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# Overconfidence, Insurance, and Paternalism

By ALVARO SANDRONI AND FRANCESCO SQUINTANI\*

The behavioral economics literature has produced broad empirical evidence that agents do not always act in their own best interest. In single-agent models, a possible implication of behavioral biases is paternalism: policies designed to affect agents' choices for their own good.<sup>1</sup> However, this implication has not been thoroughly investigated in fully developed market models.<sup>2</sup> As behavioral biases are difficult to observe, it is natural to approach this investigation in markets with asymmetric information.

This paper explores the policy implications of behavioral biases in the classic model of insurance markets with asymmetric information by Michael D. Rothschild and Joseph E. Stiglitz (1976). Insurance companies are perfectly competitive and cannot observe their subscribers' risk, which may be either high or low. Some agents know their risk. We assume that some agents are overconfident: they believe their risk is low when, in fact, it is high. This assumption is supported by robust empirical evidence that many individuals underestimate important risks, such as those associated with driving.<sup>3</sup>

While overconfidence need not be common in all insurance markets, it is a natural first step to explore behavioral biases in the Rothschild and Stiglitz (1976) framework.

When all agents are unbiased, the Rothschild and Stiglitz (1976) model makes a strong case for government intervention. Because of asymmetric information, compulsory insurance may improve all agents' welfare.<sup>4</sup> A different rationale for compulsory insurance is behavioral. Individuals may underinsure because they are overconfident. Compulsory insurance does not harm unbiased agents because they want to be insured, and should be imposed on overconfident individuals for their own benefit.

Our main result shows that the asymmetric-information rationale and the behavioral rationale for compulsory insurance do not reinforce each other. When there is a significant fraction of overconfident agents, compulsory insurance ceases to improve all agents' welfare because it makes low-risk agents worse off. For instance, in the automobile insurance market, compulsory driving insurance translates into a tax on safe drivers that subsidizes unsafe drivers.<sup>5</sup> So, contrary to *prima facie* intuition, behavioral biases may weaken asymmetric-information rationales for government intervention because they may

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<sup>1</sup> Behavioral economists typically advocate only mild forms of intervention which guarantee the possibility of opting out. See, among others, Ted O'Donoghue and Matthew Rabin (2003), Richard H. Thaler and Cass Sunstein (2003), and Colin F. Camerer et al. (2003).

<sup>2</sup> An exception is O'Donoghue and Rabin (2003).

<sup>3</sup> According to Werner F. M. De Bondt and Thaler (1995, 389), perhaps the most robust finding in the psychology

of judgment is that people are overconfident. Among many papers finding evidence of overconfidence, see Howard Kunreuther et al. (1978), Linda Babcock and George Loewenstein (1997), Camerer and Dan Lovallo (1999), Shlomo Benartzi (2001), and Jay Bhattacharya, Dana P. Goldmann, and Navin Sood (2003). A brief survey of this literature is presented in Sandroni and Squintani (2007).

<sup>4</sup> This argument, demonstrated by Charles A. Wilson (1977) and Bev G. Dahlby (1983), is highlighted both in textbooks (e.g., Alan J. Auerbach and Martin Feldstein 2002), and in institutional debates (e.g., Mark V. Pauly 1994).

<sup>5</sup> In the context of motorist insurance, our analysis applies only to personal loss insurance, in the forms of the Personal Injury Protection (PIP) and Uninsured Motorist (UM) insurance, which is mandatory in most US states (see the *Summary of Selected State Laws* published by the American Insurance Association, 1976–2003). PIP insurance covers loss when the driver is at fault, and UM insurance covers loss caused by another driver who is at fault and not insured. Our analysis does not apply to liability insurance, which covers the losses that a driver can cause to others.

turn policies beneficial to all agents into wealth transfers between agents.

This unexpected result holds because overconfidence changes the equilibrium of the Rothschild and Stiglitz (1976) model qualitatively. Without overconfidence, the market equilibrium is pinned down by a binding incentive compatibility constraint. Low-risk agents' insurance is constrained to ensure separation from high-risk subscribers. High-risk agents benefit from compulsory insurance because they obtain insurance coverage at lower prices. Compulsory insurance also benefits low-risk agents because it relaxes the incentive compatibility constraint. However, when the economy has a significant fraction of overconfident agents, the incentive compatibility constraint no longer binds.<sup>6</sup> Compulsory insurance becomes a transfer of wealth from low-risk to high-risk agents.

