

Article

Monopolistic Insurance and the Value of Information

Arthur Snow

Department of Economics, University of Georgia, Athens, GA 30602, USA;

E-Mail: snow@uga.edu; Tel.: +1-706-542-3752

Academic Editor: Georges Dionne

Received: 17 April 2015 / Accepted: 10 July 2015 / Published: 24 July 2015

Abstract: The value of information regarding risk class for a monopoly insurer and its customers is examined in both symmetric and asymmetric information environments. A monopolist always prefers contracting with uninformed customers as this maximizes the rent extracted under symmetric information while also avoiding the cost of adverse selection when information is held asymmetrically. Although customers are indifferent to symmetric information when they are initially uninformed, they prefer contracting with hidden knowledge rather than symmetric information since the monopoly responds to adverse selection by sharing gains from trade with high-risk customers when low risks are predominant in the insurance pool. However, utilitarian social welfare is highest when customers are uninformed, and is higher when information is symmetric rather than asymmetric.

Keywords: adverse selection; rent extraction; interim efficiency; *JEL classification:* D42; D82; G22

1. Introduction

Will a risk-neutral monopolistic insurer provide information to uninformed insurance applicants regarding their membership in either of two risk classes when that information is costless to obtain and transmit? The answer is no. The most rent the insurer can extract from a customer is the consumer surplus gained with full-and-fair insurance, which is measured by the Arrow-Pratt risk premium. Since the risk premium inherits concavity in the loss probability from concavity of utility in wealth, Jensen's inequality implies that profit is strictly greater at the average probability than at any mean-preserving combination of high and low probabilities. Indeed, the monopoly has an incentive to confuse informed

customers regarding their inherent risks, while customers are indifferent to being so manipulated since they never share in the gains from trade.

Will insurance applicants prefer symmetric information about risk class over asymmetric information? The answer is no. When information is symmetric the monopolist achieves perfect rent extraction from each risk class, and provides no consumer surplus to any class of insurance applicant. When information is asymmetric and low risks are sufficiently predominant in the applicant pool, a monopolist finds it profitable to sacrifice rent to high risks in order to extract rent from low risks. In this event, high-risk applicants realize a positive consumer surplus, and prefer contracting with asymmetric information. Indeed, from behind a veil of ignorance regarding one's risk class and the proportion of high risks among the applicants, all applicants prefer the asymmetric information regime.

Will social welfare be higher when information about risk class is asymmetric rather than symmetric? The answer is no. The applicants' preference for asymmetric information is based on their competitive behavior, which includes their taking wealth as exogenous and ignoring the wealth consequences of adverse selection. Specifically, because of adverse selection, monopoly profit is lower under asymmetric rather than symmetric information. When the monopolist is a Pareto-relevant agent, this reduction in profit is irrelevant to the applicants' preference for asymmetric information; alternatively, when rights to monopoly profit are distributed equally among the applicants, their competitive decision calculus takes wealth as exogenous and fails to account for the reduction in wealth that accompanies a change from symmetric to asymmetric information.

However, under either approach to accounting for monopoly profit, utilitarian social welfare is higher when information is symmetric. The reason is that an interim efficient sharing of risk is attained under monopolistic insurance and symmetric information. Knowing their risk types, the monopolist can achieve full rent extraction by offering contracts that provide full coverage. However, interim efficiency cannot be attained when information is asymmetric.

These conclusions stand in contrast with those implied by competitive insurance contracting. In that environment, insurers are indifferent to the informational regime, while customers prefer uninformed contracting to avoid exposure to the classification risk that accompanies symmetric information, and prefer symmetric to asymmetric information to avoid the cost of adverse selection. As with monopolistic insurance, however, social welfare is highest with uninformed contracting, and social welfare is always higher with symmetric rather than asymmetric information.

Rothschild and Stiglitz [1] initiated the study of competitive insurance contracting when applicants possess hidden knowledge of risk class, emphasizing the economic cost of adverse selection. Stiglitz [2] characterized the monopoly equilibrium for the Rothschild-Stiglitz insurance market, establishing that high-risk customers receive full coverage, while low risks are only partially covered, if at all. These conclusions assume the monopolist is an independent agent, but remain valid when rights to the monopoly profit are distributed equally among the applicants.

A model of monopolistic insurance contracting is set out in the next section, and the value of symmetric information about risk class for the monopolist and its customers is examined in Section 3. The implications of informational asymmetry for these evaluations are explored in Section 4. The social value of information is analyzed in Section 5, and conclusions are offered in Section 6.

