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The Prevention of White-collar Crime in the Food Sector. An Interdisciplinary Applied Research Approach

von

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1 Introduction: the problem of behavioural food risks

Food risks may be caused by *technological hazards*, i.e. by a genuine lack of knowledge about the effects of certain processes and substances or by safety breakdowns caused by (unintentional) human or technical failures. They may, however, also be caused by *moral hazard*, i.e. by opportunistic malpractice of suppliers who exploit the fact that their production activities as well as resulting product properties cannot be directly observed by buyers (*asymmetric information*). That is, the actions of suppliers as well as resulting product properties remain uncertain to buyers (be they food business operators or consumers) in the course of conventional market transactions. Taking the buyer's point of view, this fact of asymmetric information is sometimes described by the term *credence quality*. With asymmetric information, buyers run the risk of being deceived with regard to the quality category of products (quality risks). Moreover, they even run the risk to use or to consume substances which are harmful (health risks).

The probability that quality or health risks (here jointly referred to as "food risks") are caused by malpractice increases with the profits that can be earned through opportunistic behaviour (*white-collar crime*). However, while the probability of white-collar crime on the part of suppliers (and thus the imminence of *behavioural food risks*) can be conceptualized as varying with its expected economic benefits, there are different reactions to identical economic temptations because of different levels of *protective factors* in the social context – such as values, emotional bonds, peer groups, scenes etc. – that shield actors from deviant behaviour.

Despite a growing societal awareness of behavioural food risks, a systematic and interdisciplinary research programme has not yet been developed and applied to imminent white-collar crime in the food sector. Consequently, substantial knowledge gaps persist regarding suitable methods for the *early identification of food risks that might emerge due to human malpractice* as well as regarding an adequate design of proactive measures (*prevention*).

Designing effective measures against moral hazard requires comprehensive knowledge about how to enhance people‘s compliance with norms by way of *social engineering*. This requires an analysis of the respective action situations which includes economic incentives as well as social context factors. Up to now, *interdisciplinary applied research* did not get much of a chance due to differing disciplinary perspectives and knowledge gaps concerning the capacities of "other" disciplines. This is a particularly severe obstacle between formalized mathematical disciplines (e.g. microeconomics) and others which rely on qualitative approaches (e.g. criminology). In other words: efficient *systems analysis approaches* to human behaviour in the field of food production are impeded by the predominance of unilateralist approaches. Consequently, a full understanding of what it is that makes food business operators break (or not break) rules is still lacking.

The research approach outlined in this paper aims to mitigate this problem by combining the analytical powers of *microeconomics* (*game theory* and moral hazard approach) and *criminology* (*control theories* and protective factor approach). While differing widely in their methodical toolboxes, the involved disciplinary branches represent related streams of research in that they are fundamentally based on *methodological individualism*. This common conceptual framework facilitates cooperation across the disciplines without jeopardising the benefits of specialization. It enables analysts from both disciplines to design a joint research programme that avoids the common pitfalls of unilateralist approaches, i.e. the underestimation of the importance of social context factors that are intrinsically hard to quantify, on the part of economic analysts, and the underestimation of the power of economic incentives that can (and that need to) be quantified, on the part of criminological analysts.

Chapter 2 of this paper describes the game-theoretic moral hazard model used to analyse the economics of behavioural food risks. **Chapter 3** outlines the fundamentals of the control theories composing the theoretical backbone of the criminological analysis which looks for protective factors that make actors obey the rules in spite of contrary economic incentives. **Chapter 4** describes the common conceptual background of both disciplines and underlines the need for interdisciplinary research as well as resulting synergies. In **chapter 5**, in order to enhance intuition, the approach is applied to a realistic case from primary production where farmers might be tempted to infringe the waiting period after fungicide use. In **chapter 6** we conclude with an outlook on future research regarding white-collar crime in the food sector.

2 The economic approach: game theory, incentive analysis, and moral hazard

2.1 The game-theoretic background

Since the seminal works of BECKER (1968, 1982) who provided an explanation to norm-breaking behaviour in terms of neoclassical economic theory (i.e. by using neoclassical economics to explain areas of human behaviour usually considered outside the scope of economics), a wide strain of economic literature has evolved related to deviance. The microeconomic state of the art regarding problems associated with information imperfections, conflicting interests and opportunistic behaviour is characterized by an extensive game-theoretic literature on moral hazard and incentive problems which have also become known as principal agent (PA-) problems.[1] Moral hazard problems have been studied for quite a while and in a wide variety of contexts; to name a few examples: labour contracting (e.g. EPSTEIN 1991), insurance (e.g. ARNOTT and STIGITLZ 1991), delegation of decision-making (e.g. MILGROM and ROBERTS 1992), environmental crime (e.g. COHEN 1992), and finally transactions involving products with credence qualities (e.g. AKERLOF 1970; STIGLITZ 1987).

Moral hazard models are used to analyse the decision framework (i.e. rules of the game) and the incentives in action situations characterized by asymmetric information. They are likewise used to study how contracts should be designed in order to prevent opportunistic behaviour on the part of the better informed player. Moral hazard models assume that a less well informed principal and a better informed agent, who performs a task on behalf of the principal, have conflicting interests. While both maximise their utility, the principal – within the limits of his informational constraints – has the power to take account of the expected actions of the agent when designing the contract which he offers to the agent.

Research on contracting is riddled by the problem that economic decision-making takes place in complex environments where decisions on one level of interaction may be strongly influenced by decisions on superior or subsequent levels of interaction (multi-tier decision-making). Institutional game theory (HARSANYI and SELTEN 1988) and behavioural experiments (OSTROM and WALKER 2003) are common instruments in this complex domain of institutional research. Over the last decades extensive efforts have been made to create a meta-language and terminology for interdisciplinary analysis (OSTROM 1990 and 1999). Institutional economic concepts have in common that they are "actor centred" and that they analyse decisional behaviour in terms of multi-level games. At the same time they share the notion that decision situations must be analyzed as dilemmas of social choice in the presence of bounded rationality.