The incentive compatibility constraint does not bind in equilibrium because overconfident agents cannot be screened from low-risk agents. These agents share the same beliefs about their risk and so make identical decisions. In addition, we assume that insurance companies cannot directly observe agents' beliefs. Hence, the higher the fraction of overconfident agents in the economy, the higher is the average risk of the pool of low-risk and overconfident agents, and the higher the price that insurance firms must offer to avoid negative profits. At high prices, these contracts become unattractive to high-risk agents. For instance, consider the extreme case where the fraction of low-risk agents (relative to the fraction of overconfident agents) is small. The insurance price for low-risk and overconfident agents is close to the insurance price for high-risk agents. Therefore, low-risk agents are better off purchasing small amounts of insurance and are hurt by compulsory insurance.

Our basic result extends beyond compulsory insurance. When the fraction of overconfident agents is significant, budget-balanced government intervention cannot weakly improve the welfare of both high-risk and low-risk agents over the laissez-faire equilibrium of our model, unless it changes the fraction of biased agents

in the economy. This result also extends beyond overconfidence and still holds if we replace the assumption of a significant fraction of overconfident agents with the weaker assumption of a significant fraction of biased agents that can either be overconfident or underconfident. Finally, we show that policies that directly reduce overconfidence in the economy may benefit low-risk agents without harming high-risk agents. In the context of driving insurance, such policies materialize in voluntary training programs designed to help drivers improve their self-assessment skills.

The paper is organized as follows. Section I presents the model. Section II provides a graphical description of the equilibrium. Section III presents our main result informally. Section IV contains additional policy results. Section V concludes. The formal analysis is laid out in a Web Appendix ([http://www.e-aer.org/data/dec07/20051082\\_app.pdf](http://www.e-aer.org/data/dec07/20051082_app.pdf)).

*Related Literature.*—Our paper is related to two branches of behavioral economics. The first branch studies market interactions between sophisticated firms and biased consumers. Stefano DellaVigna and Ulrike Malmendier (2004), Glenn Ellison (2005), and Xavier Gabaix and David Laibson (2006) study models where consumers may have naive beliefs, overlook add-on prices, or underestimate the chance of being subject to hidden fees. They find that in competitive markets, naive consumers may be exploited by sophisticated consumers.

Unlike in these models, our naive, overconfident agents cannot be separated from low-risk agents because their beliefs are the same. This entails higher insurance prices and an efficiency loss, not only distributive effects. Ran Spiegler (2006) finds an efficiency loss in a market where consumers have a bounded ability to infer quality by sampling goods. Unlike our work, his emphasis is on equilibrium characterization, rather than policy analysis.<sup>7</sup>

The second related branch of behavioral economics studies the effects of behavioral biases. Roland Bénabou and Jean Tirole (2002) and Kőszegi (2006) show that overconfident agents may strategically ignore information. Bénabou and Tirole (2003) study incentives to manipulate

<sup>6</sup> This finding does not depend on the assumption of perfect competition, as demonstrated by C. Mark Armstrong (2005), in versions of our model with either a monopolistic firm or with imperfect competition.

<sup>7</sup> More distantly related, Paul Heidhues and Botond Kőszegi (2004) provide a rationale for price stickiness in a model with loss-averse consumers.

self-confidence. Muhamet Yildiz (2003) studies how excessive optimism affects bargaining. Michael Manove and A. Jorge Padilla (1999) and Augustin Landier and David Thesmar (forthcoming) study how entrepreneurs' overconfidence affects financial contracting. Kfir Eliaz and Spiegler (2006) study principal-agent problems where agents may be overconfident. Olivier Compte and Andrew Postlewaite (2004) study optimal beliefs when confidence enhances task performance. Eric J. van den Steen (2004) shows that agents with different priors may overestimate their chances of success. Luis Santos-Pinto and Joel Sobel (2005) show that rational agents may develop optimistic self-assessments if they disagree on which skills determine abilities. Anil Arya and Brian Mittendorf (2004) study an example of an insurance market with a monopolistic firm and underconfident agents: the equilibrium is a pooling, full insurance outcome and the incentive compatibility constraint does not bind.

### I. The Model

For each agent, there are two possible states of the world. In state 1, her wealth is  $W$ . In state 2, an accident of damage  $d$  occurs and the individual's wealth is  $W - d$ . An insurance contract is a pair  $\alpha = (\alpha_1, \alpha_2)$  so that the individual's wealth is  $(W - \alpha_1, W - d + \alpha_2)$  when buying  $\alpha$ . The amount  $\alpha_1$  is the premium,  $\alpha_1 + \alpha_2$  is the insurance coverage, and  $P = \alpha_1/(\alpha_1 + \alpha_2)$  is the price of a unit of insurance. We assume that  $\alpha_1 \geq 0$ ,  $\alpha_2 \geq 0$ : individuals cannot take on more risk through an insurance contract. Each agent's risk is the probability  $p$  that the accident occurs, which can either be high ( $p_H$ ) and low ( $p_L$ ), with  $p_H > p_L$ .

