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Market failure with moral hazard and side trading

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Abstract

This paper compares full-information insurance markets (a) with markets where accident-reducing effort levels are unverifiable but trades between every pair of agents are verifiable and (b) with markets where neither effort nor trades are verifiable. Markets are represented by a contracting game, with a solution concept allowing coordination among coalitions through information-constrained contracts. Each informational setting yields a correspondence between market outcomes and the appropriate notion of constrained efficiency in a social planner's problem. Although incentive externalities do not cause market outcomes to be constrained inefficient, they do imply a welfare gain from public verifiability of trades.

Keywords: Moral hazard; Side trading; Coalitions

JEL classification: D82; C71; C72; G22

1. Introduction

The two fundamental theorems of welfare economics provide a clear formulation of conditions under which competitive market equilibria correspond to the set of Pareto-efficient outcomes. These theorems pertain to an environment characterized by the absence of the following imperfections: externalities, increasing returns, imperfect competition, and imperfect information. Does the presence of one of these imperfections justify a more

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interventionist role for government in market economies? The answer depends on the extent to which the welfare theorems continue to apply in settings characterized by these imperfections. Despite an explosion of research into the economics of imperfect information in the past two decades, consensus has been slow to emerge concerning the role of informational problems such as adverse selection or moral hazard in precipitating market failure, even in extremely simple and restricted models. Consider for instance the context of insurance markets in the presence of moral hazard. Even in the simplest possible setting – two states of nature, a single consumption good, a representative risk-averse insurance customer, and a large number of risk-neutral insurance firms – different authors have drawn markedly different conclusions.

On the one hand, papers by Pauly (1974), Helpman and Laffont (1975), Arnott and Stiglitz (1986a, b) and Greenwald and Stiglitz (1986) argue that competitive market outcomes are constrained Pareto inefficient, owing to some fundamental externalities induced by moral hazard. These papers (implicitly or explicitly) model the competitive market as a two-stage noncooperative game, where in the first stage insurance firms offer insurance policies, and in the second customers choose from the policies offered. The notion of constrained efficiency is Pareto efficiency within the class of insurance allocations respecting incentive constraints with respect to the opportunistic choice of unobservable effort by consumers.

On the other hand, papers by Prescott and Townsend (1984) and Hornstein and Prescott (1987) extend the Arrow–Debreu theory of competitive equilibrium to moral hazard contexts. With an alternative notion of commodities and agents, i.e. where consumers purchase (at parametric market-clearing prices) units of (randomized) individually incentive compatible contracts over consumption–effort pairs, they succeed in extending the classical existence and welfare theorems of the Arrow–Debreu theory. In other words, using the same efficiency criterion, but a different model of competitive equilibrium, they reverse the conclusion that markets fail under moral hazard. This lack of consensus is troubling, for in an imperfect information context there is no 'obvious' way to model competitive market outcomes. These two strands seem to imply that a noncooperative game-theoretic formulation yields distinct outcomes from a Walrasian 'parametric price' approach.

The goal of this paper is to understand the dichotomy between the two views concerning the market failure implications of moral hazard, in terms of implicit assumptions regarding the underlying information structure available to market agents and a social planner. We examine the efficiency of decentralized activity in insurance markets with moral hazard, under varying assumptions regarding the structure of information verifiable by third-party contract enforcers. We consider three different information structures: (a) effort levels and trades between every pair of agents are verifiable; (b) efforts are unverifiable, but trades are verifiable; and (c) neither effort nor trades are verifiable. Market equilibrium is represented by a solution to a contracting game, with outcomes defined by a solution concept that allows coalitions of agents to coordinate their actions, subject to constraints imposed by information available about effort and trades. For each informational setting, we discover a close correspondence between market outcomes and the corresponding notion of constrained efficiency (the solution to the problem of a social planner subject to exactly the same informational constraints as third-party contract enforcers). In this sense, therefore incentive externalities do not cause market outcomes to be constrained inefficient.

We also discuss in broader terms the implications of our results for the role that governments may play in enhancing efficiency. In particular, we argue that the question of 'market failure' has been traditionally posed in too abstract and limited a manner. One ought to separate different areas in which the government may play an active role, such as (a) direct provision of insurance, and regulation or taxation of privately provided insurance; (b) monitoring of 'side' trades, in related goods by insurance customers with third parties; and (c) enforcement of contracts between private parties. Institutional mechanisms may differ with respect with the specific role played by governments in each of these three areas. Consequently, the question of market failure can be posed in many different ways. The traditional manner of posing the question in the theoretical literature usually refers to the necessity of governmental intervention in area (a) involving direct provision of insurance, *given a particular structure of monitoring and contract enforcement*. The priviso is usually left implicit. If this is the correct interpretation of the issue of market failure, then our model suggests the absence of market failure in insurance markets subject to moral hazard. On the other hand the question of market failure can be posed in terms of the usefulness of an active government in the areas of monitoring side trades or enforcing contracts. Many of the arguments advanced for market failure (in the papers cited above) should be reinterpreted as arguing for active governmental intervention in the area of monitoring and regulating side trades. This reinterpretation should allow future research to focus on the more fundamental question: What is it about governments that might give them a comparative advantage in monitoring and regulating side trading?

Section 2 of the paper elaborates on the broad issue of the meaning of market failure, and also provides an informal overview of our formal analysis. Section 3 presents the formal model, and Section 4 the social planner's problem in the three different monitoring environments. Section 5 contains the model of private contracting, and the relation to the social planner's solution in the different environments. The paper concludes with a brief discussion of the possible role of government in monitoring and regulating side trades.

2. Overview

2.1. The dimensions of government intervention

Many cases of 'market failure' involve externalities, either physical (as embodied in common resource or pollution problems), or informational (generated by adverse selection or moral hazard). The resolution of the potential inefficiency created by these externalities typically requires monitoring of certain activities or transactions. For instance, common property externalities can be ameliorated only with appropriate monitoring of usage of the common property, combined with regulated access or the payment of taxes or 'efficiency prices' on the extent of usage. Efficient allocations in moral hazard settings require monitoring of side trades of insurance, as well as of trades in related goods that are complements or substitutes for effort. These trades need to be subjected to some form of regulation or implicit pricing: for example, in automobile insurance, efficiency requires that drivers to not obtain insurance from more than a single source, and that purchases of liquor by drivers either be taxed or that information concerning such purchases be used to price the primary insurance suitably.

The problem of monitoring side trades is not limited to insurance markets: externalities from side trades are likely to pose difficulties whenever hidden information or hidden actions are present. In financial intermediation (such as investment banking) the possibility of intermediaries trading on the side on the basis of their 'inside' information can be seriously disruptive. In credit markets, different lenders exert externalities upon each other, as the lending policies of one affect the probability that others will be repaid, by affecting the incentives of borrowers with respect to effort and project selection (Kletzer, 1984; Bizer and deMarzo, 1992). The design of managerial compensation schemes is complicated by the ability of managers to purchase stock options and trade in futures markets on the side. Dynamic incentive schemes are also constrained if agents can borrow and lend (Rogerson, 1985; Fudenberg et al., 1990). In agrarian economies, the externality associated with moral hazard has been argued to constitute an important reason for the interlinking of credit and tenancy contracts (Braverman and Stiglitz, 1982). Similar externalities are exhibited in macroeconomic models based on labor contracts with imperfect information (Grossman et al., 1983; and Kahn and Mookherjee, 1988).

