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Moral Hazard, Insurance and Public Loss Prevention

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ABSTRACT

The effect of public provision of a loss-preventive good on equilibrium in an insurance market under moral hazard is analyzed. The primary advantage of public provision lies in its ability to produce information, which alleviates moral hazard since the level of the public good is publicly known. However, public provision entails an efficiency loss since the public good level cannot be tailored to suit individual demands. The analysis formalizes this cost-benefit trade-off involved in public provision, and discusses when public provision improves on market equilibrium.

Introduction

A moral hazard problem occurs when actions taken by the insured affect the probability of a loss but cannot be observed by the insurer. In this case, the insurer cannot apply correct prices (premium and indemnity) that depend on the actions of the insured, leading to a market failure. Over the last two decades, many papers have offered suggestions for correcting the inefficiency caused by moral hazard. By and large, these studies are mainly concerned with designing incentive schemes that may reduce efficiency loss by using appropriate rewards and penalties (for example, see Shavell, 1979 and Rubinstein and Yaari, 1983). However, if moral hazard is viewed as a market failure, public sector intervention would be a plausible alternative to the market mechanism. For example, Pauly (1974) considers public provision of insurance, and Arnott and Stiglitz (1986) derive an optimal commodity taxation system that subsidizes (taxes) those goods that are complementary to (substitutable for) loss-prevention activities.

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The author wishes to thank Jan K. Brueckner for comments on an earlier version of this article. Two anonymous referees and an associate editor of this *Journal* also provided useful suggestions. This research was partially supported by a grant from the School of Business and Economics at Towson State University.

More direct intervention such as public provision of a loss-preventive good financed by taxation is considered in this article.¹ While only private loss-preventive goods (e.g., burglar alarm in case of theft insurance) are considered in the literature, in reality there are many public loss-preventive goods (e.g., patrol by public police). The primary advantage of public provision lies in its ability to generate information that alleviates the moral hazard problem since the level of the public good is publicly known. On the negative side, public provision creates an efficiency loss resulting from providing a uniform level of the public good for nonuniform consumers. Thus, public provision need not improve on market equilibrium. However, one may expect public provision to dominate the market outcome if the efficiency loss is small, or if the desired levels of the public good among different consumers are not much different, given the informational advantage. Also, regardless of the size of the efficiency loss, if the consumers who are not satisfied with the public good level can reproduce the market outcome by the additional purchase of private substitutes, they are no worse off under public provision than in market equilibrium. Hence, public provision may still dominate market equilibrium given that some consumers who consume the desired level are strictly better off under public provision.

The next section presents the model and inefficiency of market equilibrium in a competitive insurance market under moral hazard. Then, the welfare effect of public provision is analyzed, and conclusions follow.

Market Equilibrium under Moral Hazard

Consider an asset that is subject to a loss. Assuming that there are only two possible states, either the loss occurring or not, let the magnitude of the loss be fixed at L once it occurs. The probability of the loss occurring, denoted $p(x)$, decreases in the level of a loss-preventive good x . Without losing generality, normalize the price of x to unity.

Equilibrium in the competitive insurance market under moral hazard is examined based on Shavell (1979). The presence of moral hazard means that x cannot be observed by the insurer. In this case, an insurance contract clearly cannot depend on x . Instead, when one buys an insurance policy (π, q) with π and q denoting a premium and coverage respectively, the consumer will choose x to maximize expected utility

$$EU = \{1-p(x)\}U(w-\pi-x) + p(x)U(w-\pi-x-L+q), \quad (1)$$

¹ "Loss prevention" is sometimes called "self protection" to mean a reduction in a probability of a loss, while "loss reduction" (sometimes called "self insurance") means a reduction in the size of a loss. For details of the distinction between the two concepts, see Ehrlich and Becker (1972).

where w is the initial value of the asset and U is the concave utility function. Since the insurer should break even in a competitive market, the insurance policy satisfies $\pi = p(x(\pi, q))q$, where $x(\pi, q)$ maximizes (1). Assuming that there is a unique break-even premium $\pi(q)$ at a given q , write $x(q)$ for $x(\pi(q), q)$. Then, expected utility may be written as a function of q such that

$$EU(q; w, L) = \{1 - p(x(q))\}U(w - \pi(q) - x(q)) + p(x(q))U(w - \pi(q) - x(q) - L + q). \quad (2)$$

Assuming that there exists a $q \in (0, L)$ maximizing $EU(q; w, L)$, denoted $\hat{q}$, the market equilibrium under moral hazard is characterized by an optimal insurance policy $(\pi(\hat{q}), \hat{q})$.² Call this market equilibrium the "NPP (No Public Provision) equilibrium" as compared to the equilibrium with public provision of a loss preventive good in the next section. For the future reference, let $\hat{x} = x(\hat{q})$ and $\pi(\hat{q}) = p(\hat{x})\hat{q}$. Since $\hat{q} < L$, the insured retains some risk despite buying insurance, and hence the NPP equilibrium is not first-best efficient.