Conditional on all observable variables, there are three types of agents in the economy. *High-risk* (type  $H$ ) and *Low-risk* (type  $L$ ) agents know that their risks are  $p_H$  and  $p_L$ , respectively. *Overconfident* (type  $O$ ) agents believe that their risk is low when in fact it is high. We let  $\lambda \in (0, 1)$  be the fraction of low-risk agents in the economy, and  $\kappa \in (0, 1)$  be the fraction of overconfident agents, so that  $\kappa + \lambda \leq 1$ . Agents are risk averse; their expected utility is  $V(W, d; p, \alpha) = (1 - p)U(W - \alpha_1) + pU(W - d + \alpha_2)$ , where  $U$  is twice differentiable,  $U' > 0$  and  $U'' < 0$ .<sup>8</sup>

<sup>8</sup> To simplify the exposition, we focus on the case in which the difference between low risk and high risk is not

The insurance market is a competitive industry of expected profit-maximizing (risk-neutral) companies. A contract  $\alpha$  sold to an agent with risk  $p$  yields expected profit  $\pi(p, \alpha) = (1 - p)\alpha_1 - p\alpha_2$ . We assume that the insurance firms cannot observe a subscriber's risk or beliefs, but they know  $\kappa$  and  $\lambda$ . A *perfectly competitive equilibrium* is a set of contracts  $A$  such that: (a) no contract  $\alpha \in A$  makes strictly negative expected profits, and (b) no contract  $\alpha' \notin A$  makes strictly positive profits.

*Remark.*—A perfectly competitive equilibrium may fail to exist in the Rothschild and Stiglitz (1976) model. A set of contracts is *locally competitive* if the insurance firms cannot make positive profits by introducing small changes in the contracts they already offer (this concept is formally defined in the Web Appendix).<sup>9</sup> Any perfectly competitive equilibrium is also locally competitive, but not vice versa. A locally competitive equilibrium always exists, and is unique, in the Rothschild and Stiglitz (1976) model, and in our model as well. A perfectly competitive equilibrium exists in our model as long as the fraction of overconfident agents is above a threshold formally defined in the following section.

### II. Graphical Description of Equilibrium

#### A. Equilibrium in Insurance Markets without Overconfidence

For future reference, we briefly consider the model without overconfidence, i.e.,  $\kappa = 0$ . Rothschild and Stiglitz (1976) show that the equilibrium is separating. Subscribers are screened according to the contract they choose. High-risk individuals fully insure. Their contract  $\alpha^H$

too small relative to the damage  $d$ . That is, we assume that  $\{[(1 - p_L)/p_L]/[(1 - p_H)/p_H]\} > \{[U'(W - d)]/[U'(W)]\}$ .

<sup>9</sup> In a general equilibrium model, Pradeep K. Dubey and John G. Geanakoplos (2002) show the existence of an equilibrium that approximates the locally competitive equilibrium. John G. Riley (1979) shows that the locally competitive equilibrium coincides with a "reactive" equilibrium where firms, before introducing new contracts, anticipate that competitors will react by offering new contracts, if they generate positive profits. Charles A. Wilson (1977) proposes an alternative reactive equilibrium where loss-making contracts are removed as a reaction to newly introduced contracts.

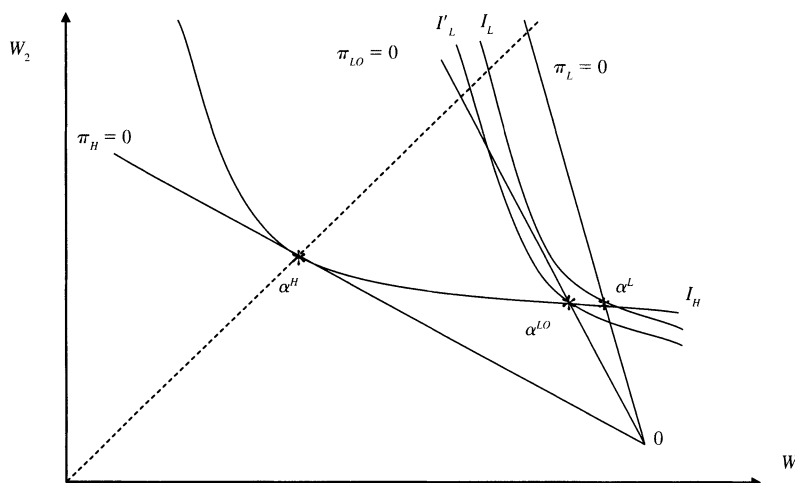


FIGURE 1. EQUILIBRIUM WITHOUT OVERCONFIDENCE, AND WITH A SMALL FRACTION OF OVERCONFIDENT AGENTS

equalizes wealth across states and lies on the intersection of the 45-degree line with the zero-profit line  $\pi_H = 0$ . Incentive compatibility requires that high-risk subscribers (weakly) prefer contract  $\alpha^H$  to the low-risk individuals' contract  $\alpha^L$ . Hence, the contract  $\alpha^L$  lies on the intersection of the zero-profit line  $\pi_L = 0$  with the indifference curve  $I_H$  (through the high-risk agents' contract  $\alpha^H$ ). The contracts  $(\alpha^L, \alpha^H)$  are a (unique) perfectly competitive equilibrium as long as the fraction  $\lambda$  of low-risk subscribers is sufficiently small. The equilibrium contracts are illustrated in Figure 1.