2. Insurance Contracting under Monopoly

The insurance market consists of a large number of insurance applicants who demand coverage for independent risks of losing an amount of wealth x . Each applicant is endowed with wealth w , the risk-averse utility function $u(w)$, and a probability of incurring the loss x . The insurance pool consists of two classes of these individual risks, a proportion $\lambda \in (0,1)$ of customers being endowed with probability p^H of incurring the loss, the remaining proportion being endowed with probability $p^L < p^H$. (Chade and Schlee [3] analyze adverse selection when a monopolistic insurer contracts with customers from many risk classes. Jeleva and Villeneuve [4] analyze monopolistic insurance in the two-type case when customers maximize rank-dependent utility. Asheim and Nilssen [5] examine the case when renegotiation is possible after customers initially choose contracts.) Uninformed customers believe they have the population's average risk,

$$\bar{p} = \lambda p^H + (1 - \lambda) p^L \quad (1)$$

when evaluating a given contract. (That is, uninformed customers share an unbiased belief about risk class and, since expected utility is linear in probabilities, the value of a given contract is based on the average risk. By contrast, uninformed customers evaluating an informational regime in which they are perfectly categorized confront a classification risk when each customer's contract, as well as the probability of loss, depends on the customer's revealed risk class.) Informed customers know their risk classes, and this information constitutes their hidden knowledge when information is asymmetric. (With asymmetric information, customers are assumed to be better-informed than the insurer. Villeneuve [6] analyzes the opposite case, when the insurer is better-informed than its customers. Customers are also assumed to be identical except for the risk of loss. Landsberger and Meilijson [7] analyze monopolistic insurance when customers possess hidden knowledge of both risk and risk aversion.) Applicants treat all these parameters as exogenous, along with the insurance contracts on offer.

The insurer is monopolistic and can make all-or-nothing contractual offers consisting of a premium m and an amount of coverage c , and can make more than one such offer. The expected utility of a t -type applicant opting for a contract with premium m and coverage c is denoted by

$$EU^t(m, c) = (1 - p^t)u(w - m) + p^t u(w - m - x + c) \quad (2)$$

A contract $[m, c]$ must satisfy the voluntary participation constraint

$$EU^t(m, c) \geq EU^t(0, 0) \quad (3)$$

if it is to attract a type t customer. When information is asymmetric, contracts must be incentive-compatible, with the members of each risk class preferring their intended contract. When customers are uninformed, the value of the contract $[m, c]$ is given by the expected value of Equation (2), $(1 - \bar{p})u(w - m) + \bar{p}u(w - m - x + c)$, denoted by $E\bar{U}(m, c)$.

Following Malinvaud's [8] lead, the law of large numbers is assumed to apply to each risk class individually, so that a contract $[m^t, c^t]$ taken exclusively by those in risk class t earns the insurer a per-customer profit equal to the contract's expected value,

$$\Pi^t = m^t - p^t c^t, \quad (4)$$

with probability one. As the aggregate risk presented by each risk class is negligible, the insurer behaves as if neutral to risk, that is, as if there were no aggregate risk. (As shown by Malinvaud [8], and discussed in more general terms by Rothschild and Stiglitz [1], individual risks are “socially removed by the operation of the law of large numbers.”) Hence, the insurer maximizes expected profit, treating the parameters describing the applicant pool as exogenous.

One way to account for the insurer’s profit is to assume that the monopolist is a Pareto-relevant agent whose welfare is measured by monopoly profit, and each applicant’s wealth is then $w = w^O$, where w^O is exogenous. An alternative approach assumes that ownership rights in the monopoly are uniformly distributed among the insurance applicants, so that the wealth w taken as exogenous by applicants and by the monopolist is actually endogenous, being given by

$$w = w^O + \Pi, \quad (5)$$

where $\Pi = \lambda \Pi^H + (1 - \lambda) \Pi^L$ is monopoly profit per applicant. Since the risk to this profit is negligible, applicants behave as if wealth w is riskless. (In this environment, the monopolist is a mutual or participating insurer. As in Picard’s [9] analysis of competitive participating insurers facing adverse selection, in equilibrium customers receive neither dividends nor calls for additional premiums, there being no aggregate risk.) In either case, when evaluating alternative information regimes, the monopolist and applicants treat w as if it were exogenous.