We will distinguish between three dimensions to government intervention.

(a) The first dimension concerns primary provision or allocation of the good in question. Along this dimension the government may retain a monopoly or an active role or it may allow private parties to enter into contracts with one another, the terms of which may be conditioned on information concerning activities related to effort provision or resource usage. Such private contracts may also be subjected to governmental regulations or fiscal controls.

(b) The second dimension concerns the monitoring of related transactions. This includes supplementary transactions in the same good and trades in related goods. If the government does monitor trades, to what use should it put its information? Should it be communicated to parties to the original contract and its enforcers, or should it be directly 'priced' by the government through taxes or subsidies?

(c) The third dimension concerns the enforcement of contracts – that is, the imposition of penalties on parties violating contract provision. In short, the government's role can involve a variety of activities: outright public ownership or provision, regulation or taxation of private contracts between owners, monitoring and regulation of related activities, and enforcement of contracts.

In this paper we abstract from issues of contract enforcement by assuming that enforcement is costless, whether by third-party courts, social norms, or reputational considerations. Instead we focus on the other two areas – primary provision and monitoring of related transactions. In the insurance context various institutional alternatives are available for handling these two roles. At one extreme is a completely 'public' solution, where the government retains a monopoly over the provision of insurance, monitors related transactions, and imposes suitable regulations or corrective taxes and subsidies on the latter. A second alternative is one in which insurance is provided by privately-owned insurance firms on a competitive market, while the government regulates and taxes trades. A third alternative retains the private provision of primary insurance but restricts government activity to the monitoring and reporting of related trades without directly regulating or taxing them. A fourth, completely 'private' alternative, allocates both monitoring and provision to (possibly distinct) private parties.

2.2. *The role of governments in insurance provision*

The formal analysis in this paper makes a clear distinction between direct regulation – that is, governmental intervention in the provision, regulation or taxation of primary goods – and information provision. We do so by distinguishing environments according to the information available pertaining to related trades. We do not model the exact process by which side trades are monitored; instead, taking the structure of such information as given, we compare alternatives that differ only in the role of the government in providing, regulating or taxing primary insurance contracts.

The main result of the paper is that: *given any particular structure of information pertaining to side trades available to primary insurance providers* *(whether government or private firms), an unregulated competitive insurance market involving private provision of insurance achieves the same level of efficiency as would welfare-optimal governmental provision of insurance.* In other words, an unregulated private market can achieve the same level of efficiency as a hypothetical social planner with access to exactly the same information concerning side trades of insurance customers. This is shown specifically for each of the three different monitoring environments we examine: first-best (where effort levels and all side trades are perfectly verifiable by insurance providers and contract enforcers); second-best (where side trades are perfectly verifiable, whilst effort levels are not); and third-best (where neither effort nor side trades are verifiable).

Before going on to discuss the exact manner in which we model private markets for insurance contracts, we note some implications of this result. First, it helps us understand the dichotomy between the two dominant views concerning market failure in moral hazard environments. Those authors stressing that competitive market solutions are constrained Pareto-inefficient, derive their views from a model of private insurance markets in which insurance firms are in a third-best monitoring environment, the outcomes of which are nevertheless compared with those achievable by a social planner with access to a second-best monitoring structure. Specifically, any assertion of inefficiency based on demonstrating the scope of tax/subsidy schemes to generate Pareto improvements implicitly assumes that the planner has the ability to monitor trades. In the absence of such monitoring, these tax/subsidy schemes cannot be implemented. Thus, arguments of this genre for the failure of a market with unobservable trades and effort implicitly use a second-best, rather than third-best efficiency standard.

The efficient market approach, on the other hand, as exemplified by the work of Prescott and Townsend (1984), corresponds to a context where all side trades are verifiable. This is implicit in their assumption that contracts defined over consumption–effort pairs (subject to effort incentive constraints alone) are enforceable. In other words, exclusive contracts are feasible, and there is no loss of generality in assuming that all consumers trade with a single centralized agency. Their demonstration of equivalence between competitive equilibria and efficient outcomes is mirrored in our model by the equivalence between market outcomes and efficient outcomes in the second-best world. However, their approach fails to take into account the real efficiency losses associated with the inability to monitor side trading.

2.3. Modeling markets for private insurance contracts

This subsection provides an outline of our approach to modeling competitive contracting outcomes. We adopt a game-theoretic formulation of the competitive market somewhat different from previous formulations, a formulation that allows a more explicit treatment of information structure. We consider the simplest possible insurance setting: two effort levels, two states of nature, a single consumption good, and homogeneous firms and agents. This setting permits us to focus on the essential externality associated with moral hazard. This externality stems from the public good character of the customer's effort: the effect of varying the amount of trade offered by one firm affects the customer's effort, and thereby also the profits of other firms transacting with the same customer. This creates the need for exclusive contracts, where each customer trades with a single firm, and where the amount of trade is limited in order to generate requisite effort incentives. Such restrictions, however, create an incentive for customers to circumvent them by engaging in additional trades with other firms. Exclusive contracts cannot be enforced if side trades between the customer and other firms cannot be prevented. In such contexts, exchange is constrained not only by the unobservability of effort, but also by the possibility of side trades with other firms.

Our formulation of the market for insurance contracts differs from the usual two-stage noncooperative formulation by incorporating a cooperative element in the form of allowing arbitrary coalitions of firms and consumers. This is natural when one seeks to model a process of equilibrium contracting, since the activity of entering into a contract has an undoubted coalitional flavor. However, the presence of moral hazard renders important certain incentive constraints pertaining to choice of unobservable actions, which have an essentially noncooperative flavor. So we choose a formulation that combines both cooperative and noncooperative elements: specifically a modification of the notion of a strong equilibrium (i.e. a Nash equilibrium which is immune to coordinated coalitional deviations), which we call a *Pairwise Incentive Compatible Strong Equilibrium* (PICSE). This is similar in spirit to the concept of Coalition Proof Nash Equilibrium (introduced by Bernheim et al., 1987), but considerably more tractable in this framework.[1] The coalitional aspect of this solution concept may be viewed as an extension of the concept of individual incentive compatibility to a notion of coalition incentive compatibility. From an economic standpoint, it also helps

[1] The use of the original definition of Coalition Proof Nash Equilibrium leads to some purely technical difficulties in our context. Kahn and Mookherjee (1992a) show how CPNE can be extended to games with nonfinite strategy sets. Using this new definition of CPNE, Kahn and Mookherjee (1991a) examine the third-best problem in the moral hazard insurance market. That paper differs from the present paper in that it focuses on the technical problems of CPNE. In contrast, the aim of the current paper is to explain welfare properties of contracting equilibria in three different informational environments. By introducing the PICSE solution concept, we are able to dispense with relatively technical game-theoretic issues and instead examine the economic issue: Is efficiency maintained as the information environment changes?

develop a theory of market behavior that incorporates Coasian criticisms of purely noncooperative formulations: see, for example, Boyd et al. (1988) who argue that noncooperative models generate market failure precisely because they impose ad hoc restrictions on the ability of certain coalitions to form.