### B. Equilibrium in Insurance Markets with Overconfidence

We now describe equilibrium with overconfidence (i.e.,  $\kappa > 0$ ). The core of our analysis is based on two intuitive insights. The first one is that *insurance firms cannot screen between overconfident and low-risk individuals* because, at the time of purchasing insurance, both types believe that their risk is low. Given this qualification, arguments analogous to the analysis of Rothschild and Stiglitz (1976) allow us to conclude that in the unique competitive equilibrium, individuals are separated on the basis of their beliefs. High-risk individuals purchase a contract  $\alpha^H$ , whereas low-risk and overconfident individuals choose a different contract  $\alpha^{LO}$ . As in the case without overconfidence, high-risk individuals fully insure.

The average accident probability of overconfident and low-risk agents is

$$p_{LO} \equiv \frac{\kappa p_H + \lambda p_L}{\kappa + \lambda}.$$

Perfect competition requires that the equilibrium contract  $\alpha^{LO}$  satisfies the zero-profit condition  $(1 - p_{LO})\alpha_1^{LO} - p_{LO}\alpha_2^{LO} = 0$  (in short,  $\pi_{LO} = 0$ ). So, the price of insurance  $P^{LO}$  coincides with  $p_{LO}$ . As the fraction of overconfidence agents  $\kappa$  increases, the zero-profit line  $\pi_{LO} = 0$  rotates counterclockwise toward the zero-profit line for high-risk types,  $\pi_H = 0$ .

This leads to the second insight. Unlike in the case without overconfidence, *incentive compatibility need not be binding in equilibrium*. As we argue below, it does not bind when the fraction of overconfident individuals  $\kappa$  is large enough relative to the fraction of low-risk agents  $\lambda$ . In order to describe the equilibrium, we distinguish between three different cases depending on the parameters  $\kappa$  and  $\lambda$ . The three significant parameter regions are characterized by the threshold functions  $\kappa_1(\lambda)$  and  $\kappa_2(\lambda)$ , formally defined in the Web Appendix.

**Case 1: Small Overconfidence.** Assume that the fraction of overconfident agents  $\kappa$  is small relative to the fraction of low-risk individuals  $\lambda$ , i.e.  $\kappa \leq \kappa_1(\lambda)$ . Then, the locally competitive equilibrium contracts  $(\alpha^{LO}, \alpha^H)$  are shown in Figure 1.

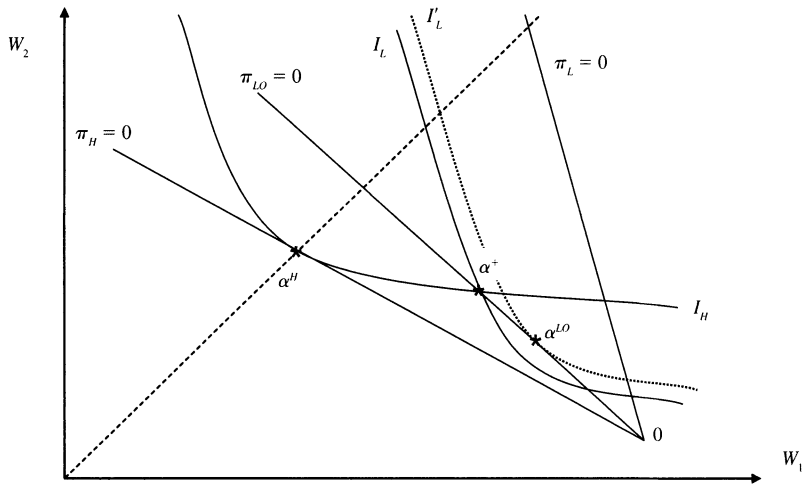


FIGURE 2. EQUILIBRIUM WITH INTERMEDIATE OVERCONFIDENCE

The only difference from the case without overconfidence is that the contract  $\alpha^{LO}$  must lie on the zero-profit line  $\pi_{LO} = 0$ , since it is chosen by low-risk and overconfident agents alike. As in Rothschild and Stiglitz (1976), the contracts  $(\alpha^{LO}, \alpha^H)$  are a (unique) perfectly competitive equilibrium if and only if the fraction  $\lambda$  of low-risk agents is sufficiently small.