3. Symmetric Information

Stiglitz [2] shows that when information is symmetric, the monopolistic insurer can attain perfect rent extraction, providing full coverage while charging a premium that extracts all consumer surplus, the latter being measured by the Arrow-Pratt risk premium, $\pi(p^t, w)$, defined implicitly by

$$u(w - p^t x - \pi(p^t, w)) = EU^t(0, 0) \quad (6)$$

Hence, the contract $[m^t = p^t x + \pi(p^t, w), c^t = x]$ maximizes monopoly profit.

Assume initially that applicants and the monopolist are “symmetrically uninformed,” so that each behaves as if the risk of loss were \bar{p} for each applicant. Monopoly profit per applicant is then $\pi(\bar{p}, w)$. Now suppose the monopolist can costlessly obtain and transmit information regarding each applicant’s risk class, thereby changing the environment into one in which applicants and the monopolist are “symmetrically informed.” Would doing so be profitable for the monopolist? When applicants are informed of their risk classes, monopoly profit varies by class, and profit per applicant is then given by $\lambda \pi(p^H, w) + (1 - \lambda) \pi(p^L, w)$, which is less than $\pi(\bar{p}, w)$ since the Arrow-Pratt risk premium inherits concavity in probability from risk aversion in utility. (Lees and Rice [10] provide a diagrammatic exposition of Lemma 1.)

Lemma 1: $\pi(p, w)$ is a strictly concave function of p if and only if u is a strictly concave function of wealth, that is, $\partial^2 \pi(p, w) / \partial p^2 < 0$ if and only if $u''(w) < 0$. (Throughout, primes are used to denote utility derivatives.)

Proof Definition (6) for the risk premium implies

$$\partial \pi(p, w) / \partial p = -x + [u(w) - u(w - x)] / \hat{u}',$$

where $\hat{u}' = u'(w - px - \pi(p, w))$. For the second derivative, one obtains

$$\partial^2 \pi(p, w) / \partial p^2 = \{[u(w) - u(w - x)] / \hat{u}'\}^2 [\hat{u}'' / \hat{u}'^2],$$

which is negative if and only if $u''(w) < 0$. ■

Intuitively, with a given state-contingent wealth $(w, w - x)$, as p increases from zero to one, the risk premium at first increases and then decreases due to the concavity of u , and thus inherits concavity in p . It follows that the monopolist is averse to risk about probability, and Jensen's inequality implies

$$\pi(\bar{p}, w) > \lambda \pi(p^H w) + (1 - \lambda) \pi(p^L, w), \quad (7)$$

establishing the monopolist's strict preference for uninformed customers.

Proposition 1: Informing applicants of their risk classes is strictly unprofitable for a monopoly insurer taking the wealth w of applicants as given.

After being informed of risk class, H -types are worse off and L -types are better off, but from an *ex ante* perspective, they are indifferent between informed and uninformed contracting since they obtain no surplus in either regime and are neutral to risk about probability. (Schlesinger and Venezian [11] analyze a risk-neutral, monopolistic insurer who can manipulate the probability of loss to maximize expected profit. Customers benefit from the monopolist's choice of probability if their risks are initially greater. By contrast, in the present context, H -types benefit and L -types lose when their risks are changed to \bar{p} , but applicants evaluate these changes with *ex ante* expected utility.)

Proposition 2: Applicants not knowing their risk classes and taking wealth w as given are indifferent between symmetrically informed and symmetrically uninformed contracting.

Proof The expected utility of an uninformed customer is

$$E\bar{U}(0,0) = (1 - \bar{p})u(w) + \bar{p}u(w - x).$$

An informed customer's utility is

$$EU^t(0,0) = (1 - p^t)u(w) + p^t u(w - x),$$

so that each applicant's *ex ante* evaluation of symmetrically informed contracting is the expected utility

$$\lambda EU^H(0,0) + (1 - \lambda) EU^L(0,0) = (1 - \bar{p})u(w) + \bar{p}u(w - x).$$

It follows that applicants are indifferent between symmetric information and uninformed contracting. ■

Proposition 1 implies that a monopolistic insurer has an incentive to confuse informed applicants and convince them of being average. Since Proposition 2 indicates that applicants are indifferent to such manipulation, the result could be an increase in social welfare. This conjecture is confirmed for utilitarian social welfare in Section 5.