HENNESSY et al. (2003) take a comprehensive view on food safety and call for integrated systems analysis approaches. Providing a typology of different sources for the systemic failure in the provision of safe food, they state that misdirected incentives and malpractice are a major source of food risks. Tackling this behavioural risk, our microeconomic analysis focuses on contracts and incentives on the operational level of economic decision-making. That is, actors involved in market transactions are seen as designing contracts and reacting to contracts within a given institutional framework. From an institutional economist's point of view, research on contracting and governing structures that considers institutions as "givens" represents a short-term view. However, regarding the prevention of food risks, systematically searching for misdirected economic incentives in the actual contract and control system represents a long-term and proactive perspective that considers

[1] For a general introduction and overview of PA-literature see, for instance, FUDENBERG and TIROLE 1991, GROSSMANN and HART 1983, KREPS 1990, MIRLEES 1999, PRATT and ZECKHAUSER 1991, RASMUSEN 1994.

causal relationships and facilitates an early identification of (and timely reaction to) risks that might emerge due to self-interested malpractice.

The contracting context on the operational level is that of a supplier (agent) and a buyer (principal) of a raw material or (semi-) processed food product. Processing decisions made by suppliers affect the probability distributions of the product properties relevant for buyers (be they food business operators or consumers). Buyers, however, cannot contract contingent on actual actions because they cannot observe them (asymmetric information). Moreover, they cannot directly observe the product quality either. Price spreads for different quality categories (e.g. conventionally vs. ecologically produced food) as well as costs of compliance with mandatory regulations may be reasons why suppliers are tempted to break the rules.

The PA-perspective has been applied to a variety of food-related problems. However, being largely theoretical in nature, most studies do not focus on how to systematically gain and use empirical estimates for the parameters which define the game and the players' interests along the food chain. Instead they concentrate on the sophisticated modelling of differing specific aspects such as risk attitudes, stochastic production functions, suppliers' heterogeneity, output observability, inspection costs etc. Recent examples are OLESEN (2003) who analyzes contract production of peas with heterogeneous growers in a tournament system. DUBOIS and VUKINA (2004) look at the moral hazard costs associated with growers' risk aversion in livestock production contracts. HUETH and MELKONYAN (2004) consider the effects of supplier heterogeneity in fruit/vegetable and livestock production contracts. LIGON (2004) suggests a procedure to design efficient contracts that takes account of stochastic production functions (estimated from experimental agronomic data) and of suppliers' risk aversion.

Furthermore, a significant knowledge gap relates to the joint impact of food inspection intensity and of traceability on the incentives that are effective for suppliers. While a few authors consider the issue of partial inspection and/or of multiple agents (c.f. e.g. DEMSKY and SAPPINGTON 1984; FOX and HENNESSY 1999; HOLMSTRÖM 1979 and 1982; STARBIRD 2005), two essential characteristics of behavioural risks – the fact that quality can usually only be observed through random sampling inspections, and the fact that products cannot always be traced to their origins) – are still to be incorporated into applicable models in the food production context. To achieve adequateness and applicability, approaches are needed which are suited to the limited availability of empirical data and which facilitate the empirical assessment of the magnitude of misdirected economic incentives with reasonable efforts and costs.

In real life, numerous situations might exist where non-compliance with norms and contractual agreements on the part of suppliers is more profitable than compliance. This is the reason why preventive measures aimed at eliminating misdirected incentives are an important field of action for public authorities who try to reduce food risks on behalf of consumers through social engineering as well as for downstream food business operators who purchase inputs.[2] Pragmatic prevention requires knowledge based on (good estimates of) empirical data and realistic model calculations. That is, interested parties first need to systematically *assess behavioural food risks* (positive analysis) in order to identify those activities and places in food chains where deviance becomes a

[2] With regard to a proactive management of food risks, useful conceptual and methodical insights may be gained from the approaches to corporate controlling, systemic risk management, and, in particular, the development of early warning systems for firms (cf. HIRSCHAUER 2001). First-generation early warning systems are based on the *surveillance of operating figures* within the firm. Thus, they only facilitate the identification of problems (of a crisis) that have already come into existence in an early phase. Second-generation systems, in contrast, include the *monitoring of indicators* in the business environment. That is, they exploit causal relationships between relevant factors and a firm's economic success (critical success factors) and aim at providing additional time for reactions that prevent critical developments from becoming problems in the first place. Third-generation systems include the *scanning of, and graduated response to, "weak signals"* in the business environment that insinuate relevant long-term developments without clearly revealing them at this early stage of observation.

viable proposition to suppliers due to the fact that it is profitable. They then need to *manage behavioural food risks* (normative analysis), e.g. by designing incentive-compatible contracts. Incentive-compatible contracts work independent of moral attitudes because they eliminate economic temptations to infringe rules (misdirected incentives) and replace the need for *character trust* by *situational trust* (cf. NOORDERHAVEN 1996). However, reducing misdirected incentives by trying to improve contracts will regularly cause increasing marginal costs. Thus, some degree of economic temptation will persist in most situations – at least for some actors. This is where the problem solving capacity of trust, social capital (cf. ARROW 2000; COLEMAN 1988) and protective factors that mitigate the problem comes into play (see chapter 0).

2.2 The formal moral hazard model

With a view to empirical application, we develop an approach for the analysis of moral hazards in food chains[3] by resorting to a general discrete PA-model as found, for instance, in KREPS (1990: 577). The model assumes that an agent has opportunity costs μ (also called "reservation utility") for accepting a contract. After accepting, the agent has the choice between discrete actions $a_1, a_2, \ldots, a_N$ and corresponding efforts $k_1 < k_2 < \ldots < k_N$. In a stochastic environment, these actions result – with given probabilities ${}_{nm}$ – in discrete outputs $y_1 < y_2 < \ldots < y_M$. For these outputs the principal defines output-dependent remunerations $w_1 < w_2 < \ldots < w_M$. The agent's utility depends on his remuneration and effort ($u(w_m) - k_n$), where $u(w_m)$ represents a von Neumann-Morgenstern utility function. If the principal is risk-neutral, his design problem can be stated as the following constrained optimization problem:

Step 1: determine the minimum wage costs $w_{min}(a_n)$ for each possible action

$$\underset{w}{Min} \sum_{m=1}^{M} \pi_{nm} w_m = w_{min}(a_n) \tag{1}$$

$$s.t. \quad \sum_{m=1}^{M} \pi_{nm} u(w_m) - k_n \geq \mu \qquad \text{(participation constraint)} \tag{2}$$

$$\sum_{m=1}^{M} \pi_{nm} u(w_m) - k_n \geq \sum_{m=1}^{M} \pi_{n'm} u(w_m) - k_{n'}, \quad n' = 1,\ldots,N \qquad \text{(incentive compatibility constraint)} \tag{3}$$

Step 2: determine the maximum payoff over all actions a_n

$$\underset{a_n}{Max} \left(\sum_{m=1}^{M} \pi_{nm} y_m - w_{min}(a_n) \right) \tag{4}$$

The first step is to minimise – for each possible action – the remuneration costs of the contract that makes that specific action attractive to the agent (incentive compatibility constraint) and that induces him to accept the contract (participation constraint) in the first place. Second, the principal selects the action that maximises profits, given the necessity to support that action with the costly remuneration contract (cf. RASMUSSEN 1994; GROSSMANN and HART 1983).