Our framework enables us to trace the effect of changes in the structure of information. A contract entered into by a coalition is a coordinated plan to buy or sell insurance bundles from one another, and to choose a certain level of effort on the part of insurance customers. To the extent that information about certain action variables is verifiable by third-party contract enforcers, the parties to the contract can enter into commitments with respect to these actions. All other action plans must be collectively self-enforcing in a suitable sense, since they cannot be enforced by third parties. Hence the set of variables that are verifiable by third-party enforcers distinguish those actions to which agents can directly commit from those which must be self-enforcing. In other words, the incompleteness of contracts is defined by the structure of publicly verifiable information, variations in which result in changes to the set of incentive constraints (with respect to opportunistic choice of the publicly unverifiable variables) that must be satisfied by feasible contracts. As mentioned earlier, we consider three different information structures concerning side trades: first-best (both effort and side trades verifiable); second-best (side trades verifiable, effort nonverifiable); and third-best (neither effort nor side trades verifiable).

In order to derive conclusions concerning market failure, we must also formulate a suitable notion of constrained efficiency with which to evaluate market outcomes. As explained above, if the question of market failure is posed in terms of the need for governmental intervention in the insurance market, given the structure of monitoring and enforcement, the corresponding efficiency standard involves the resource allocation problem of a social planner when subjected to exactly the same informational constraints as are agents in the market economy. Hence the three information structures described above correspond to three different notions of efficiency: first-best, second-best, and third-best. The first-best and second-best notions of efficiency are by now familiar from the existing literature, unlike the third-best notion. This pertains to a social planner who is subject to a 'double moral hazard problem', owing to his inability to monitor the effort choices of customers, as well as 'black market' trades entered into by them with private firms (subsequent to the planner's chosen allocation).[2]

[2] A corresponding formulation of planning problems under conditions of adverse selection and unobservable black markets has been considered earlier by Hammond (1987). A more detailed analysis of third best outcomes is provided in a related paper (Kahn and Mookherjee, 1992b).

Finally, for each of the three informational structures, we compare PICSE outcomes of the market game with solutions to the corresponding planner's problem. In the first-best and second-best scenarios, PICSE exist and there is an exact correspondence between PICSE outcomes and the set of constrained efficient outcomes. In the third-best context we establish the existence of PICSE, as well as the Second Welfare Theorem, i.e. every third-best allocation can be achieved as the outcome of a PICSE, subsequent to initial lump-sum redistributions. Hence, for each of the three monitoring environments, competitive markets achieve outcomes that are constrained efficient in the sense of solving the problem of a social planner subject to exactly the same monitoring environment.

3. The model

3.1. Basic setup

The basic analytics of insurance with moral hazard are by now familiar from past literature (e.g. Arnott and Stiglitz, 1984a, b; Pauly, 1974; Hellwig, 1983a, b). Thus our presentation of the framework will be brief. A single risk-averse consumer wishes to purchase insurance from one or more risk-neutral insurance companies. There are two states of nature: state 1 (accident) and state 0 (no accident), and a single consumption good. An accident causes the consumer's endowment of this good to be reduced by d units. By expending a utility-diminishing amount of effort e the consumer can reduce the likelihood of an accident, $p(e)$. The consumer's expected utility is described by

$$W(x, e) = u(x_0)(1 - p(e)) + u(x_1 - d)(p(e)) - e ,$$

where x is a vector (x_0, x_1) of net trades of state contingent consumption, and u is a continuously differentiable, strictly concave and strictly increasing function. The consumer's effort e can take on two values: $e \in \{0, 1\}$, where $1 > p(0) > p(1) > 0$.

Each insurer is risk neutral. If the consumer purchases policy (x_0^i, x_1^i) from insurer i, and expends effort e, then the expected payoff to insurer i is $V(x^i, e) = -x_0^i\,(1 - p(e)) - x_1^i p(e)$. There are a countably infinite number of insurers. The total insurance received by the consumer is the sum of net trades accepted from firms he trades with: $x = \sum_i x^i$.

In Fig. 1, net trades in the two states x_0 and x_1 are plotted on the axes. The origin represents the no-trade point. The straight lines $Z(1)$ and $Z(0)$ represent the trades at which firms would exactly break-even on aggregate, assuming that the effort level chosen is 1 and 0, respectively. The upward-

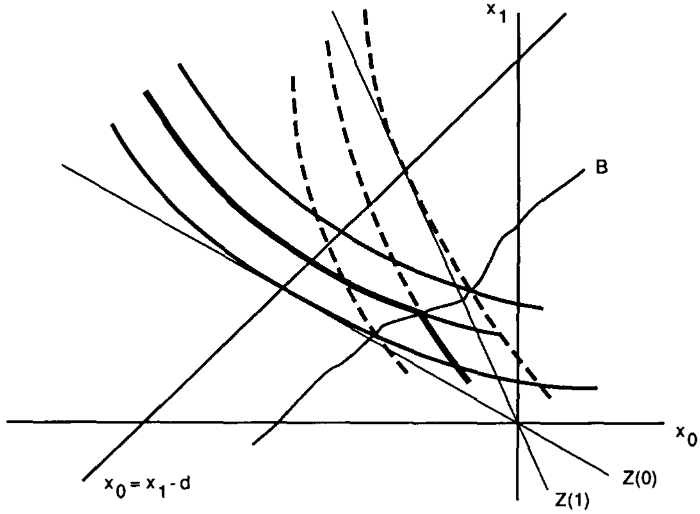

Fig. 1.

sloping line $x_0 = x_1 - d$ represents the full insurance points. The dotted curved lines represent the consumer's indifference curves, assuming that the effort chosen is $e = 1$; the solid curved lines represent indifference curves corresponding to $e = 0$.

When consumer effort is verifiable, as in first-best situations, efficient allocations necessarily involve full insurance. If effort is unverifiable, then the consumer will select effort level opportunistically, giving rise to an effort incentive constraint. Assume that in the absence of any trade the consumer prefers to choose $e = 1$, that is, $[u(0) - u(-d)][p(1) - p(0)] \geq 1$. In Fig. 1, curve B represents the boundary between the region in which the consumer prefers $e = 1$ and the region in which the consumer prefers $e = 0$. We can therefore describe the consumer's preferences for pairs (x_0, x_1) in terms of the 'reduced-form' utility function $Y(x) = \max(W(x, 1), W(x, 0))$. The heavy bold line in the diagram represents one reduced form indifference curve.

Fig. 2 describes the set of trades that enable the firms to break even, after incorporating the effect of that trade on the consumer's optimal effort choice. This is depicted by the heavy broken line, which coincides with $Z(1)$ to the right of B, and with $Z(0)$ to the left of B.