In sum, a monopolistic insurer prefers symmetrically uninformed over symmetrically informed contracting in order to extract the greatest rent from the applicant pool, while applicants are indifferent between these two contracting regimes. The situation is rather different when insurance contracting is wholly competitive. Insurers are then indifferent to their customers' information status as expected profit is always zero, while customers prefer uninformed contracting, inasmuch as symmetric

information exposes them to classification risk. Specifically, although neutral to risk about probability, applicants are averse to bearing the risk about state-contingent wealth that accompanies risk classification under competitive contracting. (In the symmetrically uninformed regime, each applicant has the average risk and competitive equilibrium provides full-and-fair insurance for this risk of loss. In the symmetrically informed regime, class-specific full-and-fair insurance is provided in equilibrium, and L -types enjoy an increase in welfare while H -types suffer a decline. Since marginal utility is diminishing, this classification risk reduces an applicant's *ex ante* evaluation of symmetrically informed contracting below that of the symmetrically uninformed regime. See Crocker and Snow [12] for further analysis of this case.) By contrast, with monopolistic insurance, each applicant's contract provides the same expected utility as the null contract, and classification introduces only risk about probability, towards which applicants are risk neutral.

4. Asymmetric Information

When customers possess hidden knowledge of risk class, a monopolist's viable contractual offers must meet not only the voluntary participation constraint in Equation (3) for both types, but must also satisfy incentive compatibility constraints,

$$EU^t(m^t, c^t) \geq EU^t(m^{t'}, c^{t'}) \quad t' \neq t, \quad (8)$$

ensuring that each type t prefers its intended contract. An optimal contractual offering satisfies these constraints while maximizing expected profit per customer,

$$\Pi = \lambda \cdot (m^H - p^H c^H) + (1 - \lambda) \cdot (m^L - p^L c^L).$$

The incentive constraints in Equation (8) impose a cost on the monopoly insurer, unless customers are uninformed. (Landsberger and Meilijson [13] show that when many loss amounts are possible, the incentive constraints in Equation (8) do not impose a cost and the monopoly can attain first-best rent extraction if there are some loss amounts that can be incurred only by H -types.) Hence, a monopoly prefers uninformed customers both to avoid the cost of adverse selection, and to then maximize the rent extracted from them.

Stiglitz [2] characterizes the monopolistic equilibrium for this environment, showing that (i) pooling contracts are not profit-maximizing; (ii) only the H -type incentive constraint is binding; (iii) the H -type contract provides full coverage; and (iv) the voluntary participation constraint for L -types is binding. Additionally, the L -type contract provides partial coverage with a positive premium if $\lambda < \lambda^*$ for a critical value $\lambda^* \in (0, 1)$, and is otherwise the null contract.

Thus, with $\lambda \geq \lambda^*$, the profit maximizing pair is

$$[0, 0] \text{ and } [m^H = p^H x + \pi(p^H, w), c^H = x] \quad (9)$$

consisting of the null contract, chosen by L -types, and the full-coverage contract that extracts maximum consumer surplus from H -types. Observe that the pair Equation (9) satisfies the voluntary participation and incentive constraints in Equations (3) and (8), and earns the insurer a positive expected profit. In contrast, with $\lambda < \lambda^*$, the profit-maximizing pair has the form

$$[m^L(c^L), c^L > 0] \text{ and } [m^H = p^H x + \pi(p^H, w) - \delta^H(\lambda), c^H = x], \quad (10)$$

where the premium $m^L(c^L)$ extracts maximum rent from L -types given coverage c^L . The L -type contract in the pair at Equation (10) provides some coverage for L -types while maintaining strict equality in their participation constraint and sacrificing profit $\delta^H(\lambda) > 0$ on the H -type contract.

Proposition 3: When $\lambda < \lambda^*$, high-risk applicants, taking wealth w as given, prefer asymmetric over symmetric information.

Proof Given wealth w , when information is symmetric, the expected utility of H -types is $EU^H(0,0)$. When information is asymmetric and $\lambda < \lambda^*$, their expected utility is

$$u(w - p^H x - \pi(p^H, w) + \delta^H(\lambda)) > EU^H(0,0),$$

where the inequality follows since $\delta^H(\lambda)$ is positive when $\lambda < \lambda^*$. ■

A more general assessment of the interests of insurance applicants is possible by adopting the veil-of-ignorance approach developed by Harsanyi [14,15] in which applicants evaluate alternative information regimes without hidden knowledge of risk class.

Proposition 4: When $\lambda < \lambda^*$, applicants choosing from behind a veil of ignorance regarding risk class and taking wealth w as given prefer contracting with asymmetric rather than symmetric information.