The specific structure of PA-problems which is caused by asymmetric information and stochastic environments is illustrated by the fairly general problem formulation used above. While the meaning of model parameters varies with contexts, PA-models have the general capacity to provide valuable insights into the structure of many real-life incentive problems, including behavioural food risks. Thus, they can contribute to answering the fundamental question why firms in the food sector comply (or do not comply) with norms. However, empirical estimations of parameters such as prices, costs of compliance, frequency of control etc. are needed to provide intelligence for specific activities and transactions. That is, if model calculations are to facilitate practical conclusions, they must be simple enough to be "filled with empirical data" from the chain activity under investiga-

[3] For a detailed description of the formal model cf. HIRSCHAUER (2004).

tion. Bearing the applicability of the model in mind, a number of modifications are made to model (1) to (4).

1. Instead of using a generally discrete formulation, we reduce the model to a binary perspective. That is, we consider only two possible actions (a1 = non-compliance; a2 = compliance), two corresponding effort levels (k1 < k2), two outcomes (y1 < y2), and two remunerations (w1 < w2). The binary perspective allows us to estimate and use simple binomial distributions for stochastic variables such as outcome and remuneration.
2. Instead of accounting for risk aversion endogenously, we assume risk neutral principals and agents in model calculations. Therefore, optimal risk sharing will not be our concern here. However, due to a costly and incomplete output observation (see 5.) we still have the non-trivial problem of how to design an optimal control and remuneration scheme.
3. Instead of accounting for a positive reservation utility μ (i.e. the agent's opportunity costs) we assume a reservation utility of zero. This matches a situation where there are binding rules on how food processing activities have to be carried out: if the agent does not officially "participate", he does not have the choice to produce a lower quality category and to sell it at a lower price, but has to refrain from production altogether.
4. Instead of accounting for a principal who maximises his utility by selecting the agent's optimal action and effort level, we assume that the principal (regulator) knows a priori that his maximum utility results from compliance (i.e. the higher effort level) on the part of the agent. Therefore, he is pre-determined to induce compliance and only strives to do so at minimum (budgetary) costs. Hence, the second step of the optimization can be omitted and the principal's problem is reduced to cost minimization for action a_2.
5. Instead of assuming that the output can be verified without costs, we take the characteristics of the food risk problem (credence qualities) into account and consider that observation is costly and that it can only take the form of random sampling inspections carried out with a control intensity $s \leq 100$ %. This results in incomplete output information.
6. The standard PA-model does not account for multiple agent settings. Incentive problems resulting from incomplete output information will be aggravated if identified properties cannot be retraced to a single upstream supplier. We consider such situations which are frequently found in food chains by accounting for a limited traceability $z \leq 100$ %.

Instead of simply reformulating the model for these modifications, we turn to its explicit food risk interpretation and a handier notation for the binary incentive problem (see table 1).

Table 1: Notation for the binary food risk model

w_1	=	$-S$	: sanction (loss) inflicted on the agent if the undesired/hazardous quality y_1 is detected
w_2	=	P	: price paid for a product of the desired quality y_2
k_2-k_1=k_2	=	K	: agent's cost of compliance with regulations
π_{11}	=	r	: probability of undesired product quality y_1 in case of non-compliance (i.e. action a_1)
π_{12}	=	1-r	: probability of desired product quality y_2 in case of non-compliance (i.e. action a_1)
π_{22}	=	q	: probability of desired product quality y_2 in case of compliance (i.e. action a_2): $q > 1-r$
π_{21}	=	1-q	: probability of undesired product quality y_1 in case of compliance (i.e. action a_2)
		s	: intensity (frequency) of random controls ($0 < s \leq 100$ %)
		z	: probability that responsible suppliers are traced ($0 < z \leq 100$ %)

In table 1 we replaced k_2-k_1 by the costs K of compliance. It is unrealistic to assume that food business operators produce the unauthorized quality at cost $k_1 = 0$. For the sake of simplicity we normalise k_1 to zero and avoid having to carry an extra variable through the analysis without impeding the general insights into the structure of the problem. A consideration of $k_1 \neq 0$ in applications will be easy.

Abstracting at first from incomplete inspection and traceability and following the binary notation of table 1 the principal's minimization problem may be restated as follows:

$$Min\, w(a_2) = Min\big(-(1-q)S + qP\big) = Min\big(P - (1-q)(P+S)\big) \qquad (1')$$

$$s.t.\ w(a_2) - k_2 = -(1-q)S + qP - K = P - (1-q)(P+S) - K \geq 0 \qquad (2')$$

$$w(a_2) - k_2 - w(a_1) = -(1-q)S + qP - K + rS - (1-r)P = (q+r-1)(P+S) - K \geq 0 \qquad (3')$$

In the next step we need to account for incomplete inspection and traceability. Prohibitively high costs of complete inspection (e.g. because the product is destroyed by testing) force the principal to resort to partial and random controls. Control intensities $s < 100$ % result in incomplete information about the relevant output (i.e. product quality). The limited traceability problem arises whenever an undesired product quality cannot be traced back to a single seller out of the many in a supply chain. This is regularly the case if the principal is dealing with multiple agents without having established an absolutely reliable traceability system.