Public Provision of a Loss-Preventive Good

There are many public loss-preventive goods. For example, the police affect theft insurance; fire stations influence fire insurance; stricter enforcement of speed limits, wearing seatbelts, and improving the traffic control system affect automobile insurance. Since public and private (loss-preventive) goods have different productivities and costs, scale economies (or diseconomies) in public provision are investigated first. Suppose that the public sector wants to provide some level of the loss-preventive good, say x , to an individual. Then, following the public finance literature (e.g., Borchering and Deacon, 1972), the public output level yielding individual consumption x may be determined by the relationship

$$x = z/n^\alpha, \quad (3)$$

where z is the public output level, n is the number of consumers, and α is a congestion (publicness) parameter.³ For example, in a community with n people, the public police station with police capacity z gives each individual police service of z/n^α .

² Shavell (1979) shows that $\hat{q} > 0$ always, and that $\hat{q} < L$ unless the cost (price) of x approaches zero.

³ If $\alpha = 1$, then the public good z is essentially a (publicly provided) private good. On the other hand, if $\alpha < 1$, then z has some publicness subject to congestion while $\alpha = 0$ means that z is a pure public good. For further discussion of the relationship between x and z , see Borchering and Deacon (1972).

Let $C(z) = \beta z$ be the cost of providing a public output level z with β denoting a constant marginal cost. Then, the cost of providing enough z to yield per capita consumption x for n consumers is

$$C(z) = C(n^\alpha x) = \beta n^\alpha x, \quad (4)$$

and the per capita cost is $\beta n^{\alpha-1}x$. Thus, $\beta n^{\alpha-1}$ represents the cost per unit of x when x is publicly provided. If $\beta n^{\alpha-1} < (>) 1$, there are cost savings (losses) from public provision. However, to focus on other more important aspects of public provision, assume that $\beta n^{\alpha-1} = 1$, and that public provision has no advantage or disadvantage over the private good in terms of the cost.

To analyze the welfare effect of public provision of a loss-preventive good, for the time being, assume that consumers are homogeneous. Since the per capita consumption of x is observable via z under public provision, the premium π can be conditioned on x . In this case, as is well known in the literature, the optimal insurance policy involves full coverage, and hence is first-best efficient, leading to the following lemma:

Lemma 1. Assume that $\beta n^{\alpha-1} = 1$. In an economy with homogeneous consumers, public provision improves on the NPP equilibrium.

To see the lemma, note first that since consumers are assumed to be homogeneous, they will choose unanimously x (actually z) by simple majority voting to maximize

$$U(w - \pi(x) - \beta n^{\alpha-1}x) = U(w - p(x)L - x). \quad (5)$$

Let x^* maximize (5), and u^* be the resulting utility level in (5). Then, comparing u^* with $EU(\hat{q}; w, L)$ in the NPP equilibrium,

$$\begin{aligned} u^* \equiv U(w - p(x^*)L - x^*) &\geq U(w - p(\hat{x})L - \hat{x}) > \\ &\{1 - p(\hat{x})\}U(w - p(\hat{x})\hat{q} - \hat{x}) + \\ &p(\hat{x})U(w - p(\hat{x})\hat{q} - \hat{x} - L + \hat{q}) = EU(\hat{q}; w, L), \end{aligned} \quad (6)$$

where the first inequality follows from the definition of x^* , and the second one follows from Jensen's inequality, establishing the result. The lemma means that public provision is superior to the NPP equilibrium due to informational advantage given that the cost of public provision is the same as that of the private good.⁴

Since the economy consists of heterogeneous consumers in general, assume that there are two types of consumers, denoted by subscripts i and j , who differ in wealth and loss with $L_j > L_i$, and that type- i 's (type- j 's) are

⁴ Note that for public provision to dominate the NPP equilibrium, the scale factor $\tau \equiv \beta n^{\alpha-1}$ need not be unity. To see this, let $f(\tau) \equiv U(w - p(x^*) - \tau x^*) - EU(\hat{q}; w, L)$. Then, since $f(1) > 0$ by Lemma 1, and since $f(\tau)$ does not increase in τ , $f(\tau) > 0$ for all τ , or there exists $\tau^* > 1$ such that $f(\tau) > (\leq) 0$ for all $\tau < (\geq) \tau^*$, establishing the claim.

the majority (the minority). Although the scale factor τ is assumed to be one, an individual's tax amount per unit of x depends on the tax system.