Proof With asymmetric information, expected utility is

$$EU^L(0,0) = (1 - p^L)u(w) + p^L u(w - x)$$

for L -types, and

$$\begin{aligned} EU^H(m^H(\lambda), x) &= u(w - p^H x - \pi(p^H, w) + \delta^H(\lambda)) \\ &= (1 - p^H)u(w) + p^H u(w - x) + \Delta u^H(\lambda) \end{aligned}$$

for H -types, where $m^H(\lambda) = p^H x + \pi(p^H, w) - \delta^H(\lambda)$. When information is asymmetric, $\delta^H(\lambda)$ and $\Delta u^H(\lambda)$ are both positive when $\lambda < \lambda^*$, and equal to zero otherwise. Not knowing risk class, each applicant's expected utility conditional on λ is

$$\lambda EU^H(m^H(\lambda), x) + (1 - \lambda)EU^L(0,0) = E\bar{U}(0,0) + \lambda \Delta u^H(\lambda) > E\bar{U}(0,0)$$

for the asymmetric information regime, where the inequality follows from the assumption $\lambda < \lambda^*$. When information is symmetric, $\delta^H(\lambda)$ and $\Delta u^H(\lambda)$ both equal zero for all values of λ , and each applicant's expected utility is

$$E\bar{U}(0,0) = (1 - \bar{p})u(w) + \bar{p}u(w - x).$$

Hence, applicants' expected utility is higher when contracting with asymmetric rather than symmetric information. ■

The following is an immediate consequence of Proposition 4.

Corollary 1: Applicants choosing from behind a veil of ignorance regarding both risk class and the proportion of high risks prefer contracting with asymmetric rather than symmetric information.

When information is asymmetric, the monopolist avoids the cost of adverse selection if applicants are uninformed, and its interests are thus in conflict with those of its customers indicated in Propositions 3 and 4. Matters are again different under competitive insurance, where insurers are indifferent between informed and uninformed customers. (Dahlby [16] explores conditions under which L -types obtain greater coverage under monopolistic contracting than under competitive contracting.) Under competition, customers prefer to remain uninformed, even if classification risk is insurable, since adverse selection imposes an additional cost.

5. The Social Value of Information

In evaluating informed vs. uninformed contracting under symmetric information, the monopolist prefers uninformed contracting while its customers are indifferent. When evaluating contracting with symmetric rather than asymmetric information, the monopolist and its customers are in conflict. In both cases, one can ask “Which option better serves social welfare?” since the evaluations of the applicants and the monopolist are based on selfish interests and competitive behavior that presumes each applicant’s wealth is wholly exogenous.

Since there is no aggregate risk, there are only two risk premiums relevant to the social welfare comparisons examined in the following sections under either approach to accounting for monopoly profit. One is an applicant’s premium for classification risk relevant in the *ex ante* assessment of symmetrically informed contracting; the other is the L -type premium for bearing residual, uninsured risk under asymmetrically informed contracting.

5.1 The Social Value of Symmetric Information

First, consider the social value of symmetric information, which generates a per-customer monopoly profit of

$$\Pi^S = \lambda \pi(p^H, w^S) + (1 - \lambda) \pi(p^L, w^S), \quad (11)$$

where $w^S = w^O + \Pi^S$ when applicants share the monopoly profit, and $w^S = w^O$ when profit is not shared. Under uninformed contracting, profit is $\Pi^U = \pi(\bar{p}, w^U)$ where w^U equals either $w^O + \Pi^U$ or w^O . From the *ex ante* perspective, there is a representative applicant whose expected utility constitutes the measure of social welfare when applicants share the monopoly profit. When the monopolist is a Pareto-relevant agent, utilitarian social welfare is measured by the representative applicant’s certainty-equivalent wealth plus the monopolist’s profit.

Proposition 5: The social value of symmetric information is negative.