Table 2: Output and remuneration probabilities

	output probabilities for ...		remuneration probabilities for …	
	y_1	y_2	$w_1 = -S$	$w_2 = P$
a_1 = non-compliance (low effort)	r	$1-r$	szr	$1-szr$
a_2 = compliance (high effort)	$1-q$	q	$sz(1-q)$	$1-sz(1-q)$

Both a control intensity s < 1 and a traceability coefficient z < 1 change the expected remuneration for non-compliance w(a1) as well as for compliance w(a2). Independent of the agent's action or the product quality, the principal has to pay P whenever the quality is not ascertained or cannot be ascribed to a single agent. The agent can at best be made to pay a sanction S if the undesired quality y1 is evident and clearly due to his making. Contrary to complete inspection and traceability where output probabilities coincide with remuneration probabilities, partial (sampling) inspection and limited traceability entail remuneration probabilities according to table 2. If we additionally consider the control costs depending on the intensity c(s), the costs for achieving different levels of traceability c(z), and the costs for imposing sanctions c(S), the principal's incentive problem needs to be restated as follows:

$$Min\, w(a_2) = Min\big(P - sz\cdot(1-q)\cdot(P+S) \quad + \quad c(s) + c(z) + c(S)\big) \qquad (1'')$$

$$s.t.\ \ w(a_2) - k_2 = P - sz\cdot(1-q)\cdot(P+S) - K \geq 0 \qquad (2'')$$

$$w(a_2) - k_2 - w(a_1) = sz\cdot(q+r-1)\cdot(P+S) - K \geq 0 \qquad (3'')$$

$$0 < sz \leq 1$$

While there are only few parameters to be considered in the model, their empirical estimation still represents a formidable task. It is not trivial, for instance, to define different control alternatives and to provide their cost estimates (let alone intensity-dependent control cost functions c(s) for different control systems and technologies). It is even more daunting to provide reliable estimates for the costs of increasing traceability or for imposing increased sanctions. In the case study in chapter 5, we therefore limit the investigation to the assessment of behavioural risk (positive analysis). However, we do not try to optimise the system as a whole. Technically speaking, we estimate the parameters K, q, r, s, z, P, and S, and then use equation (3'') to quantify the incentives in force. That is, we simply answer the question whether it is more profitable to break the rules than to comply with them in the analyzed situation.

3 The criminological approach: control theories, social context analysis and protective factors

Since Sutherland coined the expression of (and directed the attention of criminologists to) “white-collar criminality” in 1939 (cf. Sutherland 1940, 1949, 1979), the question why respected members of the professions and/or, respectively, “Why businessmen violate the law” (Lane 1953) has become an integrated part of the criminological discourse. The original concept of white-collar crime has given rise to a number of conceptual differentiations such as between *professional*, *corporate,* and *occupational* or *workplace* crime – the latter including phenomena such as *employee fraud, employee theft* and others. Attention has also been drawn to *official* deviance as a category which includes topics such as corruption, abuse of political power or police transgressions. This surge of interest in *repressive crime* and *crimes of the powerful* has been complemented by the contemporary focus on *crimes of the middle class*. Thus, the picture of theory and research in this field is not quite as bleak anymore as it used to be for a long time due to a kind of benign neglect from the parts of both the discipline of criminology and the law enforcement agencies and their traditional focus on the lower (sometimes called “dangerous”) classes.

Current introductory textbooks (FRIEDRICHS 2003, GEIS et al. 1995, SHOVER and WRIGHT 2001; SIMON 2002) and research anthologies (MAUL et al. 2003) show quite a lively scenery of dissipated and still fragmentary, but often insightful analyses and stimulating hypotheses about unlawful behaviour of organizations (VAUGHAN 1982) and of those employed within them. To a certain extent, theoretical preoccupations which mark the contemporary state of the art of general sociology like, for instance, the establishment of the micro-macro link have also attracted criminological attention (VAUGHAN 1992).

This change of focus cannot be understood without reference to the more fundamental development of the criminological perspective. In the most concise way one could describe this development as one leading away from the question why people *break* to why people *obey* the law (HESS and SCHEERER 2004, TYLER 1990). This, in turn, is a result of the fact that the criminological state of the art is being increasingly characterized by so-called control theories of deviance (HIRSCHI 1969, TITTLE 1995, 2000). This type of theory conceptualises deviance neither as an expression of individual pathology nor as one of mere ascriptions, but as a social fact the emergence of which is due to the inevitability of gaps within the system of formal and informal social control (GOTTFREDSON and HIRSCHI 1990).

The use of the word “gap” illustrates that, in a normative analysis, criminologists will regularly take the social engineering perspective. That is, they will look for ways to enhance the effectiveness of legal norms. This includes the attempt to influence societal norms (protective factors) which make people obey the law in spite of contrary economic incentives. This perspective of “protective factors” has proven to better fit with empirical findings than former ones and to produce good results in traditional criminological research areas (e.g. HOSSER 2001). Correspondingly, there has been a renewed interest in value orientations with regard to breaking and/or obeying the law (HERMANN 2003).

The more specific potential of control theories, i.e. to look for effective bonds to societal norms which induce people to conform in spite of contrary incentives, still has to be fully activated with regard to white-collar delinquency as well as empirical research in this field. This applies especially with regard to white-collar delinquency in food production. While OPP (1983) looked into the subject in note form, there seems to be no systematic empirical research to speak of that address this issue from an explicit control theories perspective.

Ethnographic perspectives with regard to deviant behaviour could also contribute important insights. They would be especially useful in cross-cultural studies using concepts of “comparative deviance” (NEWMAN 1976) and “cultural criminology” (PRESDEE 2004). Regarding malpractice in the food sector, this allows, for instance, the analysis of differences of economic and administrative cultures (including lobbying) between different countries on the one hand and cross-border mobility of food and related food hazards on the other hand. Thus, socio-cultural and economic backgrounds

of the relevant settings can be investigated together in a cross-national comparison. This will, for instance, be facilitated by the existence of useful recent work on law-breaking behaviour in a European context the methods and results of which allow for the formation of strong working hypotheses (ALBRECHT and ENTORF 2003).
As a pragmatically oriented science, criminology does not only investigate the causes of crime and delinquency – and, more recently, the determinants of obedience to the law – but also the factors which contribute to effective prevention and/or law enforcement, respectively. In contrast to former approaches focussing almost exclusively on general deterrence, more recent work has been featuring more structural and persuasive forms of control. This shift of emphasis is part of a more general widening of the perspective, which has led from an exclusive focus on the criminal law as a means of preventing law-breaking behaviour to a more encompassing view of different means of social control and their relative merits (BRAITHWAITE 1985). Instead of narrowing the attention to alleged personality disorders or character deficiencies of individual actors which would supposedly make them crime-prone, and instead of insisting on a counterfactual belief in general penal deterrence as the best means to make people refrain from otherwise tempting violations of legal norms, the criminological discourse has become aware of the decisive relevance of situations and, correspondingly, of situational crime prevention. This implies the attempt to use the largely untapped resources of "smart controls" involving rather "soft", but complex and often highly effective means of corporate regulation (for situational approaches see BLACK 1997, FELSON 1998, CLARKE 1992; for corporate regulation see BRAITHWAITE 2003).