Consider equal taxation of i and j and a Lindahl tax sequentially. Under the equal tax assumption, the tax per unit of x is unity for everyone, and the majority will choose x to maximize

$$U(w_i - p(x)L_i - x), \quad (7)$$

and let x_i^* maximize (7). Then, since the majority consume the desired level of x , Lemma 1 applies, and the majority are better off under public provision than in the NPP equilibrium. On the other hand, the minority cannot consume the desired level of x , and hence public provision need not improve on their welfare although it alleviates the informational problem related to moral hazard.

To see the welfare effect on the minority, suppose that the minority accept the public good level chosen by the majority, x_i^* , and enjoy the utility level $U(w_j - p(x_i^*)L_j - x_i^*)$. Then, since x_j^* approaches x_i^* as L_j approaches L_i , if L_j is not much different from L_i , or if $\delta \equiv L_j - L_i$ is less than some critical value δ^* at which the minority are indifferent between public provision and the NPP equilibrium,⁵ then the utility loss from consuming x_i^* would be small. Hence, the minority would be better off under public provision given the full coverage insurance benefit. Alternatively, since the minority can supplement x_i^* by the additional private purchase of x , denoted x^s , when $\hat{x}_j \geq x_i^*$, they can reproduce the NPP equilibrium outcome by purchasing privately $x^s = \hat{x}_j - x_i^*$, and they are no worse off under public provision than in the NPP equilibrium. This result is summarized without proof as follows:⁶

Proposition 1. Under the equal tax assumption, if $\delta \leq \delta^*$ or if $x_i^* \leq \hat{x}_j$, then public provision improves on (Pareto-dominates) the NPP equilibrium.

To relate the proposition to the casual observation that many consumers, not only the minority in Proposition 1, usually purchase the private good (burglar alarm) in the market even with public provision (public police), assume more realistically that there are n different consumers. Then, voting equilibrium will be the median voter's most preferred level of x . Thus, no consumer except the median voter can consume the desired level of x under public provision, and it is quite possible that many consumers supplement public provision by the additional purchase of the private good.

The problem with equal taxation is that the minority cannot consume the desired level of the public good. A solution to the problem is to allow different consumers to pay different taxes so that everyone desires to

⁵ That is, $U(w_j - p(x_i^*)L_j - x_i^*) \geq EU(\hat{q}_j; w_j, L_j)$ for $\delta \leq \delta^*$. While it is possible that the inequality holds for all δ , it is not an interesting case.

⁶ While it is desirable to know when $x_i^* \leq \hat{x}_j$, it is not possible without more knowledge of preferences, the probability $p(x)$, and the difference in wealth and loss between the two types.

consume the same amount of the public good at his or her tax, which is called "Lindahl tax."

To see how the Lindahl tax is determined, note that since per unit cost of x is unity by the assumption that $\beta n^{\alpha-1} = 1$, the government budget constraint is

$$n_i t_i x + n_j t_j x = (n_i + n_j) x. \quad (8)$$

where n_i is the number of type- i 's, and t_i is the per unit tax for type- i 's. Type- i 's will choose x (again actually z) to maximize

$$U(w_i - p(x)L_i - t_i x). \quad (9)$$

Assuming that there exists an interior solution, the first-order condition for an optimal x is

$$-U'(w_i - p(x)L_i - t_i x) [p'(x)L_i + t_i] = 0. \quad (10)$$

Analogously, type- j 's utility maximizing choice of x satisfies

$$-U'(w_j - p(x)L_j - t_j x) [p'(x)L_j + t_j] = 0. \quad (11)$$

Since the Lindahl tax induces both types to choose or desire the same amount of x , from first-order conditions (10) and (11) it must be true that

$$p'(x) = -t_i/L_i = -t_j/L_j. \quad (12)$$

and let x^{**} satisfy (12). Solving (12) and budget constraint (8) for t_i and t_j yields the Lindahl tax⁷

$$t_i = (n_i + n_j)L_i / (n_i L_i + n_j L_j) \text{ and } t_j = (n_i + n_j)L_j / (n_i L_i + n_j L_j). \quad (13)$$