Proof When applicants share monopoly profit, the representative applicant’s expected utility with uninformed contracting is given by

$$u(w^U - \bar{p}x - \pi(\bar{p}, w^U)) = u(w^O - \bar{p}x). \quad (12)$$

Under symmetric information, certainty-equivalent wealth for an H -type applicant is

$$CE_s^H = w^S - p^H x - \pi(p^H, w^S), \quad (13)$$

and for an L -type applicant is

$$CE_s^L = w^s - p^L x - \pi(p^L, w^s). \quad (14)$$

Hence, the representative applicant's evaluation of symmetric information is

$$\begin{aligned} \lambda u(CE_s^H) + (1 - \lambda)u(CE_s^L) &= u(\lambda CE_s^H + (1 - \lambda)CE_s^L - \pi^s) \\ &= u(w^o - \bar{p}x - \pi^s), \end{aligned} \quad (15)$$

where π^s is the premium for classification risk, which is positive given risk aversion. Since Equation (12) exceeds Equation (15), the social value of symmetric information is negative.

When the monopolist is Pareto-relevant, the representative applicant's certainty-equivalent wealth with uninformed contracting is $w^o - \bar{p}x - \pi(\bar{p}, w^o)$, monopoly profit is $\Pi^u = \pi(\bar{p}, w^o)$, and social welfare is

$$w^o - \bar{p}x - \pi(\bar{p}, w^o) + \Pi^u = w^o - \bar{p}x \quad (16)$$

Under symmetric information, w^s is equal to w^o in Equation (11) for monopoly profit, as well as in Equations (13) and (14) for certainty-equivalent wealth, and the representative applicant's evaluation of symmetric information is

$$\begin{aligned} \lambda u(CE_s^H) + (1 - \lambda)u(CE_s^L) &= u(\lambda CE_s^H + (1 - \lambda)CE_s^L - \hat{\pi}^s) \\ &= u(w^o - \bar{p}x - \Pi^s - \hat{\pi}^s), \end{aligned} \quad (17)$$

where $\hat{\pi}^s$ denotes the premium for classification risk when profit is not distributed to applicants. It follows from Equation (17) that social welfare is $w^o - \bar{p}x - \hat{\pi}^s$, which is less than Equation (16), implying that symmetric information has negative social value. ■

Since the monopolist achieves full rent extraction under either symmetrically informed or symmetrically uninformed regimes, monopolistic contracting results in an interim efficient sharing of risk as risk-averse applicants receive full coverage. However, by the accounting of Proposition 5, social welfare is higher with symmetrically uninformed contracting, and thus social welfare increases when a monopolist can, at no cost in resources, successfully convince informed applicants that they are average.

5.2 The Social Value of Symmetric vs. Asymmetric Information

Under asymmetric information, profit is

$$\Pi^a = \lambda[\pi(p^H, w^a) - \delta^H(\lambda)] + (1 - \lambda)[\pi(p^L, w^a) - \delta^L(\lambda)], \quad (18)$$

where w^a equals either $w^o + \Pi^a$ or w^o . In this expression, $\delta^L(\lambda)$ is the potential rent the monopolist fails to extract from each L -type applicant due to adverse selection. Note that $\delta^L(\lambda)$ is positive for all $\lambda \in (0, 1)$, and bounded above by $\pi(p^L, w^a)$, which is attained when λ is greater than or equal to λ^* . The following result shows that profit is higher when information is symmetric rather than asymmetric regardless of applicant preferences and the allocation of monopoly profit.

Lemma 2: $\Pi^S > \Pi^a$ for all $\lambda \in (0,1)$.

Proof The difference in profit between symmetric information given in Equation (11) and asymmetric information given in Equation (18) is

$$\begin{aligned} \Pi^S - \Pi^a = & \lambda[\pi(p^H, w^S) - \pi(p^H, w^a)] + (1-\lambda)[\pi(p^L, w^S) - \pi(p^L, w^a)] \\ & + (1-\lambda)\delta^L(\lambda) + \lambda\delta^H(\lambda) \end{aligned} \quad (19)$$

for all $\lambda \in (0,1)$. When applicants do not share profit, both w^S and w^a equal w^o in Equation (19), which then reduces to $\Pi^S - \Pi^a = (1-\lambda)\delta^L(\lambda) + \lambda\delta^H(\lambda) > 0$ for all $\lambda \in (0,1)$, and thus $\Pi^S > \Pi^a$.