**Case 2: Intermediate Overconfidence.** When the fraction of overconfident individuals is intermediate, i.e.,  $\kappa_1(\lambda) < \kappa < \kappa_2(\kappa)$ , there is always a unique (locally and) perfectly competitive equilibrium. The equilibrium is represented in Figure 2.

*The incentive compatibility constraint no longer binds.* To see this, let  $\alpha^+$  be the intersection of the zero-profit line  $\pi_{LO} = 0$  with the indifference curve  $I_H$  passing through  $\alpha^H$ . Note that the indifference curve of low-risk agents passing through  $\alpha^+$  is steeper than the zero-profit line  $\pi_{LO} = 0$  (in contrast, in Figure 1 it was flatter). Hence,  $\alpha^+$  is no longer an equilibrium because any contract lying to the right of  $\alpha^+$  between the indifference curve  $I_L$  and the zero-profit line  $\pi_{LO} = 0$  would make strictly positive profits.<sup>10</sup> The equilibrium contract

for low-risk and overconfident agents, denoted by  $\alpha^{LO}$ , is determined by the tangency point of the indifference curve  $I_L$  on the zero-profit line  $\pi_{LO} = 0$ .<sup>11</sup> Under regularity conditions, low-risk and overconfident agents' utilities decrease in  $\kappa$ .<sup>12</sup> By revealed preferences, low-risk agents' utilities are higher than high-risk agents' utilities, which are higher than overconfident agents' utilities.

**Case 3: Large Overconfidence.** When the fraction of overconfident individuals is large,  $\kappa \geq \kappa_2(\kappa)$ , the incentive compatibility constraint still does not bind. The zero-profit line  $\pi_{LO} = 0$  is sufficiently close to the zero-profit line  $\pi_H = 0$  that it becomes flatter than the indifference curve  $I_L$  that passes through the no-insurance contract  $0$ . Hence, a corner solution  $\alpha^{LO} = 0$  is obtained. In the unique locally and perfectly competitive equilibrium, low-risk and overconfident agents believe that the insurance contracts they are offered are so unfavorable that they do not insure.

indifference curve  $I_L$ . High-risk agents still prefer  $\alpha^H$  to the contract  $\alpha$ , because  $\alpha$  lies below the indifference curve  $I_H$ .

<sup>11</sup> The correlation between coverage and risk in markets, such as the automobile insurance market and the health insurance market, can be used to deliver testable implications of our model.

<sup>12</sup> Specifically, this result holds if the coefficient of Relative Risk Aversion  $-wU''(w)/U'(w)$  is smaller than the bound  $(W - d)/W$  for any wealth amount  $w \in [W - d, W]$ .

<sup>10</sup> Any such contract  $\alpha$  makes strictly positive profits because it is purchased only by low-risk and overconfident agents and its price is larger than  $P^{LO}$ , as  $\alpha$  lies below the zero-profit line  $\pi_{LO} = 0$ . Low-risk and overconfident agents prefer this contract  $\alpha$  to  $\alpha^+$ , because  $\alpha$  lies above the

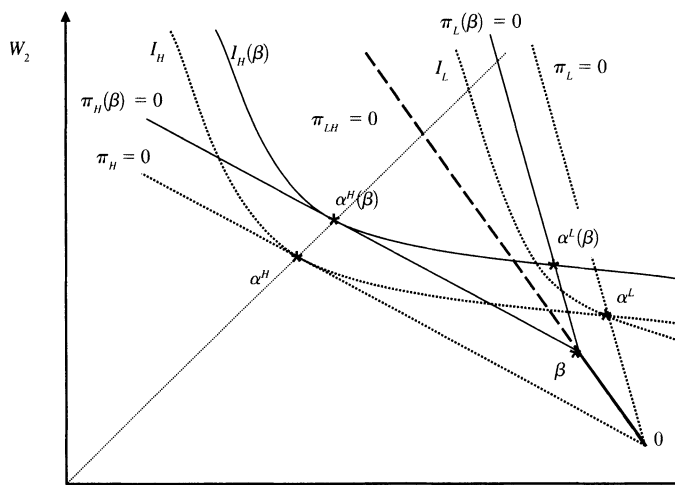


FIGURE 3. COMPULSORY INSURANCE WITHOUT OVERCONFIDENCE

### III. Compulsory Insurance

#### A. Compulsory Insurance without Overconfidence

A *compulsory insurance* requirement is a contract  $\beta = (\beta_1, \beta_2) > \mathbf{0}$  that makes zero profits if imposed uniformly across all agents. Each agent is required to buy contract  $\beta$  and is free to buy additional insurance  $\alpha(\beta)$  on top of  $\beta$ . Formally, let  $p_{LH} \equiv (1 - \lambda)p_H + \lambda p_L$  be the average probability of accident in the economy. Any compulsory insurance contract  $\beta$  that keeps the budget balanced must lie on the zero-profit line  $\pi_{LH} = 0$ , i.e.,  $(1 - p_{LH})\beta_1 - p_{LH}\beta_2 = 0$ .