While both the majority and the minority may consume the desired level of the public good under the Lindahl tax, the Lindahl tax poses an adverse selection problem, and cannot be implemented when types are not observable. That is, since $t_j > t_i$ by the assumption that $L_j > L_i$, type- j 's will misrepresent themselves as type- i 's to avoid the higher tax. Thus, to make the Lindahl tax incentive compatible, the public sector may use an additional lumpsum subsidy and tax, as discussed in Rothschild and Stiglitz (1976) and Lee (1991), such that

$$U(w_j - p(x)L_j - t_j x + T) \geq U(w_j - p(x)L_j - t_j x - n_j T/n_i) \quad (14)$$

⁷ Since the Lindahl tax is nothing but a personalized willingness to pay for the public good, it may depend on expected utility in a complicated way. However, under the Lindahl tax everyone buys full insurance as discussed in the text, and there is no uncertainty. Thus, one's willingness to pay for x is simply a marginal reduction in his or her premium or expected loss, $-p'(x^{**})L_i$, due to a marginal increase in x .

$$U(w_i - p(x)L_i - t_j x - n_j T/n_i) \geq U(w_i - p(x)L_i - t_j x + T), \quad (15)$$

where $T (-n_j T/n_i)$ is the per capita subsidy (tax) to anyone who pays the per unit tax t_j (t_i). Note that this subsidy scheme does not change government budget constraint (8), because n_i consumers pay $n_j T/n_i$ and n_j consumers receive T .⁸ Furthermore, since T does not depend on x , the subsidy scheme does not change first-order conditions (10) or (11), and hence the Lindahl tax with the subsidy still induces both types to desire the same level of the public good, x^{**} . Then, since both types should pay the same amount of tax for x^{**} in order to satisfy incentive compatibility constraints (14) and (15), the per capita subsidy T should satisfy

$$t_j x^{**} - T = t_i x^{**} + n_j T/n_i, \text{ or } T = n_j x^{**} (t_j - t_i) / (n_i + n_j). \quad (16)$$

Substituting T from (16) into the utility functions yields $U(w_i - p(x^{**})L_i - t_i x^{**} - n_j T/n_i) = U(w_i - p(x^{**})L_i - x^{**})$ and $U(w_j - p(x^{**})L_j - t_j x^{**} + T) = U(w_j - p(x^{**})L_j - x^{**})$, which means that the actual tax per unit of x (taken into the subsidy account) is unity. Then, since both types would choose different levels of x from x^{**} if the tax per unit of x were unity ($t_i = t_j = 1$), x^{**} does not maximize $U(w_k - p(x)L_k - x)$ with $k = i, j$. In fact, x_i^* in (7) maximizes $U(w_i - p(x)L_i - x)$, and analogously x_j^* .

Thus, public provision under the Lindahl tax with the subsidy need not improve on the NPP equilibrium, because neither types consume the desired level of the public good at their tax-subsidy while both types enjoy the full coverage insurance benefit. However, since both x_j^* and x_i^* approach x^{**} as L_j approaches L_i , if δ is less than some critical value δ^{**} ,⁹ then public provision improves on the NPP equilibrium by the same reasoning as one used in Proposition 1, and this result is stated as follows:

Proposition 2. Under the Lindahl tax with the subsidy, if $\delta < \delta^{**}$, then public provision improves on (Pareto-dominates) the NPP equilibrium.

There are two points to be made regarding Proposition 2. First, both types can reproduce the NPP equilibrium outcome and are no worse off under public provision than in the NPP equilibrium by supplementing x^{**} in the private market when $\hat{x}_i \geq x^{**}$ and $\hat{x}_j \geq x^{**}$. However, neither types may be strictly better off under public provision, and hence the condition that $\hat{x}_i \geq x^{**}$ and $\hat{x}_j \geq x^{**}$ is not sufficient for public provision to improve on the NPP equilibrium. Second, if types are observable and the subsidy is not needed to implement the Lindahl tax t_i and t_j , then both types consume the desired level of the public good, x^{**} . However, since $t_j > 1 > t_i$, type- j 's pay the tax

⁸ Although types are not observable, a standard assumption in the literature uses n_i type- i 's and n_j type- j 's.

⁹ That is, there are two critical values of δ such that $U(w_i - p(x^{**})L_i - x^{**}) \geq EU(\hat{q}_i; w_i, L_i)$ for $\delta \leq \delta_i^*$ and $U(w_j - p(x^{**})L_j - x^{**}) \geq EU(\hat{q}_j; w_j, L_j)$ for $\delta \leq \delta_j^*$. Then, choose $\delta^{**} = \min(\delta_i^*, \delta_j^*)$.

per unit of x greater than the market price, and need not be better off under public provision than in the NPP equilibrium although they enjoy the full coverage insurance benefit. In this case, type- i 's are, of course, better off under public provision.