3.2. *Efficiency criteria: The social planning problem*

Consider the problem of a social planner choosing an *allocation* for this economy. An allocation specifies trades (x_0^i, x_1^i) between every firm i and

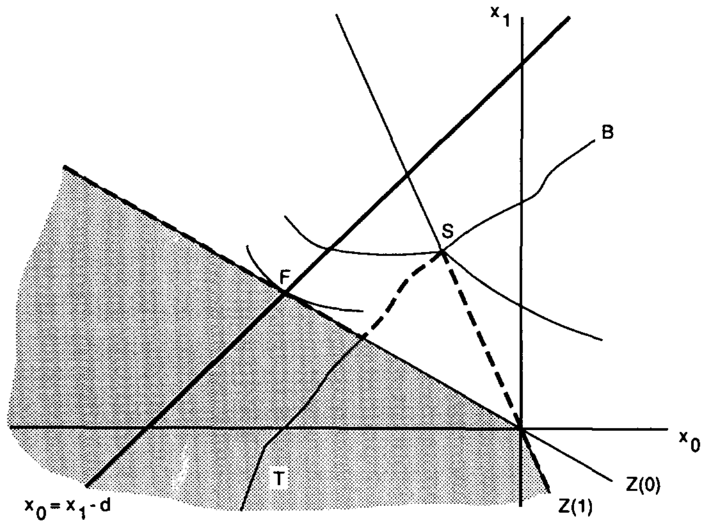

Fig. 2.

the consumer, as well as an effort level e for the consumer. In the world where all trades as well as the consumer's effort are observable by the planner, the planner can choose any allocation whatsoever. Since we are interested in Pareto-efficient allocations, we assume that the planner's objective is to maximize the welfare of the consumer, subject to the constraint that firms attain a predetermined aggregate profit target.[3] Alternatively, the planner may directly provide insurance to the customer, subject to a break-even constraint. Then in the *first-best outcome* the planner chooses any allocation with the property that x, the consumer's net trade and the effort e, maximizes $W(x, e)$ subject to $V(x, e) \geqslant \pi$. In the *second-best* situation, trades are observable, but the consumer's effort choice is not. Hence the planner is constrained to allocations $(\{x^i\}, e)$ satisfying the effort incentive constraint: $W(x, e) = \max\{W(x, 0), W(x, 1)\}$. For strictly risk-averse consumers, the point will either be F, full insurance with zero effort, or S, less than full insurance with positive effort. At the latter solution the consumer is restricted in the amount of insurance

[3] More generally, the planner will incorporate a minimum profit target for each firm separately. It is straightforward to check that the more general problem is equivalent, since the former is solved by solving this as a first step, and then distributing trades among firms to attain the profit targets for each of them separately. We shall continue to use the same aggregate formulation in the second- and third-best scenarios as well, for the same reason.

provided, to the minimal extent necessary to induce him to choose the high level of effort. In what follows we assume that the second-best allocation is at S.

Now consider what is likely to happen if the consumer can obtain additional insurance on the side from private firms, and the planner is powerless to prevent such side trades. Once the consumer has accepted the trade S, he will prefer to find an additional firm from whom to purchase additional insurance. Given the additional insurance, the consumer will choose to reduce effort. Nonetheless, the additional insurer will be able to offer an insurance contract that makes a profit even assuming $e = 0$, and the consumer would find this additional purchase desirable. This implies, however, that it is no longer actuarially fair for the initial provider of S: given the reduction in effort, it will sustain a loss. Thus, as other authors have noted, the second-best outcome will no longer be feasible if trades are unobservable.

In the third-best setting, feasible allocations must therefore incorporate the incentives of the consumer to enter into an unmonitored side trade with some firms. A detailed treatment of this problem is provided in Kahn and Mookherjee (1992b): we reproduce the essential argument here. A precise statement of the corresponding coalitional incentive compatibility constraint requires us to formulate the set of side trades that third-party firms will be willing to enter into. Such a set will certainly include any trade that is profitable irrespective of the consumer's effort choice. The set of such 'safe' side trades is the cone $T = \{\tau \in \mathbb{R}^2 \mid V(\tau, e) \geqslant 0 \text{ for } e = 0 \text{ and } 1\}$, which is represented by the shaded area in Fig. 2. Hence, a *necessary* condition for an allocation to be immune to an unmonitored side trade of this form is that (x, e), the aggregate consumption and effort of the consumer, satisfy the following coalitional constraint:

$$(0, e) \in \underset{\tau \in T, \tilde{e} \in \{0,1\}}{\operatorname{argmax}} \; W(x + \tau, \tilde{e}) \, .$$

However, it is not clear that this condition is sufficient to rule out all side trades, since it considers only side trades that make non-negative profits *irrespective of the consumer's effort choice*. For the economy we examine, it nevertheless turns out that this is indeed the case.[4]

[4] For a formal proof, see Kahn and Mookerjee (1992b). Intuitively, any insurance firm i offering a side trade to the consumer has to worry not only about the effort chosen by the consumer in the event of having consumption $x + \tau$, but also the possibility that given the additional trade τ offered by i, the consumer may have an incentive to enter into yet another side trade τ' with a different insurance firm, and the effort level e that is optimal for the consumer given consumption $(x + \tau + \tau')$ may cause the provider of τ to lose money.

We thus define the *third-best* planning problem to be

$$\max_{x,e} W(x, e)$$

subject to

$$V(x, e) \geqslant \pi \tag{1}$$

and

$$(0, e) \in \operatorname*{argmax}_{\tau \in T, \tilde{e} \in \{0,1\}} W(x + \tau, \tilde{e}) . \tag{2}$$

Note that constraint (2) implies satisfaction of the effort incentive constraint as well. We will call a solution to this problem a third-best outcome.[5] In Kahn and Mookherjee (1992b) it is shown that given any pre-assigned level of profits π, a third-best outcome exists. Any such third-best outcome (x_0, x_1) satisfies $x_0 + \pi < 0$, $x_1 + \pi > 0$, $x_0 > x_1 - d$. In particular, the set of third-best outcomes lies within a bounded set. Subsequent to an initial redistribution to ensure attainment of the profit target π, a third-best outcome does not give negative insurance and does not give more than full insurance. Such an outcome (for $\pi = 0$) is depicted in Fig. 3. Let the point P be the maximum point on or below the actuarially fair locus $Z(1)$ such that the reduced-form indifference curve through P lies

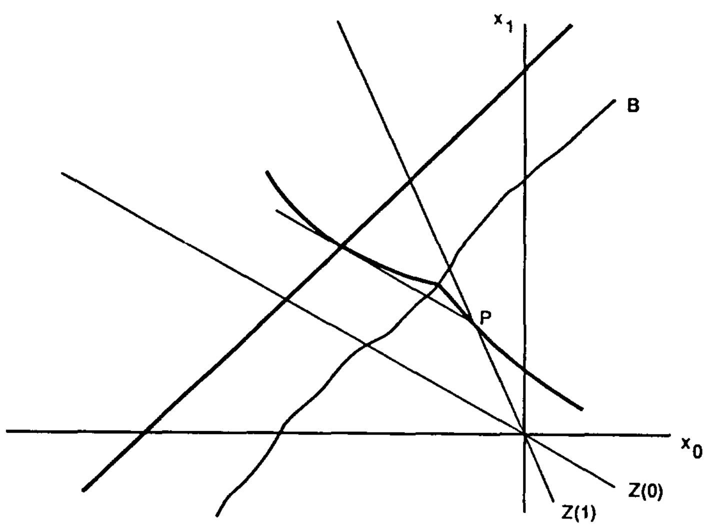

Fig. 3.

[5] When more than one allocation solves this problem, we will restrict attention to those maximizing firm profits $V(x, e)$.