When applicants share the monopoly profit, $w^S - w^a$ equals $\Pi^S - \Pi^a$, and Equation (19) implies that we cannot have $w^S = w^a$ for that would imply both $\Pi^S = \Pi^a$ and $\Pi^S > \Pi^a$. Therefore, assume $w^S \neq w^a$ so that $\Pi^S \neq \Pi^a$. The mean value theorem implies the existence of wealth levels w^H and w^L between w^S and w^a such that

$$\pi(p^t, w^S) - \pi(p^t, w^a) = [\partial\pi(p^t, w^t)/\partial w] \cdot (w^S - w^a) \quad (20)$$

for $t = H, L$. Using Equation (20) and the fact that $w^S - w^a$ equals $\Pi^S - \Pi^a$, Equation (19) can be written as

$$\begin{aligned} & (1-\lambda)\delta^L(\lambda) + \lambda\delta^H(\lambda) \\ & = (\Pi^S - \Pi^a) \{1 - \lambda[\partial\pi(p^H, w^H)/\partial w] - (1-\lambda)[\partial\pi(p^L, w^L)/\partial w]\}. \end{aligned} \quad (19)$$

Since the left-hand side of Equation (21) is positive, $\Pi^S < \Pi^a$ if and only if the term within braces is negative, which requires that one or both of the derivatives within braces must be greater than one. However, differentiating Equation (6) for the risk premium with respect to wealth yields

$$u'(w - p^t x - \pi(p^t, w)) \cdot [1 - \partial\pi(p^t, w)] = \partial EU^t(0,0)/\partial w,$$

which implies $\partial\pi(p^t, w)/\partial w < 1$. Hence, regardless of wealth effects on the applicants' degrees of risk aversion, profit is greater under symmetric rather than asymmetric information when applicants share the monopoly profit. ■

The difference in monopoly profit between the symmetric and asymmetric information regimes is mirrored in the social ranking of the two regimes.

Proposition 6: Social welfare is greater with symmetric rather than asymmetric information.

Proof For H -types, certainty-equivalent wealth under asymmetric information is

$$CE_a^H = w^a - p^H x - \pi(p^H, w^a) + \delta^H, \quad (20)$$

and for L -types is

$$CE_a^L = w^a - p^L x - \pi(p^L, w^a). \quad (21)$$

When applicants share monopoly profit, the difference in social welfare between symmetric and asymmetric information, obtained from Equations (13), (14), (22), and (23), is

$$\begin{aligned}
& \lambda[CE_s^H - CE_a^H] + (1-\lambda)[CE_s^L - CE_a^L] \\
& = \Pi^S - \Pi^a - \lambda[\pi(p^H, w^S) - \pi(p^H, w^a) \\
& \quad - \lambda\delta^H - (1-\lambda)[\pi(p^L, w^S) - \pi(p^L, w^a)]] \\
& = (1-\lambda)\delta^L,
\end{aligned} \tag{22}$$

where the second equality uses Equations (11) and (18) for profit. Since Equation (24) is positive for all $\lambda \in (0,1)$, social welfare is higher with symmetric rather than asymmetric information when monopoly profit is shared by applicants.

When applicants do not share the profit, w^S is equal to w^O in Equations (11), (13), and (14), and replaces w^a in Equations (18), (22), and (23), so the difference in social welfare between symmetric and asymmetric information is

$$\begin{aligned}
& \lambda[CE_s^H - CE_a^H] + (1-\lambda)[CE_s^L - CE_a^L] + \Pi^S - \Pi^a \\
& = \Pi^S - \Pi^a - \lambda[\pi(p^H, w^O) - \pi(p^H, w^a)] \\
& \quad - \lambda\delta^H - (1-\lambda)[\pi(p^L, w^O) - \pi(p^L, w^a)] \\
& = (1-\lambda)\delta^L,
\end{aligned} \tag{23}$$

since the monopolist is Pareto relevant. Again, social welfare is higher with symmetric information. ■

The intuition for Proposition 6 is that monopoly profit either represents a transfer of wealth to a Pareto-relevant agent (the monopolist), which has no social value, either positive or negative, under utilitarian social welfare, or is distributed to applicants and, on average, just offsets the rent extracted from them. The problem with asymmetric information is that profit is too low. With symmetric information, the monopolist offers interim efficient contracts, but with asymmetric information, adverse selection prevents the monopolist from achieving full rent extraction from L -type customers, and the contracts offered are, therefore, not interim efficient.

Finally, Koch's [17] analysis suggests an important caveat relevant to Proposition 6. Recognizing that, in a dynamic insurance context, both adverse selection and (re)classification risk can impose costs on the contractual relationship, Koch explores the interaction between these two market failures. Reporting simulation results for a model calibrated to US data, Koch demonstrates a Theory of the Second Best result by showing that eliminating one but not both market failures need not be Pareto improving. Although developed in the context of a (regulated) competitive environment, the same conclusion surely holds when insurance contracting is monopolistic. (In a related vein, Handel *et al.* [18] report simulation results suggesting that eliminating reclassification risk by banning its use, thereby artificially creating hidden knowledge, could nonetheless be welfare enhancing. Mahoney and Weyl [19] present simulation results investigating the tradeoff between market power and adverse selection, suggesting that greater market power can be socially valuable as an instrument for mitigating an adverse selection externality.)