4 The joint conceptual background and the synergies of interdisciplinary research

Micro-economists study human decision-making in a world with limited resources. They explore how individuals, firms, and other organizations make choices, and how these choices determine the way the resources of society are used and distributed. In recent years, neoclassical economists have included game-theoretic concepts and even undertaken laboratory experiments aiming to investigate strategic decision making. Game theory is the study of situations involving competing interests and cognitive constraints, modelled in terms of the strategies, probabilities, actions, gains, and losses of opposing players in a game. Micro-economists are to be classified as methodological individualists. While focusing on individual choice, they have adopted the concepts of imperfect information, bounded rationality and opportunism as well as multidimensional objectives. That is, the extended neoclassical conception of decision-making leaves behind the unrealistic assumption of man who is exclusively profit maximising (i.e., who has a single objective and whose utility depends on monetary pay-offs only) and completely rational (i.e., who has neither informational nor cognitive constrains).
Social psychologists are very close to neoclassical micro-economists in that they, too, focus on the individual. While adopting the concept of choice (cf. e.g. JOHNSON and PAYNE 1986), they put – compared to economists – more emphasis on the individual's behaviour depending on his social context factors and intrinsic motivation. That is, social psychologists focus on examining the social settings, patterns of interaction and corresponding value system which influence the behaviour of the individual. In the field of crime and delinquency, *criminologists* can also be seen as social psychologists understanding deviance as a result of behavioural strategies of coping with personal goals (cf. KAPLAN 1995) and with strain (cf. AGNEW 1992, 1999). This can be linked up with the fact that, in modern criminology, the conception of man, while not being based on classical "homo oeconomicus", is based on the rational choice paradigm as specified by the so-called RREEMM model of man. That is, the human actor is being conceptualized as "resourceful, restricted, expecting, evaluating and maximizing man" (cf. ESSER 1999: 237-239). It can also be linked up with the above-mentioned control theories which conceptualise an individual's behaviour as a result of reasoned action based on (economic) motives and the framework of formal and informal social control.

The overall conceptions of modern economists and micro-level criminological analysts, are quite similar in that they assume that purposive action[4] in conjunction with the individual's social context factors are responsible for his behaviour. The criminological conception based on the control theories, while certainly focussing on different aspects, fits very well with the modern concepts of bounded rationality from microeconomics, information economics and game theory. However, this is not yet fully realized by all members of the two disciplines.

The fact that the two approaches focus on different aspects of the actor's attributes and decision framework may nonetheless lead to a different perception of empirical facts. This may be enhanced by their respective affinity to either highly mathematical or purely qualitative methodical approaches. Thus, economists may underestimate the influence of social context factors (that are intrinsically hard to quantify) because they mainly try to quantify economic incentives and treat social context factors merely as constraints or subordinate objectives. In other words: Even the extended neoclassical model of the human actor may be still too "thin" to explain behaviour in complex decision-situations, especially those involving reciprocity and trust (cf. OSTROM 2003). The reverse, that is, the risk to underestimate the power of given economic incentives (that can, and need to be, quantified) may arise in a purely criminological approach. Such misconceptions are a fatal flaw to both disciplines in the investigation of social action and problems involving transactions, trust and deviance (e.g. white collar crime in general, moral hazard in food chains, drug traffic, environmental crime etc.).

The limitations resulting from the prevalence of certain perspectives as well as from methodical limits within unilateralist approaches – be they microeconomic or criminological ones – show that the understanding of what it is that makes people choose or not choose certain actions could be improved through integrated systems approaches which include relevant perspectives and disciplines. That is, with regard to social dilemmas, interdisciplinary approaches which combine the economic and the social perspective are needed to allow an understanding of social actions as well as their conditions and consequences in any particular context. This is the precondition for an adequate reconstruction of human behaviour and for purposeful social engineering (cf. Popper) which fulfils the social sciences' claim to social utility and provides their legitimation through desirable policy outcomes (cf. WALLERSTEIN et al. 1996).

It seems that with regard to behavioural food risks a lot of useful knowledge could be gained by combining the analytical power of economics with that of criminology. On the one hand, the formal models derived from game theory allow for a quantitative analysis of (the magnitude of) misdirected economic incentives. On the other hand, the criminological insights gained from the control theories allow for a qualitative reconstruction and structured understanding of protective factors which make actors comply with norms in spite of contrary economic incentives. Synthesising the two disciplinary results facilitates the early identification of risks and critical points according to the behavioural rationale that offences are imminent if (significant) misdirected economic incentives coincide with missing protective factors.

Consequently, in a normative social engineering perspective, the question can be answered which variables can and should be changed in which way by which stake-holders (i.e. corporate buyers, public authorities, associations, consumers) in order to reduce the probability of opportunistic behaviour. Through the interdisciplinary approach, economic and social findings can be considered simultaneously. This facilitates the design of a consistent set of complementary measures. In this context, search for consistency implies trying to avoid that progress in one field (e.g. reduction of misdirected economic incentives through increased controls) is thwarted by drawbacks in others (e.g. decreasing social acceptance of rules by control-averse agents). That is, in an interdisciplinary

[4] The term "rational" is often associated both with the absence of informational and cognitive constraints as well as with purely self-interested decision-making. We use the term "purposive" to describe the assumption that an individual, while having multidimensional objectives (including intrinsic motivation) and while being only boundedly rational, makes a deliberate choice and attempts to do as well as possible.

approach, the cooperating disciplines can align their respective conclusions and recommendations through a permanent feed-back and adjustment process that avoids the pitfalls of narrow disciplinary views and that captures the complexities of real-life decision-making. This includes, for instance, dysfunctional effects of increased controls which might arise if agents are control-averse.

5 The case study: the situational incentives for farmers after fungicide use

5.1 The situational background

Grain farmers regularly apply a last dose of fungicides approximately five to six weeks before harvesting. Applied products are labelled for control of fungal infections which could otherwise significantly reduce the quality and quantity of harvested grain. Under certain weather conditions, profit maximising farmers might be tempted to breach the minimum waiting period of 35 days. This is particularly tempting if, a few days before the end of the waiting period, the weather is ideal for harvesting, whereas a long period of rain is expected afterwards.