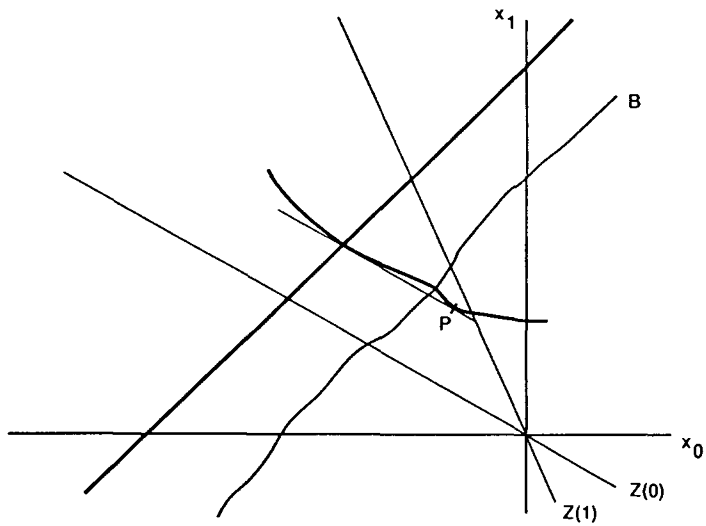

Fig. 4.

entirely above the half-line extended from P parallel to $Z(0)$. If this point is north-west of the origin, then it is the third-best outcome. It can be shown that a third-best outcome is either point F of the previous diagram (full insurance with zero effort), or it is an outcome involving high effort and strictly less insurance than is required to provide effort incentives (i.e. it lies to the right of the curve B). It is possible that firms make more profits than they are entitled to in the third-best outcome; Fig. 4 gives an example where despite $\pi = 0$, they end up earning positive profits.[6]

3.3. *Market outcomes*

3.3.1. *The contracting game*

In this subsection we formulate a contracting game that describes the process by which individual agents deal with one another in economies with private actions. We begin by describing the formulation in the insurance setting described above; at the end we briefly give a formal definition of a contracting game applicable to general economies with private actions.

[6] Note that even though the supplier of insurance is making positive profits, the planner cannot increase the consumer's utility by redistributing consumption in his favor; the resultant allocation would violate the coalitional constraint (2). That is, although the new insurance would give the consumer higher utility, it would also cause him to want to purchase still more insurance, which other firms would be willing to supply at prices which are profitable irrespective of the consumer's effort. The additional insurance would cause the consumer to switch his effort choice in a manner that would make existing insurance providers lose money.

In the insurance setting the game will be played by many insurance firms and a single consumer. The consumer can potentially trade with multiple firms. It can enter agreements with firms individually or write a common contract with a conglomerate of firms. We define the notion of a contract more precisely below.

We consider a two-step procedure. In the second step, agents are engaged in a simultaneous bid–offer trading process, where firms make offers of trades and the consumer makes requests to trade. If the request to a firm matches an offer by the firm the corresponding trade occurs; otherwise no trade occurs with that firm. The consumer also chooses the level of effort. Let x^i denote the trade between the consumer and firm i and $x = \Sigma^i$; then the payoffs for the consumer and firm i are, respectively, $W(x, e)$ and $V(x^i, e)$.

Formally, we assume a countable infinity of firms, $i = 1, 2, \ldots$. Firm i offers the set $S^i \subseteq \mathbb{R}^2$. The consumer requests $r^i, i = 1, 2, \ldots$, and chooses effort e. Trade occurs if $r^i \in S^i$. We prohibit the consumer from making an infinite number of nonzero trade requests. This restriction avoids some technical problems and guarantees that the total trade is well defined. It is also a natural way to guarantee that the market has free entry, since the assumption implies that there is always an unlimited number of inactive firms ready to make additional trades with the consumer. We use N to denote the set of agents $\{0, 1, 2, \ldots\}$, where agent 0 is the consumer.

Prior to the trading stage there is a communication/contracting stage. Here different agents may attempt to coordinate their second-stage trading activities. If some of their second-stage activities are publicly observable, they may write contracts binding themselves to certain behavior. We assume these contracts over publicly observed variables are perfectly enforced by an outside agency.

The *information structure* for the economy indicates which second-stage actions are publicly observable. We deal with three different scenarios. In the full-information world, the enforcement agency can distinguish all second-stage actions; under moral hazard with observable trades, contract enforcers can observe all trade offers and requests, but not the effort chosen by the consumer. Finally, if there is moral hazard and trades are unmonitorable, then contract enforcers can observe no actions whatsoever and first-period contracts do not bind agents at all. Formally, if A_i is agent i's set of second-stage actions, then the information structure defines a partition Θ_i of A_i, whose cells θ_i are publicly observable.

We now describe a *contract* more precisely. It is (1) listing of the *parties* to the contract $I \subseteq N$ and (2) an enforceable commitment for each $i \in I$ – that is, a specification of a cell θ_i in θ_i for each i. For a contract c, we let $I[c]$ denote the parties to the contract and $\theta_i[c]$ the commitment by player i in the contract. As the information structure changes, so does the set of enforceable contracts.

In the first stage of the game, agents write contracts to coordinate their trades in the following way: each agent i proposes a contract c_i. A contract c is *executed* if all parties to c unanimously propose contract c, i.e. if $c = c_i$ for all $i \in I[c]$. Agent i is bound to the commitment $\theta_i[c_i]$ only if c is executed; otherwise he is bound to no commitment at all. Hence, as a function of first round contract proposals $\boldsymbol{c} = \{c_0, c_1, c_2, \ldots)$ agent i is constrained to choose a second-stage action from the set

$$F_i(\boldsymbol{c}) = \begin{cases} \theta_i[c_i], & \text{if } c_i \text{ is executed}, \\ A_i, & \text{otherwise}. \end{cases}$$

Thus a strategy for an agent in this two-stage game consists of a contract proposal at the first stage plus a plan for second-stage actions g_i. This plan is a function of *all* contract proposals and must be consistent with the agent's commitments, if any, i.e. $g_i(\boldsymbol{c}) \in F_i(\boldsymbol{c})$. This game is studied for the three information structures: first, second and third best.

We conclude this subsection by describing the procedure for making *any* noncooperative game into the second step of a two-step contracting game. Take any noncooperative game Γ defined by strategy sets A^i for $i \in N$, and payoffs $W_i: \times_{i \in N} A^i \to \mathbb{R}$. Take an information structure for this game. Let $\mathscr{C}$ be the set of all feasible contracts given the information structure, and let $\mathscr{C}_i$ denote the set of contracts to which i is a party. Then the contracting game $\bar{\Gamma}$ is defined as follows. For each individual i in the set of players N, the strategy set is

$$\mathscr{D}^i = \left\{(c_i, g_i) \mid c_i \in \mathscr{C}^i \text{ and } g_i(\boldsymbol{c}) \in F_i(\boldsymbol{c}) \text{ for all } \boldsymbol{c} \in \mathop{\times}_{i \in N} \mathscr{C}^i\right\}.$$

Given a strategy vector $(\boldsymbol{c}, \boldsymbol{g}) \in \times_{i \in N} \mathscr{D}^i$, player i's payoff[7] is $w_i(\boldsymbol{g}(\boldsymbol{c}))$.