In the Rothschild and Stiglitz (1976) model, the introduction of compulsory insurance yields a Pareto improvement, as long as the fraction of low-risk individuals is above a threshold. To see this, note that the adoption of  $\beta$  is equivalent to a change of endowment from  $(W, W - d)$  to  $(W - \beta_2, W - d + \beta_1)$ . Given this, the remainder of the analysis is qualitatively unchanged. High-risk agents' contracts  $\alpha^H(\beta)$  fully insure. Low-risk agents' contracts  $\alpha^L(\beta)$  lie in the intersection of the zero-profit line  $\pi_L(\beta) = 0$  and the indifference curve  $I_H$  passing through  $\alpha^H(\beta)$  (see Figure 3).

Compulsory insurance makes high-risk individuals better off because the terms of the compulsory contract  $\beta$  are more favorable than the

terms of the equilibrium contract  $\alpha^H$ . Low-risk agents pay the cost of being pooled together with high-risk individuals on the contract  $\beta$ . However, compulsory insurance relaxes the incentive compatibility constraint imposed by the high-risk subscribers. This can be seen in Figure 3, as the compulsory insurance contract  $\beta$  shifts the indifference curve  $I_H$  up. When the fraction of high-risk subscribers is sufficiently small, the relaxation of incentive compatibility is large enough to make low-risk agents better off.<sup>13</sup>

#### B. Compulsory Insurance with Overconfidence

Now consider the case in which the fraction of overconfident agents in the economy is intermediate or large, i.e.,  $\kappa > \kappa_1(\lambda)$ .<sup>14</sup> Because the incentive compatibility constraint does not bind in equilibrium, Result 1, below, shows that the introduction of compulsory insurance

<sup>13</sup> Unlike the Rothschild and Stiglitz (1976) equilibrium and the Wilson (1977) equilibrium, the Miyazaki-Wilson-Spence equilibrium cannot be improved by compulsory insurance (see Keith J. Crocker and Arthur Snow 1985). In this equilibrium, insurers are not profit maximizers: they sell loss-making contracts to high-risk agents, subsidized with profit-making contracts sold to low-risk agents.

<sup>14</sup> If  $\kappa < \kappa_1(\lambda)$ , the analysis is analogous to the case without overconfidence.

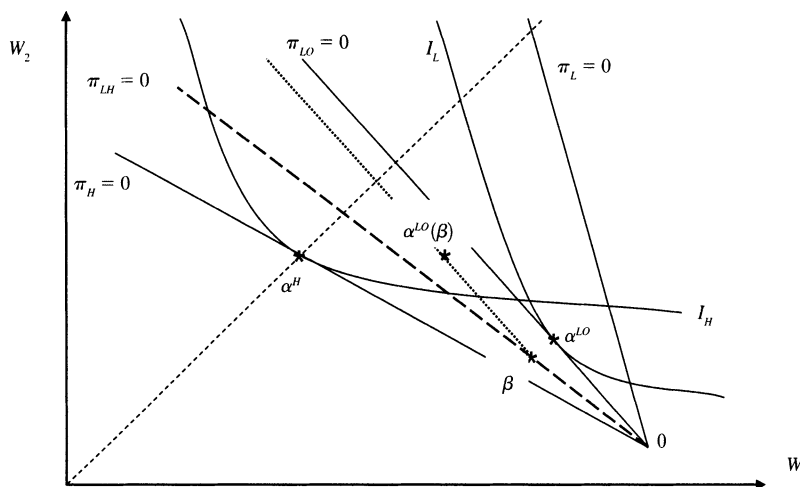


FIGURE 4. COMPULSORY INSURANCE WITH OVERCONFIDENCE

cannot improve all agents' welfare over the laissez-faire equilibrium. Specifically, it makes low-risk individuals worse off. Unlike the case that abstracts from overconfidence, compulsory insurance now induces a transfer of wealth from low-risk agents to high-risk agents without any beneficial effect on incentive compatibility constraints.

**RESULT 1:** *Suppose that the fraction of overconfident agents in the economy is either intermediate or large (i.e.,  $\kappa > \kappa_1(\lambda)$ ). Then, any compulsory insurance contract  $\beta > 0$  makes low risk agents strictly worse off.*

This result may be appreciated by inspecting Figure 4.

The low-risk and overconfident agents' zero-profit line  $\pi_{LO} = 0$  lies below the low-risk agents' indifference curve  $I_L$ , passing through the equilibrium contract  $\alpha^{LO}$ . Any budget-balanced compulsory insurance contract  $\beta$  lies on the zero-profit line  $\pi_{LH} = 0$ , which is strictly below the zero-profit line  $\pi_{LO} = 0$ . So, any contract  $\alpha^{LO}(\beta)$  purchased on top of a compulsory insurance contract  $\beta$  also lies below the zero-profit line  $\pi_{LO} = 0$  and, hence, below the indifference curve  $I_L$ . Thus, low-risk agents prefer the laissez-faire contract  $\alpha^{LO}$  over any allocation resulting from the introduction of compulsory insurance.

#### IV. Further Policy Results

We now show that the logic of Result 1 extends to any incentive-compatible budget-balanced policy (paternalistic or not). We define these policies formally in the Web Appendix. In contrast to the case without overconfidence, government intervention cannot improve all agents' welfare over the equilibrium outcome of this model.

**RESULT 2:** *Suppose that the fraction of overconfident agents in the economy is either intermediate or large (i.e.,  $\kappa > \kappa_1(\lambda)$ ). Then, no incentive-compatible budget-balanced policy can weakly improve the welfare of both low- and high-risk agents over the competitive equilibrium.*

The intuition for Result 2 is as follows.<sup>15</sup> The equilibrium contract  $\alpha^H$  strictly maximizes high-risk agents' utility among contracts on the zero-profit line  $\pi_H$ . Because the incentive compatibility constraint is not binding, the equilibrium contract  $\alpha^{LO}$  strictly maximizes low-risk agents' utility among contracts on the zero-profit line  $\pi_{LO} = 0$  (see Figure 4). Low-risk and overconfident agents cannot be separated by any

<sup>15</sup> Result 2 subsumes Result 1 because compulsory insurance is a special case of incentive-compatible budget-balanced government policy. Thus, Result 1 is demonstrated as a corollary of Result 2.



incentive-compatible policy because they have the same beliefs. Budget-balanced government intervention cannot simultaneously assign an allocation to high-risk agents above the zero-profit line  $\pi_H = 0$  and an allocation to low-risk agents above the line  $\pi_{LO} = 0$ . So, it cannot strictly increase the welfare of either high-risk or low-risk agents without making one of the two types strictly worse off.

### A. Underconfidence

We now enrich our basic model by introducing underconfident agents who perceive that their risk is high, when, in fact, it is low. We let their fraction in the economy be  $v \geq 0$ , and we denote the fraction of unbiased high-risk agents by  $\eta = 1 - \lambda - \kappa - v$ . The average risk of high-risk and underconfident agents is

$$p_{HU} = \frac{vp_L + \eta p_H}{v + \eta}.$$

We assume that  $p_{HU}$  is larger than the average risk of low-risk and overconfident agents  $p_{LO}$ .

In the unique (locally) competitive equilibrium, the contract  $\alpha^{HU}$  is purchased by high-risk and underconfident agents, and the contract  $\alpha^{LO}$  by low-risk and overconfident agents. Incentive compatibility ensures that high-risk and underconfident agents do not prefer  $\alpha^{LO}$  to  $\alpha^{HU}$ . The main difference with respect to the equilibrium in Section II is that high-risk and underconfident agents overinsure:  $\alpha_1^{HU} + \alpha_2^{HU} > d$ . These agents are less risky, on average, then they perceive to be:  $p_{HU} < p_H$ . Hence, they are willing to overinsure at the competitive price  $P^{HU} = p_{HU}$  of contract  $\alpha^{HU}$ .

Result 3, below, shows that our analysis extends beyond overconfidence. Specifically, compulsory insurance fails to make all agents in our model better off, provided that there are sufficiently many biased agents that can either be overconfident or underconfident.<sup>16</sup> Formally, Result 3 holds when the fraction of overconfident agents  $\kappa$  is larger than a threshold  $\bar{\kappa}(v, \lambda)$  defined in the Web Appendix. Because the function  $\bar{\kappa}(v, \lambda)$

decreases in  $v$ , the fraction  $\kappa$  is larger than  $\bar{\kappa}(v, \lambda)$  ( $\bar{\kappa}(v, \lambda)$  may be zero) whenever the fraction of underconfident agents  $v$  is larger than a threshold  $\bar{v}(\kappa, \lambda)$ .