The individual farmer's incentives depend on the contract, i.e. the overall conditions of the transaction including control and tracing activities on the part of the buyer. The contract details reflect the quality requirements of the grain buyer as well as the degree of trust he puts on the farmer. Since contracts are never completely enforceable (e.g. due to costly controls), farmers are left with opportunities to exploit the information asymmetry (hide rule-breaking behaviour) and to take advantage of the non-contractibility.

Aiming to illustrate the general approach of a moral hazard analysis, we use stylized facts from a case study instead of collecting data in an extensive survey. The farmers who participated in the case study sell their wheat to a local corn dealer who takes and stores samples from all individual trailer loads, tests them for their technological qualities (humidity, protein content etc.) and differentiates prices for different quality categories. However, before testing for pesticide residues, the corn dealer blends the "loads" from different farmers into "batches" according to the specific quality requirements of his downstream trading partners.

Because residues are thus monitored at downstream control points only, farmers might be tempted to infringe the waiting period. Infringements are only detected if blended batches exceed the tolerance standards. This is only the case if a critical number of farmers break the rule. Otherwise, free-riding farmers stay undetected since residues resulting from their premature harvest are "sufficiently" diluted. That is, *actual tracing* does not take place although complete *ability to trace* is assured through stored individual samples. In other words: the free-riding opportunity arises precisely because the confided group appears trustworthy on the whole, but is in fact (morally) heterogeneous. Despite a complete ability to trace, and even if 100 % of blended batches are monitored, there is only a small probability that the harmful behaviour of a minority of shirking farmers triggers the testing of stored individual samples. Technically speaking we might say that the free-riding problem "moves the distribution of the unwanted quality to the right".

5.2 The farmers' situational decision parameters

The economic parameters determining the farmers' incentive situations were assessed in oral interviews with three farmers in a grain producing area in the federal state of Brandenburg, Germany (see table 3). Additionally, the local corn dealer was asked to appraise the situation. Information is uncertain, and resulting data give evidence of the individual perception of the parameters. Since only a limited number of discrete data can be gained in a survey, the interviewees were asked to assess the economic parameters for four discrete types of weather, implying, in turn, four different "technologically optimal" harvest dates: 10 days, 6 days and 2 days prematurely (i.e. before the end of the waiting period) as well as an optimal harvest date after the expiration of the waiting period. The term "technologically optimal" implies that, in the absence of a prescribed waiting period, a farmer would harvest because he expects losses due to a reduced quality, and/or quantity, and/or increased costs for any posterior date.

Table 3: Parameters determining the profitability of shirking as perceived by interviewed farmers

	x-days	parameter	Farmer A	Farmer B	Farmer C
1) probability that the farmer exceeds the residue limit in his individual load if he harvests x-days before the end of the waiting period	10	*r*	15 %	95 %	33 %
	6	*r*	5 %	50 %	20 %
	2	*r*	0 %	0 %	0 %
	0	*1-q*	0 %	0 %	0 %
2) the farmer's probability of being detected if his individual load exceeds the residue limit		*s*	5 %	50 %	5 %
3) losses in sales and additional costs (€/ha) if the waiting period is met in spite of weather conditions making it optimal to harvest x-days prematurely	10	*K*	200	260	200
	6	*K*	100	130	100
4) losses in sales (€/ha) if non-compliance is proven		*P*	984	984	984
5) "sanctions" (€/ha) if non-compliance is proven		*S*	1 100	20 750	13 375
thereof: - short-term sanctions (fines, damages, …)			350	20 000	13 000
- capitalized long-term losses in the market			750	750	375
6) probability that the farmer can be traced		*z*	100 %	100 %	100 %

Ad 1): although none of the farmers had access to results of scientific tests concerning the decomposition of fungicides, they all agreed that there is no risk of exceeding the tolerance standard if they comply with the waiting period of 35 days. Trusting that a safety margin had been built into the prescribed waiting period, they also agreed that harvesting two days early would still involve a zero probability of exceeding the limit. According to this perception, a 2days-infringement of the waiting period has the same results as compliance (r = 1-q = 0 %). The farmers' assessments of the decomposition process before that date differed widely, however. Farmer A, for instance, estimated that the probability of exceeding the limit would rise to 5 % (15 %) in the case of a 6days- (10days-) infringement. In wide contrast to that, farmer B, for instance, believed this probability to rise to 50 % (95 %).

Ad 2): in the considered situation, the parameter *s* represents the aggregate "probability of being detected" if the individual load has exceeded the residue limit. This probability results from the joint effect of two components: (i) the control intensity (i.e. percentage of blended batches which are controlled), and (ii) the dilution effect caused by the fact that loads from different farmers are blended before being tested for residues. All farmers ignored the actual control intensity. They had no information as to whether all blended batches are inspected, or whether only random controls are being made. They likewise ignored the details responsible for the physical dilution effect.[5] However, their ad hoc estimations differed widely with regard to the overall effect of these two

[5] Explicitly determining the "physical dilution effect" requires expectations concerning one's own share in a blended batch, the residue levels in individual loads depending on the harvesting decision, and the behaviour of other farmers whose loads are part of a blended batch.

factors, i.e. the probability that an infringement would be detected if their individual load has exceeded the limit.

Ad 3): reduced sales resulting from suboptimal harvest dates are treated as opportunity costs forming the major part of the compliance costs *K*. Expected losses resulting from technologically suboptimal harvest dates are mainly due to a threatening decline of quality which could force farmers to sell their wheat as animal feed grain at 80 - 90 € per metric ton, instead of food grain at 110 - 120 € per ton. If it is technologically optimal to harvest 10 days before the end of the waiting period, the three farmers expected an almost certain loss of sales of 175 - 210 € per hectare (or 25 - 30 € per ton) due to the degradation of grain to feed quality. If there is a technological optimum for harvesting 6 days prematurely, they commonly expected the loss to occur with a 50 % probability only. Besides these opportunity costs, farmers estimated machinery costs to increase by 25 - 50 € per hectare if they were to harvest 10 days later than optimal, and by 12.5 - 25 € per hectare if they were to harvest 6 days later than optimal.

Ad 4): the three farmers are convinced that they would completely loose their income from wheat sales (including EU-subsidies) of P = 984 €/ha if non-compliance was detected. The farmers' perception that – besides sales – transfer payments would be lost can be seen as a positive result of the EU joint compliance approach that enhances incentive compatibility.