3.3.2. Solution concept

A strictly noncooperative formulation of $\bar{\Gamma}$ would be unsatisfactory, because there would always be Nash equilibria where no contracts are signed and no trade takes place. For example, if all agents but one propose null contracts and nonparticipative trading strategies, the final agent has no incentive to take any action either. Such equilibria appear unreasonable: if there are gains from trade or from writing contracts, we expect parties to coordinate their actions at the contracting and trading stages. For example, if the no-contract, no-trade equilibrium is in vogue, and we are in the full-information world, a firm and a consumer have a mutual incentive to jointly propose a contract where they commit to exchanging first-best

[7] Despite the fact that the contracting game is a two-stage game, we do not impose any perfection requirements: our formulation does not require action choices to form an equilibrium in the trading game subsequent to off-equilibrium contract proposals. For the case that we are examining, this additional restriction appears immaterial.

insurance while the consumer commits to first-best effort. This contract is enforceable under full information. Neither firm nor consumer could lose by proposing it, since if the other party fails to propose it, no one is bound by the commitment.

Coordinated strategies in $\bar{\Gamma}$ seem natural provided such coordinated arrangements are (1) to mutual advantage and (2) enforceable. There are two ways that the arrangements can be enforceable: the publicly verifiable aspects can be turned into commitments which are publicly enforced; the unverifiable aspects must be credibly self-enforcing. For example, in a world where effort is unverifiable, a firm and consumer might try to write a contract in which they commit to a trade which is profitable for the firm only if the consumer chooses high effort. Since the effort must be self-enforcing, the firm will only be willing to enter into such a contract if it were then in the consumer's own interest to choose high effort.

A natural way to model the formation of such arrangements is to start from the other extreme: to look for Pareto-optimal outcomes in a set of outcomes restricted by incentives to deviate. The incentive to deviate is modeled by formulating the notion of a credible deviating agreement in the game $\bar{\Gamma}$.

A *coalition* C is a subset of N. An *agreement* is a pair $(\boldsymbol{a}, C)$, where C is a coalition and $\boldsymbol{a}$ is a strategy vector in $\bar{\Gamma}$. An agreement has the following interpretation: taking as given the actions of those outside C as stipulated in $\boldsymbol{a}$, members of C propose to play actions $\{\boldsymbol{a}_i\}_{i \in C}$. We will say that agreement $(\boldsymbol{a}, C)$ *blocks* the agreement $(\boldsymbol{b}, D)$ if

(1) C is a proper subset of D[8];

(2) $\boldsymbol{a}_i = \boldsymbol{b}_i$ for $i \notin C$;

(3) $\boldsymbol{a}$ is weakly preferred to $\boldsymbol{b}$ by all i in C, and strictly preferred by some i in C.

Then a natural requirement for strategy vector $\boldsymbol{a}$ to be a solution exhausting all possible gains from trade is that there be no agreement $(\boldsymbol{b}, C)$ that blocks $(\boldsymbol{a}, N)$. If there exists a set of unblocked agreements among the coalition of the whole, then any agreement on the Pareto frontier of the set is a *Strong Equilibrium* (SE). In contrast, a Nash equilibrium is a strategy vector $\boldsymbol{a}$ such that $(\boldsymbol{a}, N)$ is blocked by no single-person agreement.

From our perspective, the difficulty with the SE is the credibility of the blocking agreement. For a strategy vector to be SE it must be immune to *any* unilateral deviations and to *any* joint deviation. In most situations, no SE exists; in particular, as we will see, whenever individual incentive constraints bite there cannot be a SE.

It is more natural to restrict potential blocking agreements to a set of 'credible' agreements. A minimal requirement for a credible deviating

[8] The natural notion of blocking that underlies Coalition Proof Nash Equilibrium requires C to be any subset of D. The logic is that only those party to the original agreement could deviate away from it. We impose the requirement that C be a proper subset to simplify the analysis: it can be shown that it makes no essential difference.

agreement $(\boldsymbol{b}, C)$ is that every individual member of C should either have an incentive to stick with $\boldsymbol{b}$, or any preferred deviation should not hurt any other member of the coalition. Given an arbitrary agreement $(\boldsymbol{b}, C)$ some member of C may prefer to deviate from the stipulated action, and this may jeopardize the welfare of other members of the coalition. This is essentially a mild variation on the familiar notion of individual incentive compatibility.

We call the agreement $(\boldsymbol{b}, C)$ *individually incentive compatible* (IIC) if for all members i of C, either (i) it is the case that i is playing a best response in $\boldsymbol{b}$, or (ii) there is no best response for i to $\boldsymbol{b}_{-i}$, but for any c_i in A_i, which i prefers to $\boldsymbol{b}_i$ (given $\boldsymbol{b}_{-i}$), it is the case that every other member of C is at least as well off under the strategy vector $(\boldsymbol{c}_i, \boldsymbol{b}_{-i})$ as in $\boldsymbol{b}$. The second condition is not only natural, but also enables us to avoid certain technical problems arising from the possible nonexistence of best responses for certain players. We will call the strategy vector $\boldsymbol{b}$ IIC if the agreement $(\boldsymbol{b}, N)$ is IIC.

If individual incentive compatibility is adopted as the appropriate definition of credibility, then we can define the corresponding modification of Strong Equilibrium as follows:

The strategy vector $\boldsymbol{a}$ is said to be an *Individually Incentive Compatible Strong Equilibrium* (IICSE) if

(1) $\boldsymbol{a}$ is Pareto optimal among IIC strategy vectors.

(2) There does not exist any finite player IIC agreement $(\boldsymbol{b}, S)$ which blocks $(\boldsymbol{a}, N)$.[9]

The notion of an IICSE is a natural solution concept for games in which individual incentive compatibility is a problem. In particular it is the analogue in noncooperative settings of the Incentive Compatible Core.[10] But as we will see, it is inadequate for analyzing games with the side trading, in which joint incentive problems arise. The difficulty is that an IICSE does not go far enough in requiring deviations to be credible. In an IICSE, the proposed allocation $\boldsymbol{a}$ has to be immune to all forms of joint deviations which are IIC. But the deviations themselves do not have to be immune to further joint deviations, only to individual deviations. In the case of insurance with unmonitorable trading, a joint deviation by insurance companies and the consumer may block a proposed allocation, but this deviation may be vulnerable to a further side trade between some firm and the consumer. In a third-best world it is highly unlikely that an IICSE will exist, since any proposed allocation has to be immune to side-trading *and* also to alternative that are themselves vulnerable to side trading.

[9] The finiteness restriction on the size of blocking coalitions is also motivated to retain the free entry property, i.e. there are always some firms excluded from any coalition, with whom the consumer could trade on the side.

[10] See Berliant (1992), Boyd and Prescott (1986), J. Kahn (1992) and Marimon (1988). This analogy is inevitably a rough one, since it depends precisely on the way that cooperative games are reformulated in a noncooperative setting.

These considerations motivate the introduction of a further restriction on credible deviations, requiring them to be immune to joint deviations of pairs of players, and a corresponding equilibrium notion:

The agreement $(\boldsymbol{b}, S)$ is said to be *Pairwise Incentive Compatible* (PIC) if (1) it is IIC and (2) there does not exist an IIC two-player agreement which blocks it. Again, strategy vector $\boldsymbol{b}$ is PIC if agreement $(\boldsymbol{b}, N)$ is PIC.

The strategy vector $\boldsymbol{a}$ is said to be a *Pairwise Incentive Compatible Strong Equilibrium* (PICSE) if

(1) $\boldsymbol{a}$ is Pareto optimal among PIC strategy vectors.

(2) There does not exist any finite player PIC agreement $(\boldsymbol{b}, S)$ that blocks $(\boldsymbol{a}, N)$.

