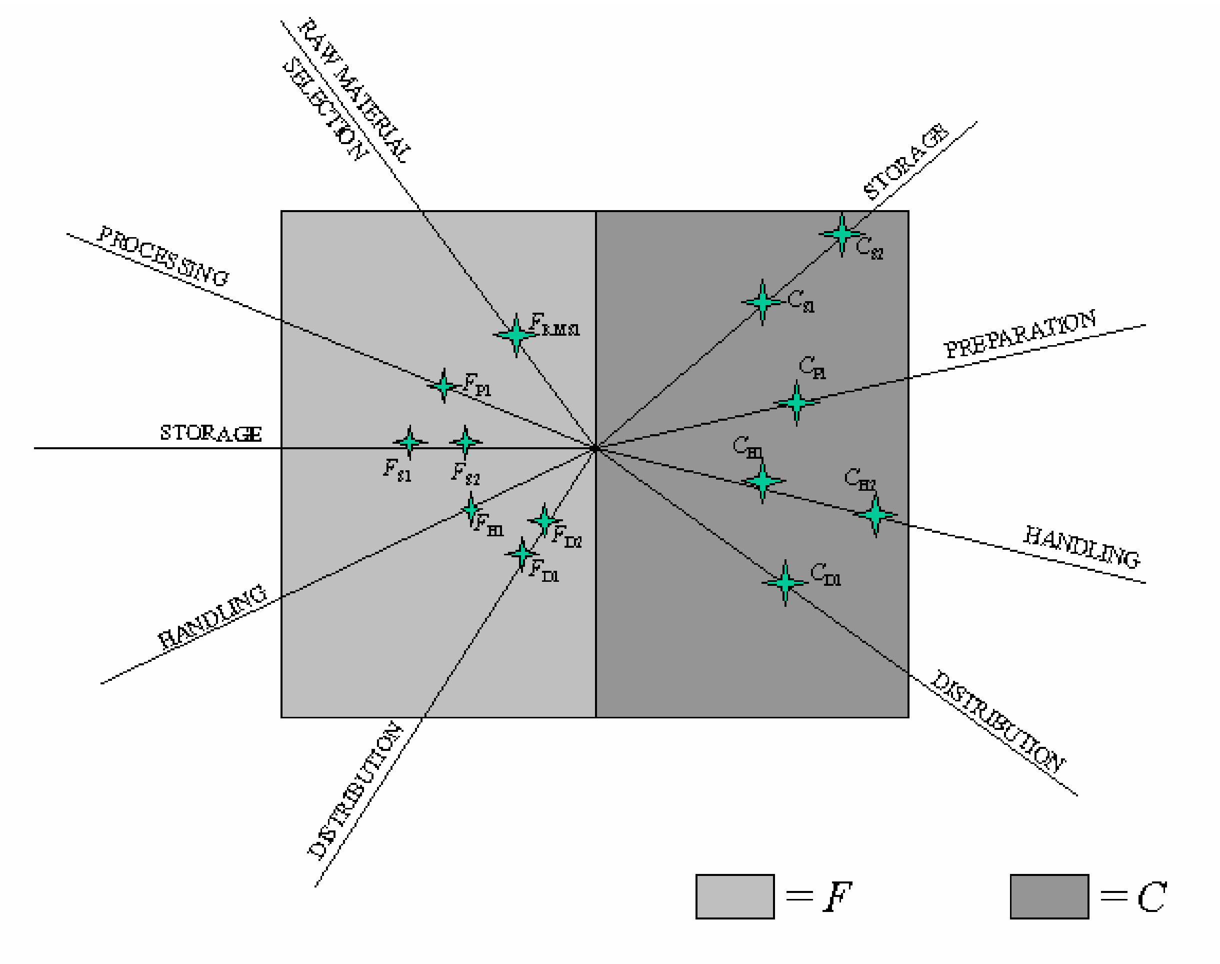


Figure 2 *Ex ante* regulation of firm activity

Figure 3 Endogenous risk



Agent	***Strategy*** ***Type A: consequences known but cause not isolated; cause is known but mixing occurs***
FP_{CSR}	Applies every reasonable effort to avoid being the source of such an outbreak
FP_{LAW}	Applies any effort that is either mandated by law for compliance purposes or is justified by profit estimates
FP_{CHEAT}	Prefers to ‘externalise’ the costs associated with risky food safety practices; only applies effort/incurs cost if the perceived probability of suffering direct financial penalty (through traceability) is sufficiently high
$CP_{\mathrm{PROACTIVE}}$	Searches for foodstuffs that are certified as being above compliance, e.g. quality assured
CP_{REACTIVE}	Assumes that regulation is adequate to ensure that food safety measures to combat this type of potential systematic failure are in place
$CP_{\mathrm{NEGLIGENT}}$	Assumes that regulation is adequate to ensure that food safety measures to combat this type of potential systematic failure are in place
REGULATOR	*Increase traceability and/or make compliance with food safety systems mandatory; sufficient penalty to provide private incentive for* FP_{CHEAT} *to comply*

Table 1 Strategic responses to System Failure Type A

Agent	***Strategy*** ***Type B: mistrust of the sender***
FP_{CSR}	Only ever sends signal that it believes it to be legitimate and informative
FP_{LAW}	Sends signal if it is profitable to do so *and* scientifically defensible
FP_{CHEAT}	Sends signal if it is profitable
$CP_{PROACTIVE}$	Actively searches for legitimate signal and might pay price premium
$CP_{REACTIVE}$	Might respond to signal depending on preferences
$CP_{NEGLIGENT}$	Any signal sent has little or no effect on purchasing behaviour
REGULATOR	*Potential economically legitimate intervention to expend greater resources on monitoring self-certified signals or to require all signals to be externally accredited*

Table 2 Strategic responses to System Failure Type B: mistrust of the sender