Ad 5): farmers estimated that they would have to pay an equivalent of 350 - 20 000 € per hectare in direct sanction payments such as fines, damage compensations etc. Farmer B's and farmer C's perception of comparably very high sanctions is mainly due to their understanding that they could be forced to pay damage compensations for large amounts of grain if these were contaminated by their individual load. In addition to these short-term sanctions, farmers assumed that their capitalized future disadvantage on the market (loss of negotiating power) would amount to 375 - 750 € per hectare of wheat.

Ad 6): farmers agreed that the traceability z amounts to 100 % due to the fact that samples are taken and stored from the individual farmers' loads.

5.3 The farmers' incentive situations

Table 4 demonstrates the incentive situation which – according to (3'') – results from the farmers' perception of the relevant parameters in force. Results are indicated for the two weather types that favour most premature harvest. We did not endogenously account for risk aversion. Besides avoiding the problem of having to empirically estimate risk utility functions, this is the due approach since risk attitudes are considered exogenously by the very way data were obtained: risk-averse farmers implicitly increased cost-benefit ratios when answering questions with regard to decision parameters (i.e. risk premiums are deducted already).

Table 4: Economic inferiority (–) / superiority (+) of complying with the waiting period according to the perception of the present decision parameters by interviewed farmers (€/ha)

weather type	technologically optimal harvest date	Farmer A	Farmer B	Farmer C
I	10 days premature	– 184	+ 10 064	+ 39
II	6 days premature	– 95	+ 5 304	+ 44

Only farmer A perceives an economic reason to infringe upon the waiting period. His actual behaviour in the light of such a temptation is not known. Using the parameters for weather type I as they have been assessed by the farmers, we identify – by using (3'') in a critical value analysis – which change of contract conditions (sanction, control intensity) would c.p. ensure/maintain incentive-compatible contracts. It should be noted that, in the example under consideration, the participation constraint (2'') does not need to be accounted for in the critical value analysis. In contrast, it is possible to design "boiling-in-oil-contracts" (cf. RASMUSEN 1994: 180) since the

probability of the desired product quality for complying farmers is $q = 1$. Thus, they are neither affected by increased sanctions nor by intensified controls. Increasing the price would nonetheless be a way to reduce the temptation to break the rule. Paying a higher price, however, directly increases the costs of the buyer. This makes only sense if it is not viable or very costly to increase sanctions and/or control intensities.
Examples of contracts which get the incentives "right" for weather type I and which replace the need for "character trust" by "situational trust" are given in table 5 for each of the three farmers.

Table 5: Incentive-compatible contract alternatives for weather type I

	Farmer A	Farmer B	Farmer C
critical sanction with retention of the present system of downstream controls (blended batches)	25 683 €/ha	no sanction needed	11 016 €/ha
critical sanction after introduction of complete upstream controls (individual loads)	349 €/ha	no sanction needed	no sanction needed
critical control intensity of individual loads with present sanctions: A: 1 100 €/ha, B: 20 750 €/ha, C: 13 375 €/ha	64 %	1.3 %	4.2 %
critical control intensity of individual loads with assumed sanctions: A: 2 200 €/ha, B: 41 500 €/ha, C: 26 750 €/ha	42 %	0.6 %	2.2 %

If the system of downstream controls is maintained and if weather type I occurs, the sanction as perceived by **farmer A** would need to be increased from its present level of 1 100 € to over 25 000 € per hectare in order to eliminate his 184 €-per-hectare temptation to break the rule. Since it does not seem to be realistic to assume that the principal succeeds in making the farmer perceive the sanction to be at this level, we consider the effects of applying controls to the individual loads. To do so is equivalent to replacing downstream control points (blended batches of grain) by upstream control points (individual loads of grain), thus eliminating the dilution effect and raising the probability that an objectionable load is detected from the perceived level of $s = 5$ % to 100 %. With complete controls of individual loads, a sanction of approximately 350 € per hectare would suffice to eliminate misdirected economic incentives for farmer A. Alternatively, in accordance with the presently perceived sanction level of 1 100 € per hectare, a control intensity of 64 % would suffice if individual loads were being analysed.
Considering **farmer B and C** reveals that, due to information uncertainties, the incentives "in force" are in the eyes of the beholder. Farmer B, for instance, in contrast to farmer A, clearly perceives no economic temptation whatsoever to break the rule, mainly because he believes economic losses resulting from detection to be very high. Thus, after applying controls to individual loads, a control intensity of roughly 1 % would suffice to generate incentive compatibility in the case of farmer B.
The **corn dealer's** view of the farmers' incentive situation is not depicted in table 4. It is summarized briefly: he believes that, in the present system of downstream controls, a shirking farmer's risk of being detected is almost zero due to the dilution effect. Knowing the approximate level of the other relevant parameters (sanctions, costs of compliance etc.), the corn dealer is convinced that situational incentives are indeed not "right". However, according to his interview statement, he relies on character trust with regard to his farmers. This statement triggers the question whether he is really motivated to act as a "responsible principal". Responsible principals would indeed act on behalf of the entire downstream chain and introduce behavioural risk management systems in order to design incentive-compatible contracts for their purchasing transactions. The "making of responsible principals" requires that they are forced, in turn, to

internalise societal costs resulting from downstream diseconomies and finally from consumers' exposure to increased residue levels. [6]

Abstracting from individual particularities, we can finally generalise from the last row of table 5 that increasing the sanction level allows for a decrease of the control intensity without compromising the incentive compatibility. There is an optimal combination to be found which obviously depends on the costs of analytical controls on the one hand, and the costs of increasing effective sanctions (lawyers, lobbying for sanctions etc.) on the other hand.

The essence of this case study can be pictured through a typology consisting of two extreme- and one mixed-type decision-maker. We arrive at these three types by distinguishing between "character trust" and "situational trust": (1) on the one extreme is the farmer who is utterly trustworthy. Because of his personal set of preferences he resists every economic temptation to break the rules. (2) On the other extreme is the farmer who is only trustworthy if, given his exclusive objective of maximising profits, the perceived situational incentives of the contract are "right". (3) Between these two extremes is the mixed-type farmer who accepts a certain profit trade-off in exchange for a personal feeling of moral integrity resulting from his decision to abide by the rules. He might yield to rule-breaking behaviour, however, if the additional profits to be gained exceed his personal resistance.