It can readily be checked by the reader that every SE is an IICSE, and every IICSE is a PICSE (and every PICSE is a Nash Equilibrium). The notion of PIC of course incorporates only invulnerability against joint deviations by pairs of members, rather than all possible subcoalitions. In this respect it does not go far enough in capturing a consistent notion of self-enforcement, as does the Coalition Proof Nash Equilibrium concept. Nevertheless, in the current context of the insurance economy, deviations involving pairings of an insurance customer with an insurance firm turn out to exhaust the set of economically useful deviations: hence consideration of pairwise incentive compatibility suffices.[11]

[11] If we continued iteratively, defining Trio-wise Incentive Compatibility, Quad-Wise Incentive Compatibility, etc., our definition of N-wise Incentive Compatibility would turn out to be essentially Coalition Proof Nash Equilibrium as defined by Bernheim et al. for finite player games. The formulation adopted here enables us to avoid many problems of a purely technical nature, without losing any essential economic aspect of the problem. As we go beyond pairwise incentive compatibility, it becomes more difficult to deal with the complications arising in the case where some player does not have a best response, i.e. faces a maximization problem over a noncompact set. A rigorous analysis for the general case of CPNE would require us to redefine the notion of agreements as involving a coordinated sequences of actions by members of a coalition, and identifying payoffs by the limit payoffs. This approach to defining a Coalition Proof Nash Equilibrium to take account of the technical problems arising from the possible nonexistence of optimal deviations, is developed in Kahn and Mookherjee (1992b), and applied to the insurance economy in Kahn and Mookherjee (1991a).

The reason that extension to Trio-wise and beyond has no real effect in the economy studied in this paper is that all gains from trade are exhausted by two-player coalitions. Since the insurance companies are risk neutral, there are no economies gained from using multiple insurance companies: arrangements with two insurance companies have no advantage to the consumer over arrangements with a single insurance company.

A referee for this journal has proposed considering an interesting alternative solution concept in the spirit of allowing flexibility in coalition formation: define a *strong* deviation as one immune to further deviation by *any* subcoalition. Since such a restriction cuts down on the permitted set of deviations, it considerably weakens the corresponding equilibrium concept; indeed, in a certain sense it is the weakest possible refinement of Nash Equilibrium along the lines described in this paper. Therefore let us call a strategy vector immune to any strong deviation a 'Weak Equilibrium'. Then every PICSE is a weak equilibrium, and part (b) of the theorem below therefore extends immediately to weak equilibria.

We now use these equilibrium concepts to analyze the insurance market game in the various informational context we have described. Our main result is the following:

Proposition. (a) *Under the first- (resp. second-) best information structure, IICSE outcomes and PICSE outcomes are identical, and coincide with the first- (resp. second-) best efficient outcomes. Under the first-best information structure, SE outcomes coincide with the first-best efficient outcomes.*

(b) *Every third-best efficient outcome can be achieved as a PICSE outcome in the third-best environment with lump-sum redistribution of endowments.*

This result establishes our main contention that if the information structure is taken as given in the same manner to both social planner and private agents, then a competitive market for private insurance contracts yields equilibria that are no less efficient than can be achieved by the social planner. In the first-best and second-best contexts, there is a complete equivalence between market outcomes and the solutions to the planning problem; moreover, the solution concepts IICSE and PICSE coincide (and, in the first-best coincide with SE as well). In the third-best setting our result is somewhat more limited, though sufficient for our purposes: it corresponds to the analogue of the Second Theorem of Welfare Economics. We have not been able to provide a satisfactory answer to the question whether in this context the analogue of the first welfare theorem also holds, i.e. is it the case that every PICSE outcome results in the third-best efficient outcome?[12] Finally, it can be shown that in the third-best setting the different solution concepts do yield different answers. Specifically, there exists no SE or IICSE for a broad class of cases (i.e. where the third-best utility level is strictly below the second-best level), so our use of the PICSE notion is indeed essential.

4. Concluding comments

4.1. The role of governments in monitoring and regulating side trades

These results suggest the lack of any strong argument for governmental intervention in the provision or regulation of insurance, once the monitoring

[12] In Kahn and Mookherjee (1991a), which deals with the related solution concept of Coalition Proof Nash Equilibrium, we establish a local version of the First Welfare Theorem, stating that under some weak continuity assumptions for the third-best utility 'frontier', every equilibrium where aggregate profits are 'small' must generate third-best utility for the consumer. However, equilibria with large profits can exist, and nothing is known about the efficiency of these. We do not attempt to provide analogous results for PICSE here because the

structure is taken as given. The same need not apply, however, to the context of monitoring activities. It is clear that monitoring of side trades is socially beneficial, since it extends the set of feasible contracts in a desirable fashion. But the above argument says nothing about the desirability of making government the monitor.

There are potential arguments for and against using the government to monitor side trades. Since the government must raise taxes for essential public goods, it is already involved in monitoring transactions in a large variety of goods and services. Therefore there may be an economy of scope in extending government monitoring activities to those transactions with moral hazard spillover effects. Secondly, since monitoring market transactions often involves a certain invasion of privacy for economic agents, it may be desirable to restrict such privileges to governments which are politically and legally accountable for possible breaches of such privilege. The power of coercion vested in governments is not typically allocated to private parties: in the absence of such power private parties may be unable to monitor suitably. However, there are potential advantages to 'privatizing' monitoring: monitoring by private parties may be less prone to corruption, and to the extent that private monitoring agencies sell their information to interested parties, the presence of market incentives and reputational concerns might enhance efficiency and reliability of monitoring activities.[13] In certain contexts, such as in the management of common property resources, it may be argued that monitoring is most economically carried out by the various users themselves, rather than by a government.[14] The value of peer monitoring has also been stressed in the context of group-based rural credit schemes.[15]

Even if governments could be argued to play an active role in monitoring related transactions, there is also the question of how the information generated by such monitoring ought to be utilized in a context involving the private provision of insurance. One possibility is for the government to directly regulate such transactions (e.g. ban side trades, or tax them suitably). A less active role would involve dissemination of this information to insurance providers and contract enforcers. The problem with the former approach is that it requires the government to have sufficient information about the utility functions of insurance customers and the structure of the insurance market to be able to calibrate the corrective taxes suitably. The problem with the latter approach is that it may involve substantial costs of communication (from the government to interested parties), as well as of information collation, memory and retrieval. For instance, information

[13] In the context of credit markets, such monitoring services are indeed provided by specialized credit rating bureaus.

[14] See Ostrom (1990).

[15] See the articles on rural credit in Hoff et al. (1993).

concerning transactions entered into by a specific customer with disparate third parties and in disparate commodities would have to have collated, aggregated, retrieved and communicated to insurance firms. The alternative of imposing a tax on such transactions may avoid most of these problems.

It may also be argued that there are essential coordination gains from combining primary insurance provision and monitoring of related activities within the same organization. Consequently, if monitoring is socially worthwhile and there are strong arguments for the government to be active in monitoring related trades, then this also implies the desirability of public provision of insurance. The coordination advantages may include costs of and speed of communicating information, or other complementarities between insurance provision and attendant monitoring. Detailed arguments concerning these, however, need to be spelt out explicitly. In view of the well-known theoretical difficulties of defining the boundaries between organizations and markets, such arguments for active government intervention in insurance provision are unlikely to be simple.