**RESULT 3:** *Unless both fractions of overconfident and underconfident agents  $\kappa$  and  $v$  are small (i.e.,  $\kappa \leq \bar{\kappa}(v, \lambda)$ ), the government cannot weakly improve the welfare of both low- and high-risk agents upon the perfectly competitive equilibrium  $(\alpha^{HU}, \alpha^{LO})$  by means of any incentive-compatible budget-balanced policy (including compulsory insurance).*

Result 3 holds because when  $v$  increases, the average risk  $p^{HU}$  of the pool of high-risk and underconfident agents decreases. So, when  $\kappa$  increases, the low-risk and overconfident agents' average risk  $p^{LO}$  also increases. As either  $v$  or  $\kappa$  (or both) increase,  $p^{HU}$  becomes closer to  $p^{LO}$ . In a competitive equilibrium, the prices  $P^{HU}$  and  $P^{LO}$  of the equilibrium contracts  $\alpha^{HU}$  and  $\alpha^{LO}$  coincide with  $p^{HU}$  and  $p^{LO}$ , respectively. Hence, as either  $v$  or  $\kappa$  (or both) increase, the price difference between the contracts  $\alpha^{HU}$  and  $\alpha^{LO}$  decreases, and thus contract  $\alpha^{LO}$  becomes less attractive to high-risk and underconfident agents. As a result, incentive compatibility does not bind. Therefore, as in Result 2, government intervention cannot improve the welfare of all agents in our model.

### B. Training Programs

We now consider policies that reduce overconfidence in the context of driving insurance. A *self-assessment training* (voluntary) program may change overconfident agents' beliefs. At cost  $c > 0$ , each overconfident agent becomes aware of her high risk with probability  $q > 0$ . The other agents' beliefs are not changed by the program. This reduces the fraction of overconfident individuals in the economy.

If the training cost  $c$  is sufficiently small, the equilibrium is as follows. Agents who do not attend the program are offered the contracts  $\alpha^{LO}$  and  $\alpha^H$  derived in Section II. Agents who attend the program are offered  $\alpha^H$  and a contract  $\hat{\alpha}^{LO}$  with a lower price than  $\alpha^{LO}$ , after they complete the program. The contract  $\hat{\alpha}^{LO}$  is purchased by low-risk agents and by those agents who remain overconfident despite participating in the program. Overconfident agents who correct

<sup>16</sup> In Sandroni and Squintani (2007), we further explore the robustness of our results and show that they still hold (with proper qualifications) when there are more than two levels of risk in the economy.

their beliefs, due to having attended the program, buy contract  $\alpha^H$ . Low-risk and overconfident agents join the program; high-risk agents do not. This is the (unique) equilibrium because, if the training cost  $c$  is sufficiently small, the low-risk and overconfident agents are attracted to lower insurance prices and join the program.<sup>17</sup> So, the fraction of overconfident individuals  $\kappa$  decreases and this results in lower insurance prices.

Low-risk agents' beliefs are not changed by the training program, but they benefit indirectly through the reduction of the insurance price. High-risk agents do not join the program and are not affected by it. So, low-risk agents are strictly better off with the voluntary training program, whereas high-risk agents are not harmed by it.<sup>18</sup>

When describing welfare of overconfident agents, we focus on *actual* welfare, defined as the average ex post utility  $V(W, d; p_H, \alpha)$  of the equilibrium contract  $\alpha$ , the *actual* risk  $p_H$ , and the wealth  $W$  (net of training costs). It is conceptually difficult to describe the effect of training programs on the perceived welfare of overconfident agents who change beliefs after the program. However, their actual welfare increases when  $c$  is sufficiently small because they make a better insurance choice. Agents who remain overconfident despite participation in the program improve actual (and perceived) welfare through the reduction of the insurance price. This is summarized in Result 4.

**RESULT 4:** *Assume that the fraction of overconfident agents in the economy is either intermediate or large (i.e.,  $\kappa > \kappa_1(\lambda)$ ). As long as benefits  $q$  are sufficiently large and costs  $c$  are sufficiently low, the introduction of a voluntary training program strictly increases the welfare of low-risk agents and the actual welfare of overconfident agents. It does not change the welfare of high-risk agents.*

<sup>17</sup> At the time they choose to join the training program, none of these agents believes that they will improve their self-assessment skill. They join only because  $\hat{\alpha}^{LO}$  is cheaper than the contract  $\alpha^{LO}$  that they would be offered if they did not attend the program.

<sup>18</sup> In Sandroni and Squintani (2007), we show that if participation in self-assessment training programs were

## V. Conclusion

In the Rothschild and Stiglitz (1976) model of insurance markets with asymmetric information, compulsory insurance may make all agents better off, provided that agents are fully rational. We build on this basic model of insurance, but we assume that a significant fraction of agents in the economy do not accurately access actual risks. In addition, we assume that insurance companies cannot directly observe agents' beliefs. Under these assumptions, compulsory insurance fails to make all agents better off because it is detrimental to low-risk agents. Our results do not deliver unqualified support for laissez-faire policies. Rather they show that while behavioral biases may support paternalistic policies in simple decision-theoretic models, they may also weaken asymmetric information rationales for government intervention in fully developed market models.

We hope that these results will motivate additional studies on the interactions between different reasons for government intervention in the economy, and also on the functioning of markets when agents are less than fully rational.

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made compulsory, the program would reduce the utility of high-risk agents.

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