It is common sense to assume that real decision-makers are of mixed-type. They are likely to differ, however, with regard to their personal resistance to economic temptations, i.e. the level of protective factors that are effective. The existence of protective factors and differences regarding their effectual level are the reason why criminology comes into play which systematically analyses formal and informal mechanisms of social control.

Taking into account that economic parameters may differ from one agent to the other and that they are seen through the eyes of the beholder, some farmers may perceive economic temptations to break the rules; others may not. Amongst the former some may break the rules; others may not. Only these rule-breakers cause a problem from a preventive point of view. Finding both adequate and cost-efficient measures of prevention is not easy. For one thing, every buyer (principal) will have great (or even insuperable) difficulties to gain information about how heterogeneous individual suppliers (agents) assess the relevant parameters. An even greater obstacle will be to gain knowledge about their individual character and resistance to economic temptations. Furthermore, even abstracting from the possibilities and the cost of gaining this information, designing individual contracts for transactions with agents that are heterogeneous in many aspects may itself be terribly costly. Hence, the only way for practical prevention seems to be "to march pragmatically in the right direction". This implies to decrease misdirected economic incentives by increasing the levels of those parameters (or more correctly: their perception) that promote compliance. However, as has been mentioned before, some level of misdirected economic incentives – at least for some actors – will persist in most situations due to the increasing marginal costs of increasingly complete contracts. That is why the structural decrease of misdirected economic incentives has to be complemented by measures ("smart controls") that enhance the effectiveness of protective factors which shield the actors from yielding to economic temptations that are inevitably left.[7]

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[6] There is a growing scientific understanding that food-borne health problems cannot be excluded by simply guaranteeing tolerance standards with regard to hazardous agents. In most cases, even exposure to low levels of these substances is detrimental. Furthermore, these levels are always subject to stochastic influences. Hence, business operators must be made to choose the right procedures which "move distributions of unwanted qualities (e.g. toxin levels) to the left", instead of simply "truncating them at arbitrary tolerance levels" through simple end-of-pipe controls.

[7] An explicit criminological analysis of the social context of the considered grain farmers has not yet been carried through. We hope, however, that we have successfully demonstrated complementary links and results which can be provided within an interdisciplinary economic-criminological approach.

6 Outlook

In this article an interdisciplinary research programme has been described which joins microeconomics and criminology and which has been designed for the analysis of behavioural risks that might arise, for instance, in food production and respective market transactions. In this context, a principal agent model has been adjusted to the characteristics of behavioural food risks. This model has the capacity to account for an incomplete inspection of the product quality as well as for limited possibilities to trace a product or ingredient to its origins in a multiple agent environment. The manageable data requirements of this model qualify it as a starting point for the specification of models that are tailored to particular action situations. The practical approach and the potential insights to be gained through an interdisciplinary research programme have been illustrated through a case study from primary grain production.

Besides the insights from this case study, lessons with regard to a systematic approach to behavioural food risk analysis may also be learned from the widely established HACCP-approach. According to its seven general principles, its users are (1) to analyse their operations and to prepare a list of potential hazards, (2) to determine “critical control points” where these hazards can be controlled, (3) to define adequate tolerance limits, (4) to establish adequate monitoring procedures, (5) to define corrective measures in case deviations are identified, (6) to document all HACCP steps, and (7) to verify that the system is working correctly.

While the use of a HACCP-system and the documentation of resulting control measures is legally mandatory in virtually all food business operations, its specification is entirely left to its corporate users. So far, the spirit of HACCP is to prevent unintentional technical and human failures within “one’s own” food business operation and production process. In the framework of a comprehensive risk analysis system, behavioural risks from supply transactions could be managed by using similar principles, thus extending conventional risk analysis to an early identification of emerging risks. That is, in addition to managing the risk of unintentional technical failures within one’s own operation, one could systematically aim to reduce behavioural risks that result from the exploitation of information asymmetries on the part of suppliers. This would require that the buyer of an input, to the best of his knowledge, defines critical control points and adequate monitoring procedures with regard to risks arising from malpractice of his (potentially opportunistic) suppliers. Our case of grain producers has shown, for instance, that some control points (i.e. monitoring residues in blended batches of grain) are less suited to manage behavioural risks than others (i.e. monitoring residues in individual loads of grain). Controlling individual loads clearly increases the probability that non-compliance is being prevented.

An innovative behavioural risk management system could be termed “moral hazard analysis and critical control points system” (M-HACCP). Its introduction could be seen as a systemic approach of avoiding the emergence of risks by remedying the externality problem which arises if buyers themselves are not motivated to manage and reduce moral hazards when purchasing inputs. If they are forced to internalise costs, they will try to reduce downstream diseconomies (and finally consumers’ exposure to increased residue levels) by trying to reduce the incidence of undesired qualities which result from opportunistic behaviour of their suppliers. Such a making of “responsible principles” who act to the best of their obtainable knowledge is in line with the subsidiarity principle which prescribes that problems must be treated at the most efficient and appropriate level, that is as closely as possible to its origins. Obviously, further scientific evidence must be provided with regard to the benefits of such a proactive identification of risks through an explicit behavioural risk management system before food business operators can be required to adopt it. If considered useful by some food chain actors for competitive reasons, its implementation could also be achieved through private contracts.

The extension of behavioural food risk analysis to a systematic analysis of whole food chains or the food sector at large may require that the structure of the PA-model is developed further and extended with regard to its restrictive assumptions. This could also imply to extend the methodical sophistication of the protective factor approach. While it should always be critically checked whether informational gains justify additional costs before increasing the complexity of applied models, the following extensions of the PA-model might be promising in certain situations: (i) instead of a binary perspective, finer partitions of the agent's scope of action such as different degrees of compliance could be accounted for; (ii) instead of considering one common set of outputs both for compliance and for non-compliance, different sets or probability distributions for continuous output values could be considered; (iii) instead of assuming a non-ambiguous observation of the output, a statistical measurement error rate could be estimated which would allow for an appraisal of first and second degree errors; (iv) instead of concentrating on the (rather straightforward) positive analysis of given situations, normative models could attack the problem of how to deal cost-efficiently with agents that are heterogeneous in many aspects (their costs of compliance, the level of protective factors etc.). That is, normative models would need to include the adverse selection aspect of the incentive problem and deal with the question of heterogeneous vs. homogeneous contracts. Normative conclusions would also need to deal with different possibilities to enhance protective factors in different social contexts.

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