4.2. Summary

The above discussion suggests that there may be some merit to the argument that governments ought to play an active role in monitoring and regulating side trades in order to enhance the efficiency of markets subject to moral hazard. But it does not contradict the basic results of the paper: holding the level of information constant, competitive insurance markets achieve constrained efficient outcomes in the presence of moral hazard, even with the possibility of side trading[16].

A more precise analysis of the pros and cons of active intervention by the government will necessitate incorporation of a complex set of issues that go beyond the ambit of conventional models of market failure. These include aspects of returns to scale in monitoring, the overall costs of monitoring relative to the benefits in terms of enhanced efficiency in insurance contracting, the efficient degree of decentralization of monitoring activities, and costs of collecting taxes vis-à-vis costs of collating, aggregating and communicating information concerning side trades. Political issues such as the feasibility of allowing private parties to monitoring transactions are also likely to be important.

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[16] Under adverse selection, efficiency is problematic even without side trading. See Myerson (1988) and Kahn and Mookherjee (1995).

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Appendix

Proof of the Proposition. (a) Consider the first-best environment: analogous arguments apply to the second-best environment as well. We first show that every SE, IICSE and PICSE must give the consumer his first-best utility level. Consider any outcome giving the consumer less than first-best utility. Since the consumer can trade with only a finite number of firms, there exists a passive firm earning zero profits. Form the coalition of the consumer and this firm, where they agree to exchange the 'first-best' exclusive contract: i.e. in which the firm promises to offer the first-best insurance bundle, the consumer will request the first-best bundle from this firm, engage in the first-best level of effort and request zero insurance from any other firm. Since all these actions are verifiable, the contract, if executed, completely restricts second-stage actions. If the contract is not executed, second-stage actions are immaterial; assume both parties engage in zero trade in that event. Since the consumer is better off, while the firm is no worse off, this is a two-player agreement that blocks the original agreement. Moreover, it is individually incentive compatible, since both the consumer and the firm are playing best responses to one another. Therefore, the initial allocation could not have been a PICSE, IICSE, or SE outcome.

Next we show that every SE, IICSE and PICSE must result in every firm earning nonpositive profit. If some firm earned positive profit, it must be the case that the consumer earns less than first-best utility, and this has already been ruled out.

Moreover, there cannot be any SE, IICSE, or PICSE resulting in any firm earning negative profit. If the firm is playing a best response and obtaining negative profit, the agreement fails to be IIC. If the firm does not have a best response, it must be the case that some response attains a positive profit (since the zero-profit response is feasible and not a best response). Moreover, IIC requires that if the firm were to unilaterally switch to an action which gave it positive profit, the consumer could not be worse off. Hence the agreement must be giving the consumer less than first-best utility, which has been ruled out above. Therefore, every SE, IICSE and PICSE must provide the consumer with first-best utility, and every firm with zero profit.

It remains to show that SE exist, and necessarily yield the first-best outcome. We claim the following is an SE. Firm 1 offers the first-best exclusive contract to the consumer who requests the same, offers first-best effort, and requests no trade with any other firm. The associated second-step actions are as described above. All other firms offer nothing and do not trade in the second step. This agreement cannot be blocked by another agreement, for if there were one, $(\boldsymbol{b}, S)$ which did block it, the resulting allocation would Pareto dominate the first-best outcome: if firm 1 were part of S, its profit would continue to be non-negative, while no other firm would suffer losses, and the consumer would be no worse off, and at least one party would be better off. If firm 1 were not part of S, even then its profit would continue to be non-negative, since if the contact offered by firm 1 with the consumer is not executed, firm 1 will end up not trading. So in this case also there must be a Pareto improvement. This completes the proof of (a).

Now consider part (b), pertaining to the third-best environment. Start with the case where in the third-best outcome aggregate profits are equal to 0. If profits in the outcome are greater than zero, redistribute those profits (in both states of nature) and repeat the argument.

Consider the following strategies. Player 1 offers the third-best contract, players $j = 2, 3 \ldots$ offer the safe cone, the consumer requests the third-best contract from 1, nothing from the other players, and chooses the third-best level of effort.

First we show that there is no IIC agreement which blocks the proposed agreement for the grand coalition and gives firm 1 non-negative profits. For if there were some such agreement, the outcome would Pareto dominate, and therefore must violate the third-best constraint. Since the coalition necessarily excludes some firm the purchase of any trade in the safe cone, T is available to the consumer. Hence the blocking coalition cannot be IIC.

Next we show that there cannot be any deviating agreement which blocks the strategy and gives firm 1 losses. To give firm 1 losses means that the consumer continues to buy the third-best level x^* from him and switches from a third-best effort of 1 to a deviating effort of 0. So the consumer must end up with more insurance than at x^* (i.e. must consume at a point to the northwest of P in Fig. 3). Therefore if the new total purchase x induces effort 0 and $x - x^*$ makes non-negative profits at an effort level of zero, then $x - x^*$ makes non-negative profits at an effort level of 1 as well. The total purchase from the other firms is thus an element of the safe cone. If the consumer is better off, we contradict the third-best property of x^*. If the consumer obtains exactly the same utility as at x^*, then the firms in the deviating agreement cannot obtain positive profit (otherwise there would exist a trade in the safe cone slightly more favorable to the consumer than $x - x^*$, which would give him higher utility, thereby contradicting the third-best efficiency of x^*), and so the deviation cannot block. From the above we conclude that the proposed agreement cannot be blocked by any other IIC agreement. Hence it is PIC, and not blocked by any PIC agreement.

The proof is completed by establishing that the utility level generated in any PIC agreement for the grand coalition cannot exceed the third-best efficient level. So the proposed agreement cannot be Pareto dominated by any such agreement, and must therefore constitute a PICSE. Note first that the IIC property for any such agreement involving the grand coalition implies that the resulting allocation (x, e) satisfies the following second-best feasibility constraints:

$$W(x, e) \geqslant \max_{e'} \quad W(0, e') ,$$

$$V(x^i, e) \geqslant 0 , \quad \text{for all } i ,$$

and

$$W(x, e) \geqslant \max_{e'} \quad W(x, e') .$$

If (x, e) is not feasible in the third-best problem, there must exist $\tau \in T$ and e^* such that $W(x + \tau, e^*) > W(x, e)$. Take an arbitrary firm f who does not trade in this agreement, and suppose that the consumer's problem of maximizing his utility by choosing a trade from all other firms, and an effort level, given a purchase of τ from firm f, has a solution (x', e'). Then consider the following two-player agreement, where firm f offers τ, the consumer chooses e', requests τ from that passive firm and x' from all the others. Then the agreement is IIC and we are done.

If the consumer's problem does not have a maximum, let e' denote the effort level that minimizes the profit of the firm f when trading τ with the consumer, i.e. $V(\tau, e') \leqslant V(\tau, e)$ for e not equal to e'. We know that since τ is in the safe cone, $V(\tau, e') \geqslant 0$. Then consider the two-player agreement where firm f offers τ, the consumer requests τ from f, chooses effort e', and requests aggregate trade x from all other firms. This agreement is IIC, since the consumer does not have a best response, but if he deviated to a superior action it would not hurt firm f. Since the consumer is better off, and firm f no worse off, the deviation blocks the original agreement. This completes the proof of the proposition. □

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