From Propositions 1 and 2, the reason why public provision does not necessarily improve on the market outcome under moral hazard is not decentralized voting behavior or the specific tax system, but the inherent efficiency loss due to provision of a uniform level of the public good for nonuniform consumers.

Discussion and Conclusion

Given the moral hazard problem in an insurance market, this article examines the possibility that the competitive market outcome is improved by public sector intervention in the form of public provision of a loss-preventive good. While public provision of loss-preventive goods has not been discussed in the literature, casual observation suggests that sometimes public loss-preventive goods play much more important roles in the insurance market than private loss-preventive goods do.

The relative superiority of public provision critically hinges on its ability to produce information that allows the insurer to indirectly observe the insured's consumption of a loss-preventive good via the public good. A natural question arises about whether a privately provided public good (e.g., private police or fire service) generates the same information. Although the private sector can provide the exactly same public good (police or fire service) as the public sector, and although the privately provided public good is also observable, the privately provided public good does not generate the same information as public provision. The private sector cannot force people to buy or pay for the public good while the public sector can by imposing taxes. Also, some consumers may not buy the public good due to different preferences and different economic conditions if they were allowed not to buy. Accordingly, an insurer cannot observe the individual consumption of the loss-preventive good even if the public good itself is observable. Thus, the public sector can make a credible commitment to the provision of the loss-preventive good for individuals while the private sector cannot make the same commitment.¹⁰

However, under different market arrangements, private agents may, to some extent, produce information regarding loss prevention. For example, insurers may sell insurance together with loss-prevention services, as discussed in a different context in Schlesinger and Venezian (1986), and clearly can solve the informational problem associated with moral hazard. Then, the relative informational advantage of public provision in general would depend on how credibly and how cheaply private agents make a

¹⁰ This discussion was inspired by the two referees.

commitment to the provision of the loss-preventive good. Further research on this point seems warranted.

Regarding the roles of private and public goods, the model in this article is not rich enough to allow individuals to choose both goods. Instead, the author primarily considers the insurance market with only a private good or only a public good (although individuals may supplement the public good by purchasing the private good). In a more general model, the probability of loss occurring would depend on both goods, and the two goods could be complements or substitutes. Thus, it is quite possible that public provision might discourage the private incentive to self-protect when the two goods are substitutes, creating another moral hazard problem. This generalization of the model would seem to be fruitful. In fact, Lewis and Nickerson (1989) discuss this issue in the case of self-insurance against natural disasters where the government provision of disaster relief (financial aid to victims) influences the care individuals exercise to protect their property from damage.

References

- Arnott, Richard and Joseph E. Stiglitz. 1986, Moral Hazard and Optimal Commodity Taxation, *Journal of Public Economics*, 29: 1-24.
- Borcharding, Thomas E. and Robert T. Deacon. 1972, The Demand for The Services of NonFederal Governments, *American Economic Review*, 62: 891-901.
- Ehrlich, Isaac and Gary S. Becker. 1972, Market Insurance, Self-Insurance, and Self-Protection, *Journal of Political Economy*, 80: 623-48.
- Lee, Kangoh, 1991, Transaction Costs and Equilibrium Pricing of Congested Public Goods with Imperfect Information, *Journal of Public Economics*, 45: 337-62.
- Lewis, Tracy and David Nickerson. 1989, Self-insurance against Natural Disasters, *Journal of Environmental Economics and Management*, 16: 209-23
- Pauly, Mark V., 1974, Overinsurance and Public Provision of Insurance: Roles of Moral Hazard and Adverse Selection, *Quarterly Journal of Economics*, 88: 44- 62.
- Rothschild, Michael and Joseph E. Stiglitz. 1976, Equilibrium in Competitive Insurance Markets: An Essay on The Economics of Imperfect Information, *Quarterly Journal of Economics*, 90: 629-50.
- Rubinstein, Ariel and Menahem E. Yaari. 1983, Repeated Insurance Contracts and Moral Hazard, *Journal of Economic Theory*, 30: 74-97.
- Schlesinger, Harris and Emilio Venezian, 1986, Insurance Markets with Loss- Prevention Activity: Profits, Market Structure, and Consumer Welfare, *Rand Journal of Economics*, 17: 227-38.
- Shavell, Steven, 1979, On Moral Hazard and Insurance, *Quarterly Journal of Economics*, 93: 541-62.

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