6. Conclusions

Whether the informational environment is symmetric or asymmetric, a monopolistic insurer always prefers contracting with uninformed applicants, and would profit from sowing confusion among them regarding their risk classes when applicants are informed. Indeed, sowing confusion increases utilitarian social welfare when information is symmetric since applicants are indifferent between uninformed contracting and contracting with symmetric information. However, choosing from behind a veil of ignorance, applicants prefer asymmetric over symmetric information as *H*-types gain consumer surplus when *L*-types dominate the insurance pool. Nonetheless, social welfare is higher with symmetric information due to the cost of adverse selection reflected in the rent the monopolist fails to extract from *L*-types, while the social value of symmetric information is negative, since it exposes applicants to a classification risk that reduces their *ex ante* expected utility.

Acknowledgments

Michael Hoy suggested this topic at the 41st Seminar of EGRIE. Two anonymous referees provided valuable criticisms of the original submission.

Conflicts of Interest

The author declares no conflicts of interest

References

1. Rothschild, M.; Stiglitz, J.E. Equilibrium in competitive insurance markets: An essay on the economics of imperfect information. *QJE* **1976**, *90*, 630–649.
2. Stiglitz, J.E. Monopoly, non-linear pricing and imperfect information: The insurance market. *REStud.* **1977**, *44*, 407–430.
3. Chade, H.; Schlee, E. Optimal insurance with adverse selection. *Theor. Econ.* **2012**, *7*, 571–607.
4. Jeleva, M.; Villeneuve, B. Insurance contracts with imprecise probabilities and adverse selection. *Econ. Theory* **2004**, *23*, 777–794.
5. Asheim, G.B.; Nilssen, T. Insurance monopoly and regulation. *Econ. Theory* **1997**, *9*, 341–354.
6. Villeneuve, B. The consequences for a monopolistic insurer of evaluating risk better than customers: The adverse selection hypothesis reversed. *Geneva Pap. Risk Insur. Theory* **2000**, *25*, 65–79.
7. Landsberger, M.; Meilijson, I. Monopoly insurance under adverse selection when agents differ in risk aversion. *JET* **1994**, *63*, 392–407.
8. Malinvaud, E. The allocation of individual risks in large markets. *JET* **1972**, *4*, 312–328.
9. Picard, P. Participating insurance contracts and the Rothschild-Stiglitz equilibrium puzzle. *Geneva Risk Insur. Rev.* **2014**, *2*, 153–175.
10. Lees, D.S.; Rice, R.G. Uncertainty and the welfare economics of medical care: comment. *AER* **1965**, *55*, 140–154.
11. Schlesinger, H.; Venezian, E.C. Insurance markets with loss-prevention activity: Profits, market structure, and consumer welfare. *RAND* **1986**, *17*, 227–238.

12. Crocker, K.J.; Snow, A. The theory of risk classification. In *Handbook of Insurance*, 2nd ed.; Dionne, G., Ed.; Springer: New York, NY, USA, 2013; pp. 281–313.
13. Landsberger, M.; Meilijson, I. Extraction of surplus under adverse selection: the case of insurance markets. *JET* **1996**, *69*, 234–239.
14. Harsanyi, J.C. Cardinal utility in welfare economics and in the theory of risk taking. *JPE* **1953**, *61*, 434–435.
15. Harsanyi, J.C. Cardinal welfare, individualistic ethics, and interpersonal comparisons of utility. *JPE* **1955**, *63*, 309–321.
16. Dahlby, B.G. Monopoly vs. competition in an insurance market with adverse selection. *JRI* **1987**, *54*, 325–331.
17. Koch, T.G. One pool to insure them all? Age, risk and the price(s) of medical insurance. *IJIO* **2014**, *35*, 1–11.
18. Handel, B.; Hendel, I.; Whinston, M.D. Equilibria in health exchanges: Adverse selection vs. reclassification risk. *Econometrica* (in press).
19. Mahoney, N.; Weyl, E.G. Imperfect competition in selection markets. *SSRN*.

© 2015 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).