

HONESTY AND ADVERSE SELECTION

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Abstract

There is substantial evidence that generalized trust improves economic outcomes at both the individual and aggregate levels. Furthermore, certain institutions such as educational and religious institutions foster trust, trade, and economic growth. A specific mechanism through which trust might operate is honest communication. We consider the problem of a parent who can enroll her child in an institution which can make her child honest with probability less than one. We assume that whether the child is honest or not is the private information of the child but that institutional membership is observable so that institutions can serve as both imperfect socialization technologies and potentially informative signals of honesty. We consider the two main benchmark adverse selection models in the literature: the screening model and a game-theoretic version of the market for lemons. We provide conditions under which market institutions provide explicit monetary incentives for socialization. When socialization occurs in equilibrium it improves allocative efficiency in the screening model and reduces adverse selection in the market for lemons.

Keywords: deception, exchange, honesty, institutions, religion, trade, trust.

JEL Codes: D02, D03, D82, Z1.

Here, then, is the greatest dialectic of economic life, that between morality and the market.
John Kenneth Galbraith (1991, p. 26)

1 Introduction

There is substantial evidence that parents attempt and often succeed in instilling certain values and cultural traits in their children. According to the literature on cultural transmission, surveyed in Bisin and Verdier (2011), *direct socialization* (i.e., parental upbringing) plays an important role in the development of preferences for discounting and risk; generalized trust; attitudes towards work, welfare, and individual responsibility; and generosity. In addition to the family itself, other technologies for cultural transmission include *homogamous* marriage¹ and educational and religious institutions. Indeed, Bisin and Verdier present evidence from a variety of sources that parents often exhibit a strong preference for children with their own religious beliefs and are willing to make the appropriate costly investments.

Which values and traits do parents emphasize the most? Successive versions of the General Social Survey (GSS) have included questions such as “Which three qualities listed on this card would you say are the most desirable for a child to have?” and “Which one of these three is the most desirable of all?” The number one response by a substantial margin is “honesty” which is rated more highly than “tries hard to succeed,” “good sense and sound judgement,” “self-control,” “gets along with other children,” and “good student.” This is consistent with the experimental results in Gneezy (2005) and Hurkens and Kartik (2009), where subjects displayed an aversion to lying even in one-shot anonymous settings. Following Kartik (2009), we say that an agent is *honest* when he incurs a cost from being deceptive and *dishonest* otherwise. Note that this definition refers to *preferences* rather than *behavior* (an honest agent can still be deceptive) and *intrinsic* rather than *extrinsic* motivation (honesty is an acquired preference rather than behavior enforced by punishments as in the literature on repeated games).

There is also substantial evidence that honesty and other values related to trust have important implications for economic and organizational performance. Fukuyama (1995) stresses the role of social capital and trust in the formation of large-scale business enterprises in countries such as Japan, the United States, and West Germany. Landes (1999) presents historical evidence that certain cultural traits promote national economic success. In support of this thesis, Tabellini (2010) finds that generalized trust, respect for others, and confidence in the virtues of individualism have

¹I.e., marriage between two individuals with similar traits which increases the probability that those traits will be passed on to children.

positive and causal effects on economic development. Likewise, Algan and Cahuc (2010) show that trust has a significant positive impact on income per capita using the inherited trust of descendants of US immigrants as an instrument for trust in the country of origin. Guiso, Sapienza, and Zingales (2009) find that religious similarity and *somatic distance* (i.e., similarity of physical appearance) are important determinants of trust, which in turn is an important determinant of trade flows, foreign direct investment, and portfolio choice. This is especially true for trade in goods characterized by asymmetric information. Using data from the European Social Survey, Butler, Giuliano, and Guiso (2014) show that trust is important not only at the aggregate level (as in the aforementioned studies) but also at the individual level. In particular, they find an inverted-U relationship between individual income and individual trust beliefs so that individuals who exhibit the “right amount of trust” are more prosperous. Butler, Giuliano, and Guiso (2013) obtain similar results in experiments using a version of the trust game. In this context they find that trustworthiness is positively correlated with parental efforts at instilling closely related values. For a survey of this literature see Algan and Cahuc (2013) and for another that emphasizes the connections between culture and institutions see Alesina and Giuliano (2013).

In this paper we consider the problem of a parent who chooses from a set of technologies that can make her child honest with some probability. After implementing the chosen technology, two random variables are realized. The first is whether the technology was successful and the child is honest or not. In the second stage of the game the child becomes the seller in an exchange context with asymmetric information and the second random variable, independent from the first, is whether the child is a high or low type. We consider the two main benchmark adverse selection models in the literature: the basic two-type screening model where the child is the agent with high or low production cost and a game-theoretic version of Akerlof’s (1970) market for lemons similar to that in Streb and Torrens (2012) where the child is the seller of a high or low quality car. In the first model the *uninformed* party (the principal) moves first and designs a direct mechanism which conditions the contract on the agent’s statement about his type. In the second the *informed* party (the seller) moves first, sends the buyer a message about the quality of the car, and makes a take-it-or-leave-it offer with respect to the price. In both cases deception consists of the informed party making false statements about their type.

The crucial assumptions of the paper concern the nature of the technologies available to the parent and what the uninformed player can observe in the game with asymmetric information. As Frank (1987) notes, the fact that a seller is honest cannot influence trade unless honesty can be credibly signaled. This is the focus of the experiments in Frank, Gilovich, and Regan (1993), who

find that subjects can predict with “considerable accuracy” how other players will choose in a one-shot prisoner’s dilemma when the players can interact for 30 minutes prior to play. Although these experiments do not identify specific signaling mechanisms, Frank (1987) points to several physical signals of an involuntary nature.² In contrast, Ockenfels and Selten (2000) find little evidence of such involuntary signaling in their bargaining experiments.

Another empirical literature focuses on religion beginning with Max Weber’s *The Protestant Ethic and the Spirit of Capitalism* and its subsequent revival by Landes (1999). Guiso, Sapienza, and Zingales (2003) find that Christianity has a stronger association with attitudes conducive to economic growth than other religions. In particular, Christianity fosters trust, but more so for Protestants than Catholics. The economic consequences are confirmed in Guiso, Sapienza, and Zingales (2009) discussed previously. McCleary and Barro (2006) find that religious belief (i.e., belief in the afterlife) has a large and positive impact on economic growth. Algan and Cahuc (2010) find no relationship between religion and trust (see their Table 2) but the percentage of nonreligious persons and religious fractionalization have negative effects on income per capita which are much larger than inherited trust, lagged income per capita, political institutions, and historical preschool enrollment (Table 12). Norenzayan and Shariff (2008) survey the literature on religious pro-sociality, costly signaling, and trust and conclude that: (i) religious individuals are perceived to be more cooperative and trustworthy, (ii) religious groups with more costly requirements have more committed members, and (iii) in experiments religion is associated with trusting behavior. For example, in the trust game proposers forward more money to responders perceived to be religious and religious responders are more likely to reciprocate.³

In this paper we therefore stress the role of *institutions* as imperfect technologies for instilling honesty and fostering trust and *institutional membership* as a potentially observable and informative signal of trustworthiness.⁴ Although the above evidence points to specifically religious institutions, a variety of secular institutions may serve a similar function such as schools; medieval guilds and their modern equivalent, trade unions; as well as the family itself. E.g., Ariely, Garcia-Rada, Hornuf, and Mann (2014) find that cheating declined with education in their experiments. We

²E.g., Brown and Moore (2002) distinguish between posed smiles, which are asymmetrical and controlled by the left hemisphere of the brain, and spontaneous smiles, which are symmetrical and controlled by both hemispheres. In experiments they find that symmetrical smiles elicit higher offers in the dictator game.

³Religion also has a darker side: Guiso, Sapienza, and Zingales (2003) find that religious individuals tend to be more racist and Bénabou, Ticchi, and Vindigni (2013) that religion can suppress innovation both theoretically and empirically.

⁴The Calvinists (the subject of Weber’s original thesis) represent an extreme case as they were often distinguishable from other denominations due to strict dress codes. According to Murdock (2000, p. 195), “Concealment of the body in dark, undecorated clothing was therefore a visible means of expressing acceptance of normative moral behavior among Calvinists, both lay and clerical.”

emphasize that in our model institutional membership is not necessarily a guarantee of trustworthy behavior but under certain conditions it may serve as an endogenous and informative signal of honesty. Indeed, we will show that some members do in fact lie in equilibrium.

In the second stage of the game when exchange occurs we assume the uninformed party can observe which institution the informed party belongs to but not whether that institution was successful at making the informed party honest. In the screening model we show that an altruistic parent faces the following tradeoffs with respect to her choice of the optimal institution. On the negative side, institutional membership is costly and honest children have the disturbing tendency to surrender information rent. On the positive side, socialized children may receive higher wages in a competitive labor market. Furthermore, when the institution is unsuccessful the dishonest high type collects greater information rent. The primary beneficiary of investments in honesty is therefore the dishonest child rather than the honest one. In the market for lemons the parent faces a different set of tradeoffs. When the market is inefficient an investment in honesty allows high quality types to trade who would otherwise be barred by adverse selection. Specifically, the corresponding semi-separating equilibrium with socialization is one where the honest low quality type separates, tells the truth, and charges a low price while all other types (including the dishonest low type) claim to be high types and pool on a high price which is increasing in the level of socialization. The dishonest low type therefore lies in equilibrium. In contrast, when the market is efficient socialization is unnecessary and may in fact impede the efficient operation of the market.

The model therefore predicts there may be less adverse selection in the used car market than standard theory predicts.⁵ The empirical evidence is indeed mixed. Peterson and Schneider (2013) do find evidence of adverse selection which they characterize as “moderate”; e.g., recently purchased used cars have 12% more engine repairs than all used cars, traded and non-traded. They also find no evidence of moral hazard (another dimension of trustworthiness) in the sense of cutting back on maintenance prior to sale. The empirical results in Lacko (1986) suggest relatively high levels of trust even between strangers. In particular, there is no significant difference in the quality of used cars traded between friends and relatives as compared with trade initiated by newspaper ads for cars between 1-7 years old. For cars between 8-15 years old, the difference is significant but again not very large: average repair expenditures are only \$166 dollars less for trade between friends and relatives as compared with trade based on newspaper ads. In Lacko’s hedonic regressions there is no significant relationship between price and quality which is consistent with pooling as in our

⁵ A complementary explanation is provided by Hendel and Lizzeri (1999), who show that adverse selection is reduced when the interaction between the new and used car markets is explicitly modeled which makes the valuations of used car sellers endogenous.

semi-separating equilibrium with honesty. Finally, warranties had no significant effect on quality as one would expect in a world of asymmetric information and signaling.

The present paper identifies conditions under which the market provides monetary incentives for the emergence of endogenous honesty. It therefore contributes to the venerable multidisciplinary debate about the effects of capitalism on culture, morals, and values and vice-versa. One prominent view, which Zelizer (1998) refers to as the *boundless market hypothesis*, is that the market does not need morals, norms, or any form of social relations for its functioning and indeed actively works to undermine such values.

The market community as such is the most impersonal relationship of practical life into which humans can enter with one another... Where the market is allowed to follow its own autonomous tendencies, its participants do not look toward the persons of each other but only toward the commodity; there are no obligations of brotherliness or reverence, and none of those spontaneous human relations that are sustained by personal unions. They all would just obstruct the free development of the bare market relationship, and its specific interests serve, in their turn, to weaken the sentiments on which these obstructions rest.

Max Weber, *Economy and Society* (1978, p. 636)

In an influential survey, Bowles (1998) observes that experimental results tend to approximate rational self-interested behavior in settings that mimic market institutions (e.g., auctions) whereas other-regarding preferences such as reciprocity tend to be observed in non-market settings like the ultimatum game. Vohs, Mead, and Goode (2006) find that the mere suggestion of money (e.g., screensavers involving dollar bills) induces anti-social behavior. Likewise, Falk and Szech (2013) find a greater disregard for (animal) life the closer the experimental setting resembles a large anonymous market. Dufwenberg *et al.* (2011) provide necessary and sufficient conditions such that demand functions are independent of other-regarding preferences. In that case, the set of general Walrasian equilibria is unaffected by such preferences and the market does not provide any incentive to adhere to or acquire them. Hiller and Verdier (2014) develop a principal-agent model where the product and labor markets are explicitly modeled and motivation is provided by either monetary incentives or corporate culture. In their model an increase in product market competition reduces investments in corporate culture.

But there is also evidence in the opposite direction. Henrich *et al.* (2010) conduct experiments with a diverse sample of international subjects and find that religion and the level of market integration (the proportion of calories purchased in markets) are positively correlated with fairness (offers in the dictator, ultimatum, and third-party punishment games). Francois, Fujiwara, and Ypersele (2011) find that greater competition in the form of banking deregulation which stimulated entry or an increase in US census competition measures leads to greater trust as measured by the

GSS. Finally, Ariely, Garcia-Rada, Hornuf, and Mann (2014) conduct experiments with East and West Germans and find that dishonesty is increasing in the subject's exposure to socialism.

In this paper we reconcile these seemingly contradictory findings by showing that there is no simple relationship between markets and values; the market can either encourage or discourage the development of such values depending on specific aspects of the market in question. In particular, when the market is efficient the boundless market hypothesis obtains in the sense that its functioning does not require "sentiment" and honesty may actually impede its efficient operation. In contrast, when the market is inefficient it provides monetary incentives for the emergence of honesty to reduce adverse selection.

Our paper contributes to the literature on cultural transmission pioneered by Bisin and Verdier (2000, 2001), including Doepke and Zilibotti (2008), Guiso, Sapienza, and Zingales (2008), and Tabellini (2010), who shows how generalized trust can emerge in the context of the Prisoner's Dilemma through a dynamic process governed by direct socialization. For a comprehensive survey of this literature see Bisin and Verdier (2011). Our paper also contributes to a growing literature on honesty initiated by the experimental results in Gneezy (2005) and subsequently replicated in Hurkens and Kartik (2009) albeit with a different interpretation. The associated theoretical literature begins with Kartik (2009), who shows how deception costs affect communication in a general class of sender-receiver games. The literature on honesty and mechanism design includes Kartik, Tercieux, and Holden (2014), who show that when there are at least two agents and a separable punishment condition holds, any social choice function can be implemented by a simple mechanism in two rounds of iterated elimination of strictly dominated strategies.

The plan for the rest of the paper is as follows. In the next section we consider the endogenous development of honesty in the context of screening mechanisms and in section 3 in the market for lemons. Section 4 concludes. All proofs are in the appendix.

2 Honesty and Screening

We first consider exchange under asymmetric information where the uninformed party (i.e., the principal) moves before the informed party (the agent). Specifically, we extend the textbook two-type screening model to the case of endogenous honesty.⁶ We assume a unit mass of identical parents (she) and a corresponding unit mass of ex ante identical children (he) where each parent has exactly one child. We conceptualize *institutions* (e.g., the family, schools, and religious institutions)

⁶We assume familiarity with this standard model. E.g., see chapter 2 in Laffont and Martimort (2002).

as imperfect technologies which can instill certain traits with some probability through a process of socialization. In this paper we focus on *honesty* in the form of a deception cost $\psi \geq 0$ which the child incurs when he is deceptive. Formally, an *institution* is a random variable $\tilde{\psi}$ such that $\tilde{\psi} = 0$ (the child is *dishonest*) with probability $0 < \nu < 1$ and $\tilde{\psi} = \psi$ (the child is *honest* with deception cost ψ) with probability $1 - \nu$. Since ψ is the level of honesty that the institution is attempting to achieve we often refer to it as the level of socialization provided by institution $\tilde{\psi}$.

We assume the parent can choose from a *complete* set of institutions in the sense that for all $\psi \geq 0$ there exists a corresponding institution $\tilde{\psi}$ which imparts ψ with probability $1 - \nu$.⁷ Let $(1/2)\psi^2$ be the cost associated with institution $\tilde{\psi}$. Such costs include explicit membership costs (e.g., dues, fees, or tithes), participation costs (e.g., the opportunity cost of attending religious services and other activities), and direct socialization costs (e.g., instruction and other activities in the home). Note that the parent is free to choose $\tilde{0}$ which is costless and makes the child dishonest with probability one. We assume the parent is *altruistic* in the sense that she chooses the institution which maximizes the expected payoff of the child less socialization costs $(1/2)\psi^2$. The key assumption is that institutional membership is observable although the realization of the random variable $\tilde{\psi}$ (whether or not the child is honest) is not.

After a period of socialization within the institution $\tilde{\psi}$ chosen by the parent, two random variables are realized. The first is $\tilde{\psi}$, which determines whether the child is honest or not. The second $\tilde{\theta}$ is the child's production cost, which can be low $\underline{\theta} \geq 0$ with probability $0 < \gamma < 1$ or high $\bar{\theta}$ with probability $1 - \gamma$, where $\Delta\theta = \bar{\theta} - \underline{\theta} > 0$. We assume $\tilde{\psi}$ and $\tilde{\theta}$ are independent for each agent and across agents. The realizations of these random variables are observed only by the child and constitute his private information.

After observing the realizations of $\tilde{\psi}$ and $\tilde{\theta}$ the child enters the labor market where a unit mass of identical principals (she) each demands one agent to produce output q . The labor market operates as follows. Each principal identifies the institution $\tilde{\psi}$ that maximizes her expected profit and randomly selects one agent from that institution. The principal offers that agent a direct mechanism $(q(\hat{\psi}, \hat{\theta}), t(\hat{\psi}, \hat{\theta}))$, where output q and the agent's pay t depend on the agent's announcement $(\hat{\psi}, \hat{\theta})$ about his type. In this context the agent is deceptive when he lies to the direct mechanism. The principal chooses the direct mechanism that maximizes her expected profit from the set of all such mechanisms that satisfy the incentive compatibility (truth-telling) and participation constraints.

⁷Note that ν is constant across institutions. A richer set of institutions would be the set of all (ν, ψ) , where $0 \leq \nu \leq 1$ and $\psi \geq 0$. In this case, the parent could choose both the deception cost ψ and the probability $1 - \nu$ at some cost which is increasing in ψ and decreasing in ν . In this paper we assume ν is constant across institutions for simplicity.

The case where the principal makes no offer or the agent rejects it is off the equilibrium path. We may therefore assume that an agent from institution $\tilde{\psi}$ believes that he can earn $\alpha\psi$ if he returns to the labor market and the principal believes that she can select another agent from institution $\tilde{\psi}$ which is ex ante statistically identical to the one before. The outside option of an agent from institution $\tilde{\psi}$ is therefore $\alpha\psi$ which determines the agent's outside option and participation constraint.

The term α is endogenous and determined as follows. Given α , each parent selects an institution to enroll their child and each principal selects an institution from which they will recruit. From the principal's perspective the outside option $\alpha\psi$ is the minimum payment or wage of an agent from institution $\tilde{\psi}$. The term α is therefore the price per unit of deception cost ψ which the institution $\tilde{\psi}$ attempts to instill. Since socialization is only successful with probability $1 - \nu$ we refer to the principal's *demand for socialization* rather than demand for honesty. The equilibrium price α equates the aggregate demand for socialization by principals and the aggregate supply of socialization by parents and the equilibrium institution $\tilde{\psi}$ determines the equilibrium level of socialization in the economy.

The expected payoff of the principal is $V = S(q) - t$, where $S(q)$ is the expected benefit of output q . The payoff to a dishonest agent is $U = t - \theta q$ depending on the realization θ of $\tilde{\theta}$. The payoff to an honest agent is $U - \psi$ when he is deceptive (and hence bears the cost ψ) and U otherwise. Utilitarian welfare not including deception costs is

$$W(q, \theta) = V + U = S(q) - \theta q. \quad (1)$$

The following assumptions ensure the principal's screening problem has a unique interior solution.

Assumption 1 *The principal's expected benefit $S : [0, \infty) \rightarrow [0, \infty)$ is twice differentiable on $(0, \infty)$ with $S(0) = 0$, $S' > 0$, $\lim_{q \rightarrow 0} S'(q) = \infty$, $\lim_{q \rightarrow \infty} S'(q) = 0$, and $S'' < 0$.*

We summarize the timing of the game as follows.

- (i) Each parent chooses an institution $\tilde{\psi}$.
- (ii) The random variables $\tilde{\psi}$ and $\tilde{\theta}$ are realized and become the child's private information.
- (iii) Given the price α of socialization, each principal chooses an institution and randomly selects one agent from that institution.

- (iv) If the principal makes an offer the agent either accepts or rejects. If the principal does not make an offer or the agent rejects the agent returns to the labor market where he anticipates an expected payoff of $\alpha\psi$.
- (v) If the agent accepts then he announces his type and the corresponding contract is executed. We assume that when the agent is indifferent between a set of options he is willing to choose as the principal directs.

We solve the model using backward induction starting from stage (iv). We first briefly consider the complete information benchmark. When the principal observes the realization θ of the agent's production cost there is no reason for investments in honesty and none are demanded or supplied. In this case the principal chooses the output-payment combination (q, t) that maximizes her expected payoff $V = S(q) - t$ subject to the participation constraint $t - \theta q \geq 0$.

Lemma 1 *Under complete information the first best outputs \underline{q}^* and \bar{q}^* are given by*

$$S'(\underline{q}^*) = \underline{\theta} \quad \text{and} \quad S'(\bar{q}^*) = \bar{\theta}, \quad (2)$$

where $0 < \bar{q}^* < \underline{q}^*$.

We now return to the incomplete information case. An agent from institution $\tilde{\psi}$ has four possible types: the efficient honest type $(\psi, \underline{\theta})$ with deception cost ψ , the inefficient honest type $(\psi, \bar{\theta})$, the efficient dishonest type $(0, \underline{\theta})$, and the inefficient dishonest type $(0, \bar{\theta})$. In what follows an underlined variable refers to an efficient agent, an overlined one to an inefficient agent, a subscript ψ to an honest agent, and a subscript 0 to a dishonest one. The principal's problem is to choose the menu $(\underline{t}_\psi, \underline{q}_\psi)$, $(\bar{t}_\psi, \bar{q}_\psi)$, $(\underline{t}_0, \underline{q}_0)$, and (\bar{t}_0, \bar{q}_0) to maximize expected profit

$$\gamma\nu [S(\underline{q}_0) - \underline{t}_0] + \gamma(1 - \nu) [S(\underline{q}_\psi) - \underline{t}_\psi] + (1 - \gamma)\nu [S(\bar{q}_0) - \bar{t}_0] + (1 - \gamma)(1 - \nu) [S(\bar{q}_\psi) - \bar{t}_\psi] \quad (3)$$

subject to the incentive compatibility and participation constraints.⁸ For example, the incentive

⁸Since there are 4 types, there are 4 participation constraints and 12 incentive compatibility constraints. We do not list them all here; for a complete statement of the problem see the appendix.

compatibility constraints of the efficient honest type are

$$\underline{t}_\psi - \underline{\theta} \underline{q}_\psi \geq \underline{t}_0 - \underline{\theta} \underline{q}_0 - \psi \quad (4)$$

$$\underline{t}_\psi - \underline{\theta} \underline{q}_\psi \geq \bar{t}_\psi - \bar{\theta} \bar{q}_\psi - \psi \quad (5)$$

$$\underline{t}_\psi - \underline{\theta} \underline{q}_\psi \geq \bar{t}_0 - \bar{\theta} \bar{q}_0 - \psi \quad (6)$$

because the agent is honest and therefore incurs the deception cost ψ whenever he claims to be a different type. The participation constraint is

$$\underline{t}_\psi - \underline{\theta} \underline{q}_\psi \geq \alpha \psi. \quad (7)$$

We solve this problem in the standard way. We first re-write it using the following change of variables

$$\underline{U}_\psi = \underline{t}_\psi - \underline{\theta} \underline{q}_\psi \quad (8)$$

$$\underline{U}_0 = \underline{t}_0 - \underline{\theta} \underline{q}_0 \quad (9)$$

$$\bar{U}_\psi = \bar{t}_\psi - \bar{\theta} \bar{q}_\psi \quad (10)$$

$$\bar{U}_0 = \bar{t}_0 - \bar{\theta} \bar{q}_0. \quad (11)$$

In what follows we refer to \underline{U}_ψ etc. as the agent's *payoff* and the difference $\underline{U}_\psi - \alpha \psi$ between the payoff and the outside option as the agent's *rent*. Let $\vec{q} = (\underline{q}_\psi, \underline{q}_0, \bar{q}_\psi, \bar{q}_0)$ be the vector of outputs and $\vec{U} = (\underline{U}_\psi, \underline{U}_0, \bar{U}_\psi, \bar{U}_0)$ the vector of payoffs for each type. The principal now chooses \vec{q} and \vec{U} to maximize

$$\begin{aligned} & \gamma \nu W(\underline{q}_0, \underline{\theta}) + \gamma(1 - \nu)W(\underline{q}_\psi, \underline{\theta}) + (1 - \gamma)\nu W(\bar{q}_0, \bar{\theta}) + (1 - \gamma)(1 - \nu)W(\bar{q}_\psi, \bar{\theta}) \\ & - \gamma \nu \underline{U}_0 - \gamma(1 - \nu)\underline{U}_\psi - (1 - \gamma)\nu \bar{U}_0 - (1 - \gamma)(1 - \nu)\bar{U}_\psi \end{aligned} \quad (12)$$

subject to

$$\underline{U}_\psi \geq \underline{U}_0 - \psi \quad (13)$$

$$\underline{U}_\psi \geq \bar{U}_\psi + \Delta \theta \bar{q}_\psi - \psi \quad (14)$$

$$\underline{U}_\psi \geq \bar{U}_0 + \Delta \theta \bar{q}_0 - \psi \quad (15)$$

$$\underline{U}_\psi \geq \alpha \psi \quad (16)$$

and the incentive compatibility and participation constraints for the other types. I.e., the principal chooses the menu that maximizes expected utilitarian welfare less the expected payoff to the agent.

Recall that \vec{q} is *implementable* if there exists a \vec{U} such that \vec{q} and \vec{U} satisfy the incentive compatibility constraints. We now employ the usual two-step procedure where in the first step we take as given an implementable \vec{q} and find the \vec{U} that minimizes the expected cost

$$\gamma\nu\underline{U}_0 + \gamma(1 - \nu)\underline{U}_\psi + (1 - \gamma)\nu\bar{U}_0 + (1 - \gamma)(1 - \nu)\bar{U}_\psi \quad (17)$$

of implementing \vec{q} subject to the incentive compatibility and participation constraints. We have assumed $S'(0) = \infty$ so it is clear that the principal will select non-zero outputs for all four types. It is also clear that efficient types will produce more than inefficient types (as shown in Proposition 2 below) so the following result is limited to implementable \vec{q} with these properties.⁹

Proposition 1 *Let \vec{q} be implementable with non-zero output for each type. Let $\bar{q} = \max\{\bar{q}_\psi, \bar{q}_0\}$ and $\underline{q}_\psi, \underline{q}_0 \geq \bar{q}$. The payoffs \vec{U} that minimize the principal's expected cost (17) subject to the incentive compatibility and participation constraints are given by*

$$\bar{U}_\psi = \bar{U}_0 = \alpha\psi, \quad (18)$$

$$\underline{U}_0 = \alpha\psi + \Delta\theta\bar{q}, \quad (19)$$

and

$$\underline{U}_\psi = \begin{cases} \alpha\psi & \text{if } \psi \geq \Delta\theta\bar{q} \\ \alpha\psi + \Delta\theta\bar{q} - \psi & \text{if } \psi < \Delta\theta\bar{q}. \end{cases} \quad (20)$$

Recall that in the textbook two-type screening model with zero outside option the efficient type has an incentive to lie and claim to be the inefficient type. If the efficient type takes the contract (\bar{U}, \bar{q}) of the inefficient type his payoff will be $\bar{U} + \Delta\theta\bar{q}$, the payoff \bar{U} of the inefficient type plus the cost savings $\Delta\theta\bar{q}$ of the efficient type. To make the contract (\bar{U}, \bar{q}) as unattractive as possible to the efficient type the principal sets $\bar{U} = 0$ so the inefficient type receives no rent. The principal then offers the efficient type *information rent* $\underline{U} = \Delta\theta\bar{q}$ equal to his cost savings to make him indifferent between his contract $(\underline{U}, \underline{q})$ and that (\bar{U}, \bar{q}) of the inefficient type.

The textbook intuition carries over to the present setting but with some modifications to take

⁹In the textbook model the implementability condition is $\underline{q} \geq \bar{q}$, where \underline{q} is the output level of the efficient type and \bar{q} that for the inefficient type. In the present model the implementability conditions (see the appendix) no longer imply that efficient types must produce more than inefficient types; this must be derived from the optimization problem of the principal. See Proposition 8 in the appendix for a complete solution.

account of the efficient honest type. We first consider the incentive compatibility constraints of the efficient dishonest type

$$\underline{U}_0 \geq \underline{U}_\psi \quad (21)$$

$$\underline{U}_0 \geq \bar{U}_\psi + \Delta\theta\bar{q}_\psi \quad (22)$$

$$\underline{U}_0 \geq \bar{U}_0 + \Delta\theta\bar{q}_0. \quad (23)$$

Since the efficient dishonest type can always mimic the efficient honest type, it is clear that the constraint (21) never binds. From (22) and (23) any rent paid to the inefficient types merely increases the rent that has to be paid to the efficient dishonest type. As in the textbook model the principal therefore offers the inefficient types the outside option and their participation constraints bind. Substituting $\bar{U}_\psi = \bar{U}_0 = \alpha\psi$ into (22) and (23), the minimum rent necessary to satisfy the incentive compatibility constraints of the efficient dishonest type is

$$\underline{U}_0 = \alpha\psi + \Delta\theta \max\{\bar{q}_\psi, \bar{q}_0\} = \alpha\psi + \Delta\theta\bar{q} \quad (24)$$

as stated in the result. If the efficient honest type lies and claims to be the efficient dishonest type then he receives information rent $\Delta\theta\bar{q}$ but incurs the deception cost ψ . If $\psi \geq \Delta\theta\bar{q}$ the efficient honest type prefers his own contract and his participation constraint binds. If, however, $\psi < \Delta\theta\bar{q}$ the efficient honest type requires some information rent to truthfully reveal his type but the principal can reduce his rent by exactly ψ to make him indifferent between his contract and that for the efficient dishonest type.

Step two in the two-step procedure is to find the optimal \vec{q} that maximizes expected profit (12) given the cost-minimizing \vec{U} we found in the first step.

Proposition 2 *Let*

$$S'(\bar{q}_L) = \bar{\theta} + \frac{\gamma\Delta\theta}{1-\gamma} \quad (25)$$

and

$$S'(\bar{q}_H) = \bar{\theta} + \frac{\gamma\nu\Delta\theta}{1-\gamma} \quad (26)$$

where $\bar{q}_L < \bar{q}_H < \bar{q}^*$. Define

$$I_L = [0, \Delta\theta\bar{q}_L] \quad (27)$$

$$I_M = [\Delta\theta\bar{q}_L, \Delta\theta\bar{q}_H] \quad (28)$$

$$I_H = [\Delta\theta\bar{q}_H, \infty). \quad (29)$$

The optimal output levels are $q_0 = q_\psi = \underline{q}^*$ and

$$\bar{q} = \begin{cases} \bar{q}_L & \text{if } \psi \in I_L, \\ \psi/\Delta\theta & \text{if } \psi \in I_M, \\ \bar{q}_H & \text{if } \psi \in I_H. \end{cases} \quad (30)$$

In the textbook model the principal faces the classical *rent-extraction/efficiency tradeoff*: the principal can reduce the rent $\underline{U} = \Delta\theta\bar{q}$ of the efficient type by reducing the output \bar{q} of the inefficient type but doing so decreases allocative efficiency in the sense of reducing utilitarian welfare $W(q, \bar{\theta})$ for the inefficient types which is maximized at the first best level $q = \bar{q}^*$. In the textbook model the output level \bar{q} which optimally balances this tradeoff is precisely \bar{q}_L in (25). This is also the optimal output level in our model when socialization is sufficiently low in the sense that $\psi \in I_L$.

At medium levels of socialization $\psi \in I_M$ the principal faces a second consideration not present in the textbook model in addition to the rent-extraction/efficiency tradeoff: if \bar{q} is sufficiently low in the sense that $\Delta\theta\bar{q} \leq \psi$ then from (20) the principal does not have to pay the efficient honest type any rent. On the other hand, the \bar{q} that optimizes the rent-extraction/efficiency tradeoff for the efficient dishonest type is given by $\bar{q} = \bar{q}_H$ in (26). If $\psi \in I_M$ is not at the extreme right endpoint

$$\Delta\theta\bar{q}_L \leq \psi < \Delta\theta\bar{q}_H \iff \bar{q}_L \leq \frac{\psi}{\Delta\theta} < \bar{q}_H \quad (31)$$

there is a tension between these two objectives because the principal cannot shut off rents to the efficient honest type (which requires $\bar{q} \leq \psi/\Delta\theta$) and optimize the rent-extraction/efficiency tradeoff for the efficient dishonest type (which requires $\bar{q} = \bar{q}_H$). According to the above result the solution is to choose the highest output level $\bar{q} = \psi/\Delta\theta$ consistent with zero rent for the efficient honest type. Note that an increase in the deception cost ψ reduces this tension because it allows the principal to choose a higher $\bar{q} = \psi/\Delta\theta$ and improve allocative efficiency for the inefficient types while keeping the efficient honest type at zero rent. This also increases the rent $\Delta\theta\bar{q}$ of the efficient dishonest type who is in fact the primary beneficiary of investments in honesty on this region I_M

even though such investments raise the wage $\alpha\psi$ of all four types when α is non-zero.

Finally, at high levels of socialization $\psi \in I_H$ we have $\bar{q}_H \leq \psi/\Delta\theta$ so the output level $\bar{q} = \bar{q}_H$ achieves both of the aforementioned objectives at once and is therefore clearly optimal. In all cases the efficient types produce their first best output levels $\underline{q}_0 = \underline{q}_\psi = \underline{q}^*$.

We now consider stage (iii) of the game where given the market price α of socialization each principal chooses an institution $\tilde{\psi}$ and then randomly selects an agent from that institution. The next result derives the representative principal's demand for socialization.¹⁰

Proposition 3 *The principal's demand for socialization as a function of the price α is given by*

$$\psi_D(\alpha) = \begin{cases} \psi_I(\alpha) & \text{if } 0 \leq \alpha < \gamma(1 - \nu) \\ \psi \in I_L & \text{if } \alpha = \gamma(1 - \nu) \\ 0 & \text{if } \alpha > \gamma(1 - \nu). \end{cases} \quad (32)$$

where $\psi_I(\alpha)$ is the solution to the equation

$$S' \left[\frac{\psi_I(\alpha)}{\Delta\theta} \right] = \bar{\theta} + \frac{(\alpha + \gamma\nu)\Delta\theta}{1 - \gamma}. \quad (33)$$

The intuition is as follows. From Propositions 1 and 2, at low levels of socialization $\psi \in I_L$ the principal sets the output of the inefficient types at \bar{q}_L and pays rents

$$\underline{U}_\psi = \alpha\psi + \Delta\theta\bar{q}_L - \psi \quad (34)$$

$$\underline{U}_0 = \alpha\psi + \Delta\theta\bar{q}_L. \quad (35)$$

Since \bar{q}_L does not depend on ψ , the value of honesty on the region I_L is that an increase in ψ allows a one-for-one reduction in the rent of the efficient honest type. The expected marginal benefit of socialization is therefore the probability $\gamma(1 - \nu)$ of that type. The marginal cost is the price α which determines the wage $\alpha\psi$ for all four types. If the marginal cost α exceeds the expected marginal benefit $\gamma(1 - \nu)$ the principal demands zero socialization as indicated in (32). If $\gamma(1 - \nu)$ is equal to α the principal is indifferent between all honesty levels in the interval I_L . Demand is therefore a correspondence rather than a function.

At low levels of socialization $\psi \in I_L$ the principal values honesty because it allows her to reduce the rent that has to be paid to the efficient honest type. At medium levels $\psi \in I_M$ of socialization

¹⁰The *market* demand for socialization is the integral of (32) over the unit mass of identical principals; e.g., $[0, 1]$ with Lebesgue measure. Since the integral of a correspondence is the set of all integrals of measurable selections one can verify that (32) represents the market as well as individual demand as is intuitively obvious.

the efficient honest type earns zero rent

$$\underline{U}_\psi = \alpha\psi \quad (36)$$

$$\underline{U}_0 = \alpha\psi + \Delta\theta\bar{q} = \alpha\psi + \psi \quad (37)$$

so the principal values honesty for somewhat different reasons. In this region I_M an increase in ψ reduces the tension between keeping the efficient honest type at zero rent and the rent-extraction/efficiency tradeoff for the efficient dishonest type. In particular, it allows the principal to keep the efficient honest type at zero rent but at a higher output level $\bar{q} = \psi/\Delta\theta$ for the inefficient types which entails less allocative inefficiency. The costs are the increase in the wage $\alpha\psi$ for all four types and the increase in rent $\Delta\theta\bar{q} = \psi$ to the efficient dishonest type. The optimal level $\psi_I(\alpha)$ of socialization is determined by (33) which we re-arrange to make its intuitive content clearer

$$(1 - \gamma) \left\{ S' \left[\frac{\psi_I(\alpha)}{\Delta\theta} \right] - \bar{\theta} \right\} \frac{1}{\Delta\theta} = \alpha + \gamma\nu. \quad (38)$$

The left-hand side is the expected marginal benefit of honesty to the principal: an increase in ψ increases the output level $\bar{q} = \psi/\Delta\theta$ of the inefficient types which improves utilitarian welfare for those types. The first term on the left-hand side is the probability of an inefficient type, the second term is the improvement in allocative efficiency from an incremental increase in output \bar{q} , and the final term is the increase in output $\bar{q} = \psi/\Delta\theta$ due to an incremental increase in honesty ψ . The right-hand side is the marginal cost of honesty to the principal: an increase in ψ increases the wage $\alpha\psi$ that must be paid to all four types as well as the rent of the efficient dishonest type which occurs with probability $\gamma\nu$. Note that $\psi_I(\alpha)$ is decreasing in the price α .

As the level ψ of socialization increases on I_M the tension between shutting off rent to the efficient honest type and optimizing the rent-extraction/efficiency tradeoff for the efficient dishonest type decreases until $\psi = \Delta\theta\bar{q}_H$ where it disappears. At $\psi = \Delta\theta\bar{q}_H$ the principal selects \bar{q}_H which entails zero rent for the efficient honest type as well as the optimal rent-extraction/efficiency tradeoff for the efficient dishonest type

$$\underline{U}_\psi = \alpha\psi \quad (39)$$

$$\underline{U}_0 = \alpha\psi + \Delta\theta\bar{q}_H. \quad (40)$$

Any further increase in socialization would increase the wage $\alpha\psi$ the principal pays to all four types but without any corresponding benefit to the principal. In fact, the principal demands $\psi = \Delta\theta\bar{q}_H$

when socialization is free $\alpha = 0$ as can be seen from (33). This is therefore the maximum possible level of socialization which can occur in equilibrium as well as the optimal level of socialization from the principal's perspective. It is not necessarily the socially optimal level because the costs of socialization must be accounted for. To do so we need to consider the supply as well as the demand for socialization.

In summary, at low levels $\psi \in I_L$ of socialization the representative principal values honesty because it allows her to reduce the information rent of the efficient honest type. At medium levels $\psi \in I_M$ she values honesty because it allows her to improve allocative efficiency. The principal does not value high levels $\psi \in I_H$ of socialization (except for the left endpoint which is also in I_M).

We now consider the supply of socialization determined by the institutional choices of parents. The representative parent's problem is to choose the institution $\tilde{\psi}$ (indexed by the deception cost $\psi \geq 0$) that maximizes the expected payoff of the child less socialization costs

$$P = \alpha\psi + \text{expected rent} - (1/2)\psi^2. \quad (41)$$

The first term is the wage which reflects the *market* valuation α of socialization while the second term captures the effects of honesty on information rents *within the firm*. Let $\psi_S(\alpha)$ denote the supply correspondence. For each $\alpha \geq 0$, $\psi_S(\alpha)$ is the set of optimal institutions from the perspective of the representative parent.

Since the principal offers different menus on I_L , I_M , and I_H , the parent's objective function consists of three separate pieces. At low levels of socialization $\psi \in I_L$ the payoffs of the efficient types are given by (34) and (35) and the parent's expected payoff is

$$P_L = [\alpha - \gamma(1 - \nu)]\psi + \gamma\Delta\theta\bar{q}_L - (1/2)\psi^2. \quad (42)$$

On this region the parent values honesty because it increases the wage $\alpha\psi$ of all four types. The cost of honesty is that it reduces the information rent of the efficient honest type (which occurs with probability $\gamma(1 - \nu)$) in addition to socialization costs. At medium levels of socialization $\psi \in I_M$ the payoffs of the efficient types are (36) and (37) and the parent's expected payoff is

$$P_M = (\alpha + \gamma\nu)\psi - (1/2)\psi^2. \quad (43)$$

On this region the parent values honesty because it increases the wage $\alpha\psi$ of all four types as well as the information rent of the efficient dishonest type which occurs with probability $\gamma\nu$. For reasons

that will become clear (see Lemma 2) we examine this region in more detail. Consider the problem of choosing ψ to maximize P_M subject to the constraint $\psi \in I_M$. The solution is

$$\psi_M(\alpha) = \begin{cases} \Delta\theta\bar{q}_L & \text{if } \alpha \leq \Delta\theta\bar{q}_L - \gamma\nu \\ \alpha + \gamma\nu & \text{if } \Delta\theta\bar{q}_L - \gamma\nu < \alpha < \Delta\theta\bar{q}_H - \gamma\nu \\ \Delta\theta\bar{q}_H & \text{if } \alpha \geq \Delta\theta\bar{q}_H - \gamma\nu. \end{cases} \quad (44)$$

At high levels of socialization $\psi \in I_H$ the payoffs of the efficient types are (39) and (40) and the parent's expected payoff is

$$P_H = \alpha\psi + \gamma\nu\Delta\theta\bar{q}_H - (1/2)\psi^2. \quad (45)$$

On this region the parent values honesty because it increases the wage.

To find the optimal solution $\psi_S(\alpha)$, for each $i = L, M, H$ we find the ψ that maximizes P_i subject to the constraint $\psi \in I_i$ as we did for the case of medium socialization in (44). Let $\psi_i(\alpha)$ denote the solution on region I_i . We then compare $P_i(\psi_i(\alpha))$ to see which local optimum is global. Formally,

$$\psi_S(\alpha) = \left\{ \psi_i(\alpha) \mid i \in \arg \max_{j \in \{L, M, H\}} P_j(\psi_j(\alpha)) \right\}. \quad (46)$$

Since supply and demand are both correspondences we define a *competitive equilibrium* to be a price $\alpha \geq 0$ and an institution $\tilde{\psi}$ with deception cost $\psi \geq 0$ such that $\psi \in \psi_D(\alpha) \cap \psi_S(\alpha)$. Since the objective function of the representative parent has three separate pieces, the expression for the supply correspondence involves several different cases and is extremely tedious and uninformative. Instead of pursuing that approach we present the following lemma which narrows down the set of possibilities considerably. Following Proposition 4 we will exhibit the supply correspondence in the three separate cases in which an equilibrium with non-zero socialization does exist.

Lemma 2 *A competitive equilibrium with non-zero socialization can only occur at a price α in the interval $0 \leq \alpha < \gamma(1 - \nu)$ where the representative parent's global optimum $\psi_S(\alpha)$ lies in I_M and $\psi_I(\alpha)$ defined in (33) intersects $\psi_S(\alpha) = \alpha + \gamma\nu$ or $\psi_S(\alpha) = \Delta\theta\bar{q}_H$.*

The result states that the intersection of supply and demand occurs along that portion of demand given by $\psi_I(\alpha)$ in (33) and along that portion of supply given by $\psi_S(\alpha) = \alpha + \gamma\nu$ or $\psi_S(\alpha) = \Delta\theta\bar{q}_H$ in (44). An equilibrium with non-zero socialization can only occur at prices $0 \leq \alpha \leq \gamma(1 - \nu)$ because demand is zero for all $\alpha > \gamma(1 - \nu)$ from (32). In the appendix we show there is no equilibrium at the price $\alpha = \gamma(1 - \nu)$ so an equilibrium can only occur on the region $0 \leq \alpha < \gamma(1 - \nu)$ where demand is downward-sloping and takes the form $\psi_D(\alpha) = \psi_I(\alpha)$. The

fact that a non-zero equilibrium level of socialization must be medium $\psi \in I_M$ is clear because the representative principal does not demand high levels of socialization $\psi \in I_H$ and from (42) the representative parent will never supply a non-zero level of socialization in I_L when $\alpha < \gamma(1-\nu)$. On the region I_M the representative principal demands honesty because it improves allocative efficiency and the representative parent supplies it because it raises the wage of all four types and increases the information rent of the efficient dishonest type. The following proposition is the main result of the section. It provides necessary and sufficient conditions for the existence of a competitive equilibrium with non-zero socialization.

Proposition 4

(i) *The unique competitive equilibrium is $\alpha = 0$ and $\psi = \Delta\theta\bar{q}_H$ when*

$$\gamma\nu \geq \Delta\theta\bar{q}_H \tag{47}$$

$$\gamma\nu \geq (1/2)\Delta\theta\bar{q}_H + \gamma\frac{\bar{q}_L}{\bar{q}_H}. \tag{48}$$

(ii) *Let $D = \Delta\theta\bar{q}_H - \gamma\nu$. There exists a unique equilibrium with $0 < \alpha < D$ and $\gamma\nu < \psi < \Delta\theta\bar{q}_H$ when*

$$\Delta\theta\bar{q}_L < \gamma\nu < \Delta\theta\bar{q}_H \tag{49}$$

$$\gamma\nu \geq \frac{2\Delta\theta\bar{q}_L}{\nu}. \tag{50}$$

(iii) *Let $F = \sqrt{2\gamma\Delta\theta\bar{q}_L} - \gamma\nu$. There exists a unique equilibrium with $F < \alpha < \gamma(1-\nu)$ and $\sqrt{2\gamma\Delta\theta\bar{q}_L} < \psi < \Delta\theta\bar{q}_H$ when*

$$\psi_D(F) \geq \sqrt{2\gamma\Delta\theta\bar{q}_L} \tag{51}$$

$$2\nu\Delta\theta\bar{q}_L < \gamma\nu < \min\left\{\frac{2\Delta\theta\bar{q}_L}{\nu}, \frac{\nu\Delta\theta\bar{q}_H^2}{2\bar{q}_L}\right\}. \tag{52}$$

Under other parameter configurations an equilibrium either involves zero honesty or does not exist.

The result shows that an equilibrium with non-zero socialization exists under three different sets of circumstances. The first type occurs in (i) where the supply of socialization is so great that the equilibrium price α is zero. We construct the corresponding supply curve as follows. When $0 \leq \alpha < \gamma(1-\nu)$ the parent's optimum on I_L is $\psi_L = 0$ with expected payoff $P_L = \gamma\Delta\theta\bar{q}_L$. From

ψ_M in (44), the condition (47) implies that the optimum on I_M is $\psi_M = \Delta\theta\bar{q}_H$ for all $\alpha \geq 0$ with expected payoff

$$P_M = (\alpha + \gamma\nu)\Delta\theta\bar{q}_H - (1/2)(\Delta\theta\bar{q}_H)^2. \quad (53)$$

Intuitively, the parent values socialization on I_M because the efficient dishonest type earns rent ψ [see (37)] and (47) implies a high probability $\gamma\nu$ for that type. A simple calculation reveals that the representative parent prefers (53) over $P_L = \gamma\Delta\theta\bar{q}_L$ for all $\alpha \geq 0$ iff (48) holds. The supply curve is therefore perfectly inelastic at $\psi = \Delta\theta\bar{q}_H$ with α on the vertical axis and ψ on the horizontal. From Proposition 3 we observe that demand intersects supply at $\alpha = 0$ and $\psi = \Delta\theta\bar{q}_H$.

We now consider (ii) where the unique equilibrium price α is now positive. As we now show, this positive equilibrium price reflects stronger demand and weaker supply as compared to the previous case. Comparing (47) and (49), the probability $\gamma\nu$ of an efficient dishonest type is smaller than in (i). From (33), a reduction in $\gamma\nu$ causes that portion $\psi_I(\alpha)$ of demand to pivot out about the horizontal intercept. This increase in demand is due to the smaller chance that the representative principal will have to pay information rent. We now turn to the supply curve. As before, the optimum is $\psi_L = 0$ on I_L with expected payoff $P_L = \gamma\Delta\theta\bar{q}_L$ when $0 \leq \alpha < \gamma(1 - \nu)$. The condition (49) implies that the optimum on I_M is $\psi_M = \alpha + \gamma\nu$ with expected payoff $P_M = (1/2)(\alpha + \gamma\nu)^2$ for all $0 \leq \alpha < D$. Intuitively, the optimum on I_M is smaller than in (i) because the probability $\gamma\nu$ of an efficient dishonest type is now lower. A straightforward calculation shows that $P_M \gtrless P_L$ iff $\alpha \gtrless F$, where F is defined in (iii). The condition (50) implies that $F \leq 0$ so the parent prefers $\psi_M = \alpha + \gamma\nu$ for all $0 \leq \alpha < D$. The supply curve is therefore $\psi_S = \alpha + \gamma\nu$ from $\alpha = 0$ up to $\alpha = D$ where it becomes vertical at $\psi = \Delta\theta\bar{q}_H$. This represents an inward shift relative to the previous case and hence weaker supply. Since demand exceeds supply at $\alpha = 0$ and supply exceeds demand at $\alpha = D$ there exists a unique equilibrium at a price somewhere in between. In this equilibrium the representative parent invests in socialization not only because the efficient dishonest type collects information rent but also because it results in higher wages $\alpha\psi$ for all four types.

Finally, we consider (iii) where the probability $\gamma\nu$ is the smallest of all three cases as can be seen from (50) and (52). This induces another shift in demand to the right and in supply to the left as compared with (ii). Omitting the details (see the proof of Proposition 4 in the appendix),

under (51) and (52) the supply curve takes the form

$$\psi_S(\alpha) = \begin{cases} 0 & \text{if } 0 \leq \alpha < F \\ \psi \in \{0, \sqrt{2\gamma\Delta\theta\bar{q}_L}\} & \text{if } \alpha = F \\ \alpha + \gamma\nu & \text{if } F < \alpha < D \\ \Delta\theta\bar{q}_H & \text{if } \alpha \geq D. \end{cases} \quad (54)$$

The new and relevant feature of supply occurs at the price $\alpha = F$ where the representative parent is indifferent between $\psi = 0$ and $\psi = \sqrt{2\gamma\Delta\theta\bar{q}_L}$ as discussed in (ii). Since the parent strictly prefers the latter two socialization levels over all levels in between, this indifference implies a horizontal gap in the supply curve at the price $\alpha = F$ with α on the vertical axis. An equilibrium does not exist if the demand curve passes through this gap and condition (51) ensures that demand intersects supply to the right of that gap.

In summary, an equilibrium with non-zero socialization can only occur for medium levels of socialization where the demand for socialization is based on improvements in allocative efficiency and the supply of socialization on rents to the efficient dishonest type. When the probability $\gamma\nu$ of the efficient dishonest type is too low such an equilibrium does not exist. This means that for a given probability $\gamma > 0$ of an efficient type, the probability ν of a dishonest type cannot be too low. Paradoxically, an equilibrium with non-zero socialization cannot exist when institutions are too effective. Likewise, such an equilibrium does not exist when institutions are not effective enough in the sense that ν is too high.¹¹ In this context an equilibrium with non-zero socialization therefore requires *effective* but *imperfect* institutions.

3 Honesty and the Market for Lemons

In the previous section the *uninformed* party (the principal) moved first. In this section we consider a game-theoretic version of Akerlof's (1970) market for lemons where the *informed* party (the seller of the used car) moves first. This creates a role for communication and signaling.¹² In particular, we extend a simplified version of Streb and Torrens (2012) to the case of endogenous honesty. There are three players: the parent, the child who is also the seller of the used car, and the buyer B . As before in the first stage of the game the parent chooses an institution $\tilde{\psi}$ which makes the

¹¹If $\nu = 1$ then (52) is clearly violated. Since $\nu = 1$ implies $\bar{q}_H = \bar{q}_L$, (48) and (49) are also violated.

¹²Akerlof (1970) assumes the used car market is perfectly competitive so there can only be one price. A game-theoretic approach allows for separating as well as pooling equilibria so that communication can convey information.

seller honest $\tilde{\psi} = \psi$ with probability $1 - \nu$ and dishonest $\tilde{\psi} = 0$ with probability $0 < \nu < 1$. The parent chooses the institution $\tilde{\psi}$ that maximizes the seller's expected profit less deception costs (if applicable) and socialization costs $C(\tilde{\psi})$. For simplicity we assume $C(\tilde{\psi}) = c\psi$ where $c > 0$.

In subsequent stages of the game the buyer B and seller S meet to discuss trade. The seller's car is low quality L with probability $0 < \rho < 1$ and high quality H with probability $1 - \rho$. The deception cost of the seller and the quality of the car are independent random variables. The seller therefore has four types (j, k) , where $j \in \{0, \psi\}$ is the deception cost and $k \in \{H, L\}$ is the quality of the car. The seller's type is private information but the buyer can observe the institution $\tilde{\psi}$. Let v_i^k be the value of a car of type k to player i , where $i \in \{B, S\}$. We assume

$$v_S^L < v_B^L < v_S^H < v_B^H \quad (55)$$

to allow for potential gains from trade and to ensure the high-quality car has a higher price under complete information.

The timing of the game is as follows.

- (i) The parent chooses the institution $\tilde{\psi}$ which is publicly observable.
- (ii) The seller's type (j, k) is realized.
- (iii) The seller decides whether or not to sell his car. If he decides to sell, he posts a price p^{jk} and sends the buyer a message $m^{jk} \in \{H, L\}$ about the quality of the car. We assume the seller's offer is take-it-or-leave-it and the seller withholds his car from the market when indifferent.
- (iv) If the seller makes an offer then the buyer observes the price p^{jk} and the message m^{jk} and updates her prior belief ρ about the quality of the car.
- (v) The buyer then decides whether or not to buy at the stated price. We assume she buys when indifferent.

In this context deception consists of making a false statement $m^{jk} \neq k$ about the quality of the car. If the car is sold the payoff to the buyer is $u^k = v_B^k - p^{jk}$. The payoff to the seller is

$$\pi^{0k} = p^{0k} - v_S^k \quad (56)$$

$$\pi^{\psi k} = p^{\psi k} - v_S^k \quad (57)$$

$$\pi^{\psi k} = p^{\psi k} - v_S^k - \psi \quad (58)$$

when the seller is dishonest, honest and not deceptive, and honest and deceptive, respectively.

Since the seller makes take-it-or-leave-it offers, under complete information the price of a high-quality car would be v_B^H , the price of a low-quality car would be v_B^L , and the expected total surplus

$$R^F = \rho(v_B^L - v_S^L) + (1 - \rho)(v_B^H - v_S^H). \quad (59)$$

We refer to the above as the *first best* expected surplus.

The following result characterizes the set of equilibria when the seller is dishonest $\psi = 0$ with probability one. In this case there are only two types: the *low* type with a low-quality car and the *high* type with a high-quality car.

Proposition 5 *Let*

$$p^P \equiv \rho v_B^L + (1 - \rho)v_S^H. \quad (60)$$

If $\tilde{\psi} = \tilde{0}$ the set of perfect Bayesian equilibria is as follows:

- (i) the lemons equilibrium where the high type withholds his car and the low type offers his car at the price v_B^L and sends either message.
- (ii) If $p^P > v_S^H$ there is also a set of pooling equilibria where both types charge p such that $v_S^H < p \leq p^P$ (which could be either message).

A separating equilibrium where both types are on the market but with different strategies cannot exist because the low type will always try to mimic the high type. An equilibrium which always exists is the lemons equilibrium where the high type withholds his car and the low type charges the buyer's reservation value. When the two types pool and charge the same price p and send the same message, the buyer maintains her prior belief that the probability of a low-quality car is ρ with maximum willingness to pay (60). If $p^P > v_S^H$ there is a range of prices p such that $v_S^H < p \leq p^P$ that are high enough to support entry by the high type (recall that an indifferent high type withholds his car). Note that in the pooling equilibrium where both types charge $p = p^P$ at least one type lies and the expected total surplus is first best R^F . If $p^P \leq v_S^H$ the only equilibrium is the lemons equilibrium with expected total surplus $R^L = \rho(v_B^L - v_S^L)$ and there is *market failure* relative to both the first best and the pooling equilibrium with price p^P .

We now see how the presence of honest types changes the set of equilibria. In the following result we only report those equilibria which survive the Cho-Kreps (1987) *intuitive criterion*.¹³ In

¹³In our model, an off-the-equilibrium-path pair (p, m) is *equilibrium-dominated* for type (j, k) if (j, k) receives a

the appendix we report the full set of equilibria.

Proposition 6 *Let*

$$q^A = \frac{\rho}{\rho + (1 - \rho)\nu}, \quad (61)$$

$$q^E = \frac{\rho\nu}{\rho\nu + (1 - \rho)}, \quad (62)$$

and

$$p^l = q^l v_B^L + (1 - q^l) v_B^H \quad (63)$$

for $l = A, E$. If $\psi > 0$ the following perfect Bayesian equilibria survive the intuitive criterion:

- (i) the lemons equilibrium where both high types are withheld from the market, both low types charge $p^{\psi L} = p^{0L} = v_B^L$, the honest low type tells the truth $m^{\psi L} = L$, and the dishonest low type can send either message.
- (ii) If $p^A > v_S^H$ it is an equilibrium for all types to charge p such that $v_S^H < p \leq p^A$, for the honest high type to tell the truth $m^{\psi H} = H$, and all other types to send the message $m^{0H} = m^{\psi L} = m^{0L} = L$.
- (iii) If $p^P > v_S^H$ it is an equilibrium for all types to charge p such that $v_S^H < p \leq p^P$ and send messages $m^{\psi H} = m^{0L} = H$ and $m^{0H} = m^{\psi L} = L$.
- (iv) If $p^P > v_S^H$ and $p^P \geq v_B^L + \psi$ it is an equilibrium for all types to charge p such that $v_S^H < p \leq p^P$ and $p \geq v_B^L + \psi$ and for all types to send the message H .
- (v) If $p^E > v_S^H$ and $v_B^L + \psi > v_S^H$ it is an equilibrium for the honest low type to set $p^{\psi L} = v_B^L$ and tell the truth $m^{\psi L} = L$ and for all other types to charge p such that

$$v_S^H < p \leq \min \{p^S, v_B^L + \psi\} \quad (64)$$

and send the message H .

The first result shows that the lemons strategy in 5(i) continues to be an equilibrium for all levels of socialization. In this equilibrium the high types withhold their cars from the market and the

higher payoff in equilibrium than from (p, m) assuming the buyer buys when she observes (p, m) . According to the intuitive criterion, the posterior belief of a buyer who observes (p, m) should assign probability zero to type (j, k) when possible (i.e., when there is at least one other type for whom (p, m) is not equilibrium-dominated).

two low types charge the buyer's reservation level v_B^L . Off the equilibrium path the buyer believes that the car is low quality with probability one which prevents the high types from entering. The only difference between Proposition 5(i) and 6(i) is that now the honest low type tells the truth in equilibrium because the deception cost ψ is positive. Note that in equilibrium communication does not provide any information which the buyer does not already have based on the seller's entry and pricing strategy.

We now skip ahead to the equilibria in (iii) and (iv). In these equilibria all four types charge the same price p and we focus on the equilibrium where $p = p^P$. For $p = p^P$ in (60) to be an equilibrium, the buyer must maintain her prior so communication cannot reveal any information. In (iii) the message H is uninformative about quality because it is sent by the honest high and dishonest low types. The message L is similarly uninformative. Likewise, in (iv) all four types send the uninformative message H which is an equilibrium provided the incentive compatibility constraint $p - \psi \geq v_B^L$ of the honest low type is satisfied so his deception costs are covered. Note that this is the only class of equilibria which survives the intuitive criterion where an honest type lies in equilibrium.¹⁴

The equilibria in (v) are similar to those in Proposition 3.1 in Streb and Torrens (2012). In these equilibria the honest low type separates, tells the truth, and charges $p^{\psi L} = v_B^L$. All the other types pool on a common price p and send the message H . When the buyer observes (p, H) the posterior probability q^E that the car is low quality is less than ρ so the maximum willingness to pay p^S is greater than p^P . In the equilibrium with $p = p^S$ the expected profit of the seller is the same as the first best R^F . Note that communication does not convey any information that is not already contained in prices. An investment in honesty is nevertheless necessary for this class of equilibria to exist because it separates the honest low type from the others who then form a higher quality pool with a corresponding greater willingness to pay $p^S > v_S^H$ which supports entry by the high types.

In (ii) all four types charge the same price p , the honest high type tells the truth, and all the other types send the message L . In this equilibrium the message L is informative because the posterior probability q^A that the car is low quality is higher than ρ so the maximum willingness to pay p^A is less than p^P . If the buyer receives the message H she knows the car is high quality with probability one and would be willing to pay up to v_B^H but only has to pay the price p . What keeps the honest high type from raising his price is the off the equilibrium path belief that deviators are low types. Note that this is the only class of equilibria where communication is informative.

¹⁴The case where all four types claim to be low is also an equilibrium but does not survive the intuitive criterion.

Indeed, the price is completely uninformative.

We now consider the optimal choice of institution $\tilde{\psi}$ by the parent in the first stage of the game. Since the market game has multiple equilibria we must make an assumption about which equilibrium the parent believes will be realized for each choice of $\tilde{\psi}$. We assume the parent is *optimistic* in the sense that she believes that the equilibrium with the highest expected payoff for the seller will be realized with probability one.¹⁵ We refer to this as the *optimistic* equilibrium corresponding to $\tilde{\psi}$.

Proposition 7

- (i) If $p^P > v_S^H$ the optimal choice of the parent is $\tilde{\psi} = \tilde{0}$ and the optimistic equilibrium is the pooling equilibrium in Proposition 5 with $p = p^P$.
- (ii) Let $\psi^S = p^S - v_B^L$. If $p^P \leq v_S^H < p^S$ and the parent's cost parameter c is sufficiently small in the sense that $\rho v + (1 - \rho) > c$ and $(1 - \rho)(v_B^H - v_S^H) \geq c\psi^S$ then the parent's optimal choice is ψ^S and the optimistic equilibrium is (v) in Proposition 6 with $p = p^S$.
- (iii) In all other cases the optimum is $\tilde{\psi} = \tilde{0}$ and the lemons equilibrium obtains.

We first discuss (i). If $p^P > v_S^H$ and the parent chooses $\tilde{\psi} = \tilde{0}$ then from Proposition 5 the set of equilibria consists of the lemons equilibrium and a collection of pooling equilibria with price p such that $v_S^H < p \leq p^P$. An optimistic parent believes that the pooling equilibrium with $p = p^P$ will obtain where the child earns the first best expected profit R^F . The choice $\tilde{\psi} = \tilde{0}$ is therefore optimal because it attains the first best expected profit without incurring any socialization costs. Intuitively, there is no need for socialization when the market is efficient and so none is provided. This result is consistent with the boundless market hypothesis described in Zelizer (1998) as well as Weber's characterization of the market as an institution where "sentiment" is merely an obstruction and which actively undermines such sentiments. Indeed, in this case an investment in honesty would obstruct the class of pooling equilibria in Proposition 5 which *requires* dishonesty because the high and low types must send the same message.

If $p^P \leq v_S^H$ the pooling equilibria in (ii) of Proposition 5 and (iii) and (iv) of Proposition 6 do not exist. Since $p^A < p^P$ the pooling equilibria in 6(ii) also do not exist. The parent's problem therefore boils down to a choice between $\tilde{\psi} = \tilde{0}$ and the corresponding lemons equilibrium in (i) of Proposition 5 or a positive level of socialization sufficient to induce the semi-separating equilibria in (v) of Proposition 6.

¹⁵A *pessimistic* parent would always choose $\tilde{\psi} = \tilde{0}$ because the lemons strategy for the seller is always an equilibrium.

To identify the tradeoffs involved, consider the case where

$$v_S^H < v_B^L + \psi \leq p^S \iff v_S^H - v_B^L < \psi \leq p^S - v_B^L. \quad (65)$$

In this case the optimistic equilibrium for the class of equilibria in (v) of Proposition 6 is the one where the honest low type charges $p^{\psi L} = v_B^L$ and all the other types pool on the price $p = v_B^L + \psi$. Since the latter price rises one-for-one with the deception cost, the parent's expected marginal benefit of ψ is the probability $\rho\nu + (1 - \rho)$ of a type that charges p . If the expected marginal benefit $\rho\nu + (1 - \rho)$ exceeds the marginal cost c of socialization the parent chooses the highest possible ψ consistent with (65), which is $\psi^S = p^S - v_B^L$. The corresponding optimistic equilibrium is the one in (v) with $p = p^S$ which achieves the first best expected profit R^F . The parent prefers ψ^S and the corresponding optimistic equilibrium with $p = p^S$ over zero socialization $\tilde{\psi} = \tilde{0}$ and the lemons equilibrium when

$$R^F - c\psi^S \geq R^L \iff (1 - \rho)(v_B^H - v_S^H) \geq c\psi^S. \quad (66)$$

The left-hand side of the second expression is the increase in expected profit over that in the lemons equilibrium while the right-hand side is the total cost of socialization. In comparison with $\tilde{\psi} = \tilde{0}$ and the corresponding lemons equilibrium, the optimal level ψ^S of socialization implies higher socialization costs but also higher expected profit because socialization not only allows the high types to trade in equilibrium but also to trade at higher prices according to $p = v_B^L + \psi$.

When the market is efficient there is no scope for socialization. But when the market is inefficient due to informational asymmetries the existence of observable institutions which attempt to instill trustworthiness reduces adverse selection by making communication and prices more informative. Specifically, in our model the honest low type separates allowing the rest to create a higher quality pool. This increases the buyer's willingness to pay which supports entry by the high types. The parent invests in honesty because it allows high type children to trade as well as the dishonest low type to trade at a premium. In equilibrium, three out of four types communicate honestly, including the "dishonest" high type. But the expression *caveat emptor* still applies as the dishonest low type lies in equilibrium and the buyer does not always get what he paid for.

4 Conclusion

How exactly does generalized trust improve economic outcomes? And what is the role of institutions in that process? In this paper we focus on one specific mechanism: honest communication. It is

an act of trust when trade occurs or a contract is agreed because one party accepts the word of the other regarding the latter's private information. But why should the informed party tell the truth? One possibility emphasized in the economics literature is a concern for reputation but this is unlikely to be effective in one-shot anonymous settings like the experiments in Gneezy (2005) or when one buys a used car from a private seller. Another possibility is that the seller actually *is* honest because he has been socialized within an appropriate institution. This is the first role of institutions in our paper — as imperfect socialization technologies.

But the mere existence of institutions that socialize their members to behave in a trustworthy fashion is insufficient — institutional membership must be *observable*. If the parent's institutional choice were unobservable then once the principal in the screening model or the buyer in the market for lemons takes as given that the parent has chosen a non-zero socialization level the parent then has an incentive to deviate and make the child dishonest with probability one. In other words, if institutional choice is unobservable then everyone with private information would claim to be members but all such claims would be non-credible. The same issue can also be re-stated in terms of *commitment*. For the same reason the strategic situation between the informed and uninformed parties cannot be a simultaneous-move game where the informed party (rather than the parent) makes the institutional choice himself at the same time as all other strategies are chosen. Instead, the choice of institution must be observed prior to the game between the informed and uninformed parties. Indeed, the practice where parents enroll their children in the appropriate institutions at an early and impressionable age acquires special significance in this context. Of course, institutional membership is no guarantee of behavior (the socialization technology is imperfect and some types do in fact lie in equilibrium) but when membership is observable it can still serve as a credible signal of honesty.

But this is still insufficient for socialization to occur in equilibrium because honesty is a double-edged sword as when the agent in the screening model announces that he is high cost or the seller in the market for lemons confesses that his car is low quality. For socialization to occur, market institutions must provide the appropriate incentives. In the screening model we showed that these consist of information rent for the efficient dishonest type and potentially higher wages for workers who come from the appropriate institution. In the market for lemons the incentive is that high types who would otherwise be barred by adverse selection can trade (and the dishonest low type can trade at a higher price). In this context, socialization occurs when the market would otherwise be inefficient. In the screening model, economic performance is improved by the corresponding increase in allocative efficiency.

5 Appendix (Not For Publication)

The principal's problem in section 2 is to choose the menu $(\underline{t}_\psi, \underline{q}_\psi)$, $(\bar{t}_\psi, \bar{q}_\psi)$, $(\underline{t}_0, \underline{q}_0)$, and (\bar{t}_0, \bar{q}_0) to maximize (3) subject to the incentive compatibility constraints for the efficient honest type (4)-(6), the efficient dishonest type

$$\underline{t}_0 - \underline{\theta}\underline{q}_0 \geq \underline{t}_\psi - \underline{\theta}\underline{q}_\psi \quad (\text{A1})$$

$$\underline{t}_0 - \underline{\theta}\underline{q}_0 \geq \bar{t}_\psi - \underline{\theta}\bar{q}_\psi \quad (\text{A2})$$

$$\underline{t}_0 - \underline{\theta}\underline{q}_0 \geq \bar{t}_0 - \underline{\theta}\bar{q}_0, \quad (\text{A3})$$

the inefficient honest type

$$\bar{t}_\psi - \bar{\theta}\bar{q}_\psi \geq \bar{t}_0 - \bar{\theta}\bar{q}_0 - \psi \quad (\text{A4})$$

$$\bar{t}_\psi - \bar{\theta}\bar{q}_\psi \geq \underline{t}_\psi - \bar{\theta}\underline{q}_\psi - \psi \quad (\text{A5})$$

$$\bar{t}_\psi - \bar{\theta}\bar{q}_\psi \geq \underline{t}_0 - \bar{\theta}\underline{q}_0 - \psi, \quad (\text{A6})$$

the inefficient dishonest type

$$\bar{t}_0 - \bar{\theta}\bar{q}_0 \geq \bar{t}_\psi - \bar{\theta}\bar{q}_\psi \quad (\text{A7})$$

$$\bar{t}_0 - \bar{\theta}\bar{q}_0 \geq \underline{t}_\psi - \bar{\theta}\underline{q}_\psi \quad (\text{A8})$$

$$\bar{t}_0 - \bar{\theta}\bar{q}_0 \geq \underline{t}_0 - \bar{\theta}\underline{q}_0, \quad (\text{A9})$$

and the participation constraints

$$\underline{t}_0 - \underline{\theta}\underline{q}_0 \geq \alpha\psi \quad (\text{A10})$$

$$\bar{t}_0 - \bar{\theta}\bar{q}_0 \geq \alpha\psi \quad (\text{A11})$$

$$\bar{t}_\psi - \bar{\theta}\bar{q}_\psi \geq \alpha\psi. \quad (\text{A12})$$

and (7). After the relevant change of variables, the problem is to choose $(\underline{U}_\psi, \underline{q}_\psi)$, $(\bar{U}_\psi, \bar{q}_\psi)$, $(\underline{U}_0, \underline{q}_0)$, and (\bar{U}_0, \bar{q}_0) to maximize (12) subject to (13)-(15), (21)-(23),

$$\bar{U}_\psi \geq \bar{U}_0 - \psi \quad (\text{A13})$$

$$\bar{U}_\psi \geq \underline{U}_\psi - \Delta\theta \underline{q}_\psi - \psi \quad (\text{A14})$$

$$\bar{U}_\psi \geq \underline{U}_0 - \Delta\theta \underline{q}_0 - \psi, \quad (\text{A15})$$

$$\bar{U}_0 \geq \bar{U}_\psi \quad (\text{A16})$$

$$\bar{U}_0 \geq \underline{U}_\psi - \Delta\theta \underline{q}_\psi \quad (\text{A17})$$

$$\bar{U}_0 \geq \underline{U}_0 - \Delta\theta \underline{q}_0, \quad (\text{A18})$$

and the participation constraints (16) and

$$\underline{U}_0 \geq \alpha\psi \quad (\text{A19})$$

$$\bar{U}_0 \geq \alpha\psi \quad (\text{A20})$$

$$\bar{U}_\psi \geq \alpha\psi. \quad (\text{A21})$$

Proposition 8 *Given non-zero implementable output levels \bar{q} , the payoffs \vec{U} that minimize (17) subject to the incentive compatibility and participation constraints are as follows.*

(i) *If*

$$\psi \geq \Delta\theta \bar{q}_\psi \quad (\text{A22})$$

$$\underline{q}_0 \geq \bar{q}_\psi \geq \bar{q}_0 \quad (\text{A23})$$

then $\underline{U}_\psi = \bar{U}_0 = \alpha\psi$ and

$$\underline{U}_0 = \alpha\psi + \Delta\theta \bar{q}_\psi. \quad (\text{A24})$$

(ii) *If (A22) and*

$$\bar{q}_\psi \geq \underline{q}_0 \quad (\text{A25})$$

then $\underline{U}_\psi = \alpha\psi$, (A24), and

$$\bar{U}_0 = \alpha\psi + \Delta\theta(\bar{q}_\psi - \underline{q}_0). \quad (\text{A26})$$

(iii) If

$$\Delta\theta(\bar{q}_\psi - \underline{q}_\psi) \leq \psi \leq \Delta\theta\bar{q}_\psi \quad (\text{A27})$$

and (A23) then (A24), $\bar{U}_0 = \alpha\psi$, and

$$\underline{U}_\psi = \alpha\psi + \Delta\theta\bar{q}_\psi - \psi. \quad (\text{A28})$$

(iv) If

$$\psi \leq \Delta\theta(\bar{q}_\psi - \underline{q}_\psi) \quad (\text{A29})$$

$$\psi \leq \Delta\theta(\underline{q}_0 - \underline{q}_\psi) \quad (\text{A30})$$

then (A24), (A28), and

$$\bar{U}_0 = \alpha\psi + \Delta\theta(\bar{q}_\psi - \underline{q}_\psi) - \psi. \quad (\text{A31})$$

(v) If (A25),

$$\Delta\theta\bar{q}_\psi \geq \psi \quad (\text{A32})$$

$$\psi \geq \Delta\theta(\underline{q}_0 - \underline{q}_\psi) \quad (\text{A33})$$

then (A24), (A26), and (A28).

(vi) If

$$\psi \geq \Delta\theta\bar{q}_0 \quad (\text{A34})$$

$$\bar{q}_0 \geq \bar{q}_\psi \quad (\text{A35})$$

then $\underline{U}_\psi = \bar{U}_0 = \alpha\psi$ and

$$\underline{U}_0 = \alpha\psi + \Delta\theta\bar{q}_0. \quad (\text{A36})$$

(vii) If (A35) and

$$\Delta\theta\bar{q}_0 \geq \psi \quad (\text{A37})$$

then (A36), $\bar{U}_0 = \alpha\psi$, and

$$\underline{U}_\psi = \alpha\psi + \Delta\theta\bar{q}_0 - \psi. \quad (\text{A38})$$

In each case $\bar{U}_\psi = \alpha\psi$.

Proof of Proposition 8. If $\psi = 0$ the model and results collapse to the textbook two-type case. Assume $\psi > 0$. We first derive the implementability conditions. From (14) and (A14)

$$2\psi \geq \Delta\theta(\bar{q}_\psi - \underline{q}_\psi), \quad (\text{A39})$$

from (15) and (A17)

$$\psi \geq \Delta\theta(\bar{q}_0 - \underline{q}_\psi), \quad (\text{A40})$$

from (22) and (A15)

$$\psi \geq \Delta\theta(\bar{q}_\psi - \underline{q}_0), \quad (\text{A41})$$

and (23) and (A18)

$$\underline{q}_0 \geq \bar{q}_0. \quad (\text{A42})$$

The constraints (14), (15), (A14), (A15), (A19), and (A20) are made redundant by (13) and (22), (13) and (23), (A13) and (A17), (A13) and (A18), (21), and (A16) respectively. We first consider the problem of minimizing (17) subject to the constraints (13), (22), (A16), (A17), (A18), (16), and (A21). We will show that the remaining constraints (21), (23), and (A13) are satisfied at the optimum. The Lagrangean is

$$\begin{aligned} \mathcal{L} = & -\gamma\nu\underline{U}_0 - \gamma(1-\nu)\underline{U}_\psi - (1-\gamma)\nu\bar{U}_0 - (1-\gamma)(1-\nu)\bar{U}_\psi \quad (\text{A43}) \\ & + \lambda_1(\underline{U}_\psi - \underline{U}_0 + \psi) + \lambda_2(\underline{U}_0 - \bar{U}_\psi - \Delta\theta\bar{q}_\psi) + \lambda_3(\bar{U}_0 - \bar{U}_\psi) \\ & + \lambda_4(\bar{U}_0 - \underline{U}_\psi + \Delta\theta\underline{q}_\psi) + \lambda_5(\bar{U}_0 - \underline{U}_0 + \Delta\theta\underline{q}_0) + \lambda_6(\underline{U}_\psi - \alpha\psi) + \lambda_7(\bar{U}_\psi - \alpha\psi). \end{aligned}$$

The first-order necessary and sufficient conditions are

$$\mathcal{L}_{\underline{U}_\psi} = -\gamma(1-\nu) + \lambda_1 - \lambda_4 + \lambda_6 = 0 \quad (\text{A44})$$

$$\mathcal{L}_{\bar{U}_\psi} = -(1-\gamma)(1-\nu) - \lambda_2 - \lambda_3 + \lambda_7 = 0 \quad (\text{A45})$$

$$\mathcal{L}_{\bar{U}_0} = -(1-\gamma)\nu + \lambda_3 + \lambda_4 + \lambda_5 = 0 \quad (\text{A46})$$

$$\mathcal{L}_{\underline{U}_0} = -\gamma\nu - \lambda_1 + \lambda_2 - \lambda_5 = 0, \quad (\text{A47})$$

the constraints, and the complementary slackness conditions. From (A45) $\lambda_7 > 0$ and $\bar{U}_\psi = \alpha\psi$ by complementary slackness. From (A47) $\lambda_2 > 0$ and (A24).

Result (i) Assume $\lambda_1 = 0$ and $\lambda_3 > 0$. By complementary slackness, $\bar{U}_0 = \alpha\psi$. From (A44) $\lambda_6 > 0$ and $\underline{U}_\psi = \alpha\psi$. From (13) we obtain the condition (A22). The constraint (A17) is slack because

$\underline{q}_\psi > 0$. From (A18) and the omitted constraint (23) we obtain (A23). We now check that the other omitted constraints are satisfied. Constraint (21) is slack because $\bar{q}_\psi > 0$ and (A13) because $\psi > 0$.

Result (ii) Now consider the case $\lambda_1 = \lambda_3 = 0$. As in the previous case $\lambda_6 > 0$ and $\underline{U}_\psi = \alpha\psi$. Since $\underline{q}_\psi > 0$ the constraint (A17) is slack and $\lambda_4 = 0$. From (A46) $\lambda_5 > 0$ and (A26). From (13) we obtain (A22). From (A16) we obtain (A25). We now check the omitted constraints. Constraint (21) is slack because $\bar{q}_\psi > 0$, (23) is satisfied by (A42), and (A13) by (A41).

Result (iii) Assume $\lambda_1 > 0$ and $\lambda_3 > 0$. By complementary slackness, (A28) and $\bar{U}_0 = \bar{U}_\psi = \alpha\psi$. The condition (A27) follows from (16) and (A17). Condition (A23) follows from (A18) and (23). The remaining omitted constraints (21) and (A13) are slack.

Result (iv) Let $\lambda_1 > 0$, $\lambda_3 = 0$, and $\lambda_4 > 0$. By complementary slackness, (A28) and (A31). From (A16) we obtain (A29) and from (A18) the condition (A30). From (16) we obtain (A32) but this is implied by (A29). The constraint (21) is slack, (23) is satisfied by (A40), and (A13) by (A39).

Result (v) Assume $\lambda_1 > 0$, $\lambda_3 = \lambda_4 = 0$, and $\lambda_5 > 0$. By complementary slackness, (A28) and (A26). We obtain (A25) from (A16), (A33) from (A17), and (A32) from (16). As for the remaining constraints, (21) is slack, (23) is satisfied by (A42), and (A13) by (A41).

We now consider the problem of minimizing (17) subject to the constraints (13), (23), (A16), (A17), (A18), (16), and (A21). We will show that the constraints (21), (22), and (A13) are satisfied at the optimum. The Lagrangean is

$$\begin{aligned} \mathcal{L} = & -\gamma\nu\underline{U}_0 - \gamma(1-\nu)\underline{U}_\psi - (1-\gamma)\nu\bar{U}_0 - (1-\gamma)(1-\nu)\bar{U}_\psi & (A48) \\ & + \lambda_1(\underline{U}_\psi - \underline{U}_0 + \psi) + \lambda_2(\underline{U}_0 - \bar{U}_0 - \Delta\theta\bar{q}_0) + \lambda_3(\bar{U}_0 - \bar{U}_\psi) \\ & + \lambda_4(\bar{U}_0 - \underline{U}_\psi + \Delta\theta\underline{q}_\psi)\lambda_5(\bar{U}_0 - \underline{U}_0 + \Delta\theta\underline{q}_0) + \lambda_6(\underline{U}_\psi - \alpha\psi) + \lambda_7(\bar{U}_\psi - \alpha\psi). \end{aligned}$$

The first-order necessary and sufficient conditions are

$$\mathcal{L}_{\underline{U}_\psi} = -\gamma(1-\nu) + \lambda_1 - \lambda_4 + \lambda_6 = 0 \quad (A49)$$

$$\mathcal{L}_{\bar{U}_\psi} = -(1-\gamma)(1-\nu) - \lambda_3 + \lambda_7 = 0 \quad (A50)$$

$$\mathcal{L}_{\bar{U}_0} = -(1-\gamma)\nu - \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 = 0 \quad (A51)$$

$$\mathcal{L}_{\underline{U}_0} = -\gamma\nu - \lambda_1 + \lambda_2 - \lambda_5 = 0, \quad (A52)$$

the constraints, and the complementary slackness conditions. From (A50) $\lambda_7 > 0$ and $\bar{U}_\psi = \alpha\psi$ by complementary slackness. From (A52) $\lambda_2 > 0$ and $\underline{U}_0 = \bar{U}_0 + \Delta\theta\bar{q}_0$.

Result (vi) Assume $\lambda_1 = 0$ and $\lambda_3 > 0$. From (A49) we have $\lambda_6 > 0$ which implies $\underline{U}_\psi = \alpha\psi$. By complementary slackness $\lambda_3 > 0$ implies $\bar{U}_0 = \alpha\psi$ and hence (A36). The constraint (A17) is slack and (A18) is satisfied by (A42). We now turn to the omitted constraints. The constraint (21) is slack, (22) implies (A35), and (A13) is slack.

Case (A) Consider $\lambda_1 = \lambda_3 = 0$ and $\lambda_4 > 0$. As before $\lambda_6 > 0$ and $\underline{U}_\psi = \alpha\psi$. Since $\lambda_4 > 0$

$$\bar{U}_0 = \underline{U}_\psi - \Delta\theta\underline{q}_\psi = \alpha\psi - \Delta\theta\underline{q}_\psi \quad (\text{A53})$$

which violates the relevant participation constraint.

Case (B) If $\lambda_1 = \lambda_3 = \lambda_4 = 0$ then $\lambda_5 = \lambda_2 + \nu(1 - \gamma)$ from (A51) and $\lambda_5 = \lambda_2 - \gamma\nu$ from (A52) which is a contradiction.

Result (vii) Consider $\lambda_1 > 0$ and $\lambda_3 > 0$. By complementary slackness

$$\underline{U}_\psi = \underline{U}_0 - \psi = \bar{U}_0 + \Delta\theta\bar{q}_0 - \psi \quad (\text{A54})$$

and $\bar{U}_0 = \alpha\psi$. We therefore obtain (A36) and (A38). Constraint (A17) is satisfied by (A40) and (A18) by (A42). We obtain (A37) from (16). Constraints (21) and (A13) are slack and the condition (A35) follows from (22).

Case (C) Assume $\lambda_1 > 0$, $\lambda_3 = 0$, and $\lambda_4 > 0$. By complementary slackness

$$\underline{U}_\psi = \underline{U}_0 - \psi = \bar{U}_0 + \Delta\theta\bar{q}_0 - \psi \quad (\text{A55})$$

and

$$\bar{U}_0 = \underline{U}_\psi - \Delta\theta\underline{q}_\psi \quad (\text{A56})$$

$$= \bar{U}_0 + \Delta\theta(\bar{q}_0 - \underline{q}_\psi) - \psi. \quad (\text{A57})$$

It follows that

$$\Delta\theta\bar{q}_0 - \psi = \Delta\theta\underline{q}_\psi > 0 \quad (\text{A58})$$

which implies $\underline{U}_\psi > \alpha\psi$ and $\lambda_6 = 0$. Substituting into (A49),

$$\lambda_1 = \lambda_4 + \gamma(1 - \nu). \quad (\text{A59})$$

From (A52),

$$\lambda_2 - \lambda_1 - \lambda_5 = \gamma\nu. \quad (\text{A60})$$

Substituting into (A51), we obtain the contradiction $\lambda_4 = \lambda_1 + \nu$.

Case (D) Suppose $\lambda_1 > 0$ and $\lambda_3 = \lambda_4 = 0$. From (A52) we obtain (A60). Substituting the latter into (A51) we obtain $\lambda_1 = -\nu$.

Finally, consider the problem of minimizing (17) subject to the constraints (13), (21), (A16), (A17), (A18), (16), and (A21) with (22), (23), and (A13) set aside. The solution to this problem is $\bar{U}_\psi = \bar{U}_0 = \underline{U}_\psi = \underline{U}_0 = \alpha\psi$ because it satisfies the constraints. But this solution violates (22) and (23). ■

Proof of Proposition 1. If $\bar{q} = \bar{q}_\psi$ and $\psi \geq \Delta\theta\bar{q}$ then (i) of Proposition 8 applies. If $\bar{q} = \bar{q}_0$ and $\psi \geq \Delta\theta\bar{q}$ then (vi) applies. If $\bar{q} = \bar{q}_\psi$ and $\psi \leq \Delta\theta\bar{q}$ then (iii) applies. Note that $\underline{q}_\psi \geq \bar{q}_\psi$ implies the first inequality in (A27). Finally, if $\bar{q} = \bar{q}_0$ and $\psi \leq \Delta\theta\bar{q}$ then (vii) applies. ■

Proof of Proposition 2. To find the optimal output levels \vec{q} we maximize (12) on each of the regions defined by (i)-(vii) in Proposition 8 and then compare the principal's expected payoff at each of these local solutions. We first show that we can drop the solution for (ii). The problem associated with (ii) is to maximize (12) with the payoffs \vec{U} stated in (ii) subject to (A22) with Lagrange multiplier $\lambda_1 \geq 0$ and (A25) with λ_2 . Since $S'(0) = \infty$ ensures interior solutions, the first-order conditions for \bar{q}_ψ and \underline{q}_0 are respectively

$$(1 - \gamma)(1 - \nu) [S'(\bar{q}_\psi) - \bar{\theta}] - \gamma\nu\Delta\theta - (1 - \gamma)\nu\Delta\theta + \lambda_2 - \lambda_1\Delta\theta = 0 \quad (\text{A61})$$

$$\gamma\nu [S'(\underline{q}_0) - \underline{\theta}] + (1 - \gamma)\nu\Delta\theta - \lambda_2 = 0. \quad (\text{A62})$$

If we suppose that $\lambda_2 = 0$ then these first-order conditions imply $\bar{q}_\psi < \bar{q}^* < \underline{q}^* < \underline{q}_0$ which violates (A25). We therefore have $\lambda_2 > 0$ and $\bar{q}_\psi = \underline{q}_0$. This implies that at the optimum the payoffs \vec{U} in (ii) are the same as those in (i). We can therefore re-formulate the problem as: maximize (12) with the payoffs \vec{U} stated in (i) subject to (A22) and $\bar{q}_\psi = \underline{q}_0$. If we compare this problem to the one associated with (i) we observe that the constraint (A22) is the same in both problems but the constraint (A23) relaxes the constraint $\bar{q}_\psi = \underline{q}_0$. We can therefore drop (ii) from consideration.

We now show that the problem in (iv) of Proposition 8 can be dropped in favor of the problem in (iv) with the constraint (A23) omitted. The problem in (iv) is to maximize (12) with the payoffs \vec{U} in (iv) subject to (A29) with multiplier λ_1 and (A30) with λ_2 . The first-order conditions for \bar{q}_ψ and \underline{q}_ψ are respectively

$$(1 - \gamma)(1 - \nu) [S'(\bar{q}_\psi) - \bar{\theta}] - \gamma\nu\Delta\theta - \gamma(1 - \nu)\Delta\theta - (1 - \gamma)\nu\Delta\theta + \lambda_1\Delta\theta = 0 \quad (\text{A63})$$

$$\gamma(1 - \nu) [S'(\underline{q}_\psi) - \underline{\theta}] + (1 - \gamma)\nu\Delta\theta - \lambda_1\Delta\theta - \lambda_2\Delta\theta = 0. \quad (\text{A64})$$

If we suppose $\lambda_1 = \lambda_2 = 0$ we obtain $\bar{q}_\psi < \bar{q}^* < \underline{q}^* < \underline{q}_\psi$ which contradicts (A29). If we suppose $\lambda_1 = 0$ and $\lambda_2 > 0$ we obtain $\bar{q}_\psi < \bar{q}^* < \underline{q}^* < \underline{q}_0$ and the contradiction

$$\Delta\theta(\bar{q}_\psi - \underline{q}_\psi) < \Delta\theta(\underline{q}_0 - \underline{q}_\psi) = \psi. \quad (\text{A65})$$

It follows that $\lambda_1 > 0$ and $\lambda_2 = 0$ so (A29) binds. Substituting the binding constraint into the payoffs \vec{U} in (iv) we obtain the payoffs in (iii). We can therefore re-formulate the problem as: maximize (12) with the payoffs in (iii) subject to (A30) and $\Delta\theta(\bar{q}_\psi - \underline{q}_\psi) = \psi$. We now examine the problem in (iii). If we drop the constraint (A23), the problem is to maximize (12) with payoffs \vec{U} in (iii) subject to (A27). Since this constraint set contains the previous one we may drop (iv) provided (A23) does not bind as we show later.

Finally we eliminate (v). The problem is to maximize (12) subject to \vec{U} in (v) and (A32) with λ_1 , (A25) with λ_2 , and (A33) with λ_3 . The first-order conditions with respect to \bar{q}_ψ , \underline{q}_0 , and \underline{q}_ψ are respectively

$$(1 - \gamma)(1 - \nu) [S'(\bar{q}_\psi) - \bar{\theta}] - \gamma\nu\Delta\theta - \gamma(1 - \nu)\Delta\theta - (1 - \gamma)\nu\Delta\theta + \lambda_1\Delta\theta + \lambda_2 = 0 \quad (\text{A66})$$

$$\gamma\nu [S'(\underline{q}_0) - \underline{\theta}] + (1 - \gamma)\nu\Delta\theta - \lambda_2 - \lambda_3\Delta\theta = 0 \quad (\text{A67})$$

$$\gamma(1 - \nu) [S'(\underline{q}_\psi) - \underline{\theta}] + \lambda_3\Delta\theta = 0. \quad (\text{A68})$$

Furthermore, $\bar{q}_0 = \bar{q}^*$. If (A32) binds the payoffs \vec{U} in (v) are the same as in (ii) but the constraint set for the latter contains that of the former. If (A25) binds a similar statement can be made with respect to (iii). Consider the case where (A32) and (A25) are slack so $\lambda_1 = \lambda_2 = 0$. It follows that $\underline{q}_0 < \bar{q}_\psi < \bar{q}^* < \underline{q}^* \leq \underline{q}_\psi$, so (A33) is slack and $\lambda_3 = 0$. The latter implies $\underline{q}_0 > \underline{q}^*$, which is a contradiction.

After eliminating (ii), (iv), and (v) of Proposition 8, we are left with (i), (iii), (vi), and (vii). Consider the problem in (i) of maximizing (12) with the payoffs \vec{U} and constraints in (i). We omit

the constraint $\underline{q}_0 \geq \bar{q}_\psi$ and show that it is satisfied afterwards. The solution to this simple nonlinear programming problem is $\underline{q}_0 = \underline{q}_\psi = \underline{q}^*$, $\bar{q}_\psi = \bar{q}_0 = \bar{q}$, and $\bar{q} = \bar{q}_H$ if $\psi \geq \Delta\theta\bar{q}_H$ and $\bar{q} = \psi/\Delta\theta$ otherwise. If $\bar{q}_H \leq \psi/\Delta\theta$ then

$$\bar{q} = \bar{q}_H < \bar{q}^* < \underline{q}^* = \underline{q}_0. \quad (\text{A69})$$

If $\psi/\Delta\theta < \bar{q}_H$ then

$$\bar{q} = \psi/\Delta\theta < \bar{q}_H < \bar{q}^* < \underline{q}^* = \underline{q}_0. \quad (\text{A70})$$

In both cases the constraint $\underline{q}_0 \geq \bar{q}_\psi$ is slack. This is also the solution to (vi) which is the mirror image of (i) with \bar{q}_ψ and \bar{q}_0 switched.

We now consider the problem in (iii) omitting the constraints $\underline{q}_0 \geq \bar{q}_\psi$ and $\psi \geq \Delta\theta(\bar{q}_\psi - \underline{q}_\psi)$. Let λ_1 be the multiplier on (A32) and λ_2 on $\bar{q}_\psi \geq \bar{q}_0$. The first-order conditions with respect to \bar{q}_ψ and \bar{q}_0 are respectively

$$(1 - \gamma)(1 - \nu) [S'(\bar{q}_\psi) - \bar{\theta}] - \gamma\Delta\theta + \lambda_1\Delta\theta + \lambda_2 = 0 \quad (\text{A71})$$

$$(1 - \gamma)\nu [S'(\bar{q}_0) - \bar{\theta}] - \lambda_2 = 0 \quad (\text{A72})$$

with $\underline{q}_\psi = \underline{q}_0 = \underline{q}^*$. If $\lambda_1 = \lambda_2 = 0$ we obtain the contradiction $\bar{q}_\psi < \bar{q}^* = \bar{q}_0$ so the solution must occur along the boundary of the constraint set. If $\Delta\theta\bar{q}_L \geq \psi$ then $\lambda_1 = 0$, $\lambda_2 > 0$, $\bar{q}_\psi = \bar{q}_0 = \bar{q}_L$ is the unique solution to the first-order conditions. Note that the omitted constraints are satisfied. If $\Delta\theta\bar{q}_L < \psi$ the solution cannot entail $\lambda_1 = 0$ and $\lambda_2 > 0$. It follows that $\lambda_1 > 0$ and $\psi = \Delta\theta\bar{q}_\psi$ so the solution lies within the constraint set of the problem in (i) when the constraint $\underline{q}_0 \geq \bar{q}_\psi$ is omitted from that problem. The solution for (vii) is similar.

If $\Delta\theta\bar{q}_L < \Delta\theta\bar{q}_H \leq \psi$ the solution to (i) and (vi) is $\bar{q} = \bar{q}_H$. Since $\Delta\theta\bar{q}_L < \psi$ the solutions to (iii) and (vii) lie within the constraint sets of (i) or (vi) so $\bar{q} = \bar{q}_H$ is the global solution. If $\Delta\theta\bar{q}_L < \psi < \Delta\theta\bar{q}_H$ the global solution is still the solution for (i) and (vi) which is now $\bar{q} = \psi/\Delta\theta$. Finally, if $\psi \leq \Delta\theta\bar{q}_L < \Delta\theta\bar{q}_H$ the solution for (i) and (vi) is still $\bar{q} = \psi/\Delta\theta$ which lies within the constraint sets of problems (iii) and (vii). Since the solution for (iii) and (vii) is $\bar{q} = \bar{q}_L$, this is the global solution. ■

Proof of Proposition 3. If $\psi \in I_L$ then from Propositions 1 and 2 the principal's expected payoff is

$$\gamma W(\underline{q}^*, \underline{\theta}) + (1 - \gamma)W(\bar{q}_L, \bar{\theta}) - \alpha\psi - \gamma\Delta\theta\bar{q}_L + \gamma(1 - \nu)\psi. \quad (\text{A73})$$

The part that depends on ψ is

$$-[\alpha - \gamma(1 - \nu)] \psi. \quad (\text{A74})$$

If $\psi \in I_M$ the expected payoff of the principal is

$$\gamma W(\underline{q}^*, \underline{\theta}) + (1 - \gamma)W(\psi/\Delta\theta, \bar{\theta}) - \alpha\psi - \gamma\nu\psi \quad (\text{A75})$$

and the part that depends on ψ is

$$(1 - \gamma) \left[S \left(\frac{\psi}{\Delta\theta} \right) - \bar{\theta} \frac{\psi}{\Delta\theta} \right] - \alpha\psi - \gamma\nu\psi. \quad (\text{A76})$$

If $\psi \in I_H$ the expected payoff of the principal is

$$\gamma W(\underline{q}^*, \underline{\theta}) + (1 - \gamma)W(\bar{q}_H, \bar{\theta}) - \alpha\psi - \gamma\nu\Delta\theta\bar{q}_H \quad (\text{A77})$$

and the part that depends on ψ is $-\alpha\psi$. Since $\psi = \Delta\theta\bar{q}_H$ is optimal on I_H (if $\alpha = 0$ the principal is indifferent) the principal always chooses from I_L or I_M because the latter includes $\psi = \Delta\theta\bar{q}_H$. Differentiating (A76) with respect to ψ ,

$$\frac{1 - \gamma}{\Delta\theta} \left[S' \left(\frac{\psi}{\Delta\theta} \right) - \bar{\theta} \right] - \alpha - \gamma\nu \quad (\text{A78})$$

which is decreasing in ψ . We first consider the case $\alpha > \gamma(1 - \nu)$ which implies that (A74) is decreasing in ψ on I_L . Evaluating (A78) at $\psi = \Delta\theta\bar{q}_L$, from (25) the resulting expression is negative. Since S' is decreasing, (A76) is decreasing in ψ on I_M . It follows that the unique global maximizer is $\psi = 0$. Now consider $0 < \alpha < \gamma(1 - \nu)$. In this case (A74) is increasing on I_L . Substituting $\psi = \Delta\theta\bar{q}_L$ and $\psi = \Delta\theta\bar{q}_H$ into (A78), we find that the resulting expression is positive at $\psi = \Delta\theta\bar{q}_L$ and negative at $\psi = \Delta\theta\bar{q}_H$. It follows that the unique global maximizer is determined by (33). If $\alpha = 0$ then (A78) is zero at $\psi = \Delta\theta\bar{q}_H$ which is the global optimum. Finally, we consider the case $\alpha = \gamma(1 - \nu)$. The principal is indifferent on I_L and (A76) is decreasing on I_M so every $\psi \in I_L$ is optimal. ■

Proof of Lemma 2. Since demand is zero for all $\alpha > \gamma(1 - \nu)$ an equilibrium with non-zero socialization can only occur at prices $0 \leq \alpha \leq \gamma(1 - \nu)$. In the proof of Proposition 4 we show that an equilibrium does not exist at $\alpha = \gamma(1 - \nu)$. From (32) $\psi_D(\alpha) = \psi_I(\alpha)$ for all $0 \leq \alpha < \gamma(1 - \nu)$. There cannot be an equilibrium with non-zero socialization on I_L because $\psi_L(\alpha) = 0$ for all $0 \leq \alpha < \gamma(1 - \nu)$. Note that this includes the right endpoint $\Delta\theta\bar{q}_L$ of I_L which

is also the left endpoint of I_M . Since demand is bounded above by $\Delta\theta\bar{q}_H$ an equilibrium with non-zero socialization can only occur on I_M where $\psi_S(\alpha) = \alpha + \gamma\nu$ or $\psi_S(\alpha) = \Delta\theta\bar{q}_H$. ■

Proof of Proposition 4. We first simplify our notation: $\Delta L = \Delta\theta\bar{q}_L$, $\Delta H = \Delta\theta\bar{q}_H$, and

$$\begin{aligned} A &= \gamma(1 - \nu) & B &= \Delta L + \gamma(1 - \nu) & C &= \Delta L - \gamma\nu & D &= \Delta H - \gamma\nu \\ E &= \Delta H & F &= \sqrt{2\gamma\Delta L} - \gamma\nu & G &= \frac{\Delta H}{2} + \gamma\frac{\Delta L}{\Delta H} - \gamma\nu & H &= \sqrt{\gamma(\Delta L - \nu\Delta H)}. \end{aligned} \quad (\text{A79})$$

Next, we consider the problem of choosing ψ to maximize (42) subject to the constraint $\psi \in I_L$.

The solution is

$$\psi_L(\alpha) = \begin{cases} 0 & \text{if } \alpha \leq A \\ \alpha - \gamma(1 - \nu) & \text{if } A < \alpha < B \\ \Delta L & \text{if } \alpha \geq B. \end{cases} \quad (\text{A80})$$

We re-write (44) as

$$\psi_M(\alpha) = \begin{cases} \Delta L & \text{if } \alpha \leq C \\ \alpha + \gamma\nu & \text{if } C < \alpha < D \\ \Delta H & \text{if } \alpha \geq D. \end{cases} \quad (\text{A81})$$

The solution to the problem of choosing $\psi \in I_H$ to maximize (45) is

$$\psi_H(\alpha) = \begin{cases} \Delta H & \text{if } \alpha \leq E \\ \alpha & \text{if } \alpha > E. \end{cases} \quad (\text{A82})$$

Evaluating (42) at (A80),

$$P_L(\psi_L(\alpha)) = \begin{cases} \gamma\Delta L & \text{if } \alpha \leq A \\ (1/2)(\alpha - A)^2 + \gamma\Delta L & \text{if } A < \alpha < B \\ (\alpha + \gamma\nu)\Delta L - (1/2)(\Delta L)^2 & \text{if } \alpha \geq B, \end{cases} \quad (\text{A83})$$

(43) at (A81),

$$P_M(\psi_M(\alpha)) = \begin{cases} (\alpha + \gamma\nu)\Delta L - (1/2)(\Delta L)^2 & \text{if } \alpha \leq C \\ (1/2)(\alpha + \gamma\nu)^2 & \text{if } C < \alpha < D \\ (\alpha + \gamma\nu)\Delta H - (1/2)(\Delta H)^2 & \text{if } \alpha \geq D, \end{cases} \quad (\text{A84})$$

and (45) at (A82),

$$P_H(\psi_H(\alpha)) = \begin{cases} (\alpha + \gamma\nu)\Delta H - (1/2)(\Delta H)^2 & \text{if } \alpha \leq E \\ (1/2)\alpha^2 + \gamma\nu\Delta H & \text{if } \alpha > E. \end{cases} \quad (\text{A85})$$

Let \succ denote strict preference, \succsim weak preference, and \sim indifference by the representative parent. By Lemma 2 an equilibrium with non-zero honesty can only occur at prices $0 \leq \alpha \leq A$ where demand intersects supply at $\alpha + \gamma\nu$ or ΔH in I_M . There cannot be such an equilibrium at $\alpha = A$ because demand is flat there from $\psi = 0$ to $\psi = \Delta L$ but $\alpha + \gamma\nu > \Delta L$ on I_M [see (44)] and $\Delta H > \Delta L$.

Proof of (i). From Lemma 2 there are only two possibilities. We first consider the case where $\psi_I(\alpha)$ intersects ΔH in I_M . This intersection must occur at $\alpha = 0$ because $\psi_D(\alpha) < \Delta H$ for all $\alpha > 0$ and $\psi_D(0) = \Delta H$. At $\alpha = 0$ we have $\psi_L(0) = 0$ and $\psi_H(0) = \Delta H$. If ΔH is to be the local optimum on I_M we must have $0 \geq D$ which is equivalent to (47). If $\Delta H \succsim 0$ we must have $G \leq 0$ which is equivalent to (48). ■

Proof of (ii) and (iii). We now consider the second possibility, that $\psi_I(\alpha)$ intersects $\alpha + \gamma\nu$ in I_M . For this to occur at price $0 \leq \alpha < A$ we must have $C < \alpha < D$ so $\psi_M = \alpha + \gamma\nu$. Since $\alpha < D < E$, $\psi_H = \Delta H$. Since $\psi_L = 0$ for all $0 \leq \alpha < A$ the global optimum is either $\psi_L = 0$ or $\psi_M = \alpha + \gamma\nu$. We therefore require

$$\alpha + \gamma\nu \succsim 0 \iff \alpha \geq F. \quad (\text{A86})$$

These requirements imply $C < A$, $D > 0$, $F < A$, and $F < D$ which are assumed in the next 3 cases. We first prove the following lemma.

Lemma 3 *The supply correspondence $\psi_S(\alpha)$ is increasing in α in the (Veinott) sense that $\alpha_1 \geq \alpha_2$ implies $\psi_1 \geq \psi_2$ for all $\psi_1 \in \psi_S(\alpha_1)$ and $\psi_2 \in \psi_S(\alpha_2)$.*

Proof. The proof follows from two observations. The first is that ψ_i is nondecreasing in α on I_i for each $i = L, M, H$ from (A80)-(A82). The second observation is that $P_i(\psi_i)$ is increasing in α faster than $P_j(\psi_j)$ for all $j < i$ provided $\psi_i \neq \psi_j$ as can be checked by differentiating (A83)-(A85). It follows that it is never optimal to switch from a global optimum in I_i to a local optimum in I_j for $j < i$ as the price increases. Let $\alpha_1 > \alpha_2$, $\psi_1 \in \psi_S(\alpha_1)$, and $\psi_2 \in \psi_S(\alpha_2)$. If $\psi_1 \in I_i$, $\psi_2 \in I_j$, and $i = j$ then $\psi_1 \geq \psi_2$ by the first observation. If $\psi_1 \in I_i$, $\psi_2 \in I_j$, $i \neq j$, and $\psi_1 \neq \psi_2$, then $i > j$ by the second. ■

Case 1: $C \geq 0$

For all $0 \leq \alpha \leq C$ we have $\psi_L = 0$ because $\alpha \leq C < A$, $\psi_M = \Delta L$, and $\psi_H = \Delta H$ because $\alpha \leq C < D < E$. The expected payoff of the parent is therefore decreasing and the global optimum is $\psi = 0$. From (A79), $F < A$ implies $F > C$. For all $C < \alpha < F$ we have $\psi_L = 0$, $\psi_M = \alpha + \gamma\nu$, and $\psi_H = \Delta H$ with $\psi = 0$ the global optimum. At $\alpha = F$, $0 \sim \sqrt{2\gamma\Delta L}$, where $\Delta L < \sqrt{2\gamma\Delta L} < \Delta H$. The supply correspondence therefore has a horizontal jump from $(0, F)$ to $(\sqrt{2\gamma\Delta L}, F)$ if α is on the vertical axis and ψ is on the horizontal. For an equilibrium to exist the supply curve cannot jump over the demand curve at $\alpha = F$ so we must have $\psi_D(F) \geq \sqrt{2\gamma\Delta L}$. This implies that the supply curve lies below the demand curve at $\alpha = F$. Since $\sqrt{2\gamma\Delta L} \in \psi_S(F)$ and $\Delta L < \sqrt{2\gamma\Delta L}$ the global optimum cannot be in I_L for all $\alpha > F$ by Lemma 3. At $\alpha = D$ we have $\psi_M = \psi_H = \Delta H$ so the unique global optimum is $\psi = \Delta H$. The supply curve is therefore below the demand curve at $\alpha = F$, above the demand curve at $\alpha = D$, and increasing according to $\alpha + \gamma\nu$ in between. The existence of a unique equilibrium with non-zero honesty follows. The corresponding conditions are $C \geq 0$, $C < A$, $D > 0$, $F < A$, and $F < D$. Of these, $C < A$ is redundant because $C < F < A$ and $D > 0$ is redundant because $0 \leq C < D$. We therefore have

$$C \geq 0 \iff \gamma \leq \frac{\Delta L}{\nu} \tag{A87}$$

$$D > F \iff \gamma < \frac{\Delta H^2}{2\Delta L} \tag{A88}$$

$$A > F \iff \gamma > 2\Delta L \tag{A89}$$

and $\psi_D(F) \geq \sqrt{2\gamma\Delta L}$.

Case 2: $C < 0$ and $F > 0$

Of the conditions $C < A$, $D > 0$, $F < A$, and $F < D$, $C < 0$ makes $C < A$ redundant and $0 < F < D$ makes $D > 0$ redundant. If $0 \leq \alpha < F$ then $\psi_L = 0$ because $0 \leq \alpha < F < A$, $\psi_M = \alpha + \gamma\nu$ because $C < 0 \leq \alpha < F < D$, and $\psi_H = \Delta H$ because $\alpha < D < E$. The global optimum is $\psi = 0$ because $\alpha < F$. At $\alpha = F$ we again have $0 \sim \sqrt{2\gamma\Delta L}$ and we require $\psi_D(F) \geq \sqrt{2\gamma\Delta L}$ so the supply curve does not jump over the demand curve. At $\alpha = D$ the supply curve is above the demand curve so there is a unique equilibrium with non-zero honesty. This

occurs when

$$C < 0 \iff \gamma > \frac{\Delta L}{\nu} \quad (\text{A90})$$

$$F > 0 \iff \gamma < \frac{2\Delta L}{\nu^2} \quad (\text{A91})$$

$$F < D \iff \gamma < \frac{\Delta H^2}{2\Delta L} \quad (\text{A92})$$

$$F < A \iff \gamma > 2\Delta L \quad (\text{A93})$$

and $\psi_D(F) \geq \sqrt{2\gamma\Delta L}$. Combining Cases 1 and 2 proves (iii).

Case 3: $C < 0$ and $F \leq 0$

As before $C < 0$ makes $C < A$ redundant and $F \leq 0$ makes $F < A$ and $F < D$ redundant. At $\alpha = 0$ we have $\psi_L = 0$, $\psi_M = \alpha + \gamma\nu = \gamma\nu$, and $\psi_H = \Delta H$. Since $F \leq 0$, $\alpha + \gamma\nu \gtrsim 0$ and the supply curve lies below the demand curve. After that the supply curve increases according to $\alpha + \gamma\nu$ until at $\alpha = D$ it lies above the demand curve. A unique equilibrium with non-zero honesty therefore exists under the conditions

$$C < 0 \iff \gamma > \frac{\Delta L}{\nu} \quad (\text{A94})$$

$$D > 0 \iff \gamma < \frac{\Delta H}{\nu} \quad (\text{A95})$$

$$F \leq 0 \iff \gamma \geq \frac{2\Delta L}{\nu^2}. \quad (\text{A96})$$

This proves (ii). ■ ■

Proof of Proposition 5. Throughout the proof we assume the buyer believes the car is low quality off the equilibrium path. Since there are only two types we drop the superscript j on all variables. Since the low type can always make positive profit by selling the car at the price $p^L = v_B^L$ the low type never withholds his car from the market. There cannot be an equilibrium where $p^H \neq p^L$ because equilibrium requires $v_S^L < p^L \leq v_B^L$ (recall that an indifferent seller withholds his car) and $v_S^H < p^H \leq v_B^H$ so the low type will deviate and charge p^H . Consider a strategy for the seller where both types charge the price p . If their messages were different then equilibrium would require $p \leq v_B^L < v_S^H < p$ so their messages must be the same. On the equilibrium path the buyer's posterior belief is that the probability of a low-quality car is ρ with maximum willingness to pay p^P . Since deviators are believed to be the low type, this is an equilibrium provided $v_S^H < p \leq p^P$. Finally, consider a strategy for the seller where the high type withholds his car. Since the buyer

believes that quality of the car is low on and off the equilibrium path we must have $p^L = v_B^L$. The high type will not enter because if he does the buyer will believe that he is the low type. ■

Proof of Proposition 6. As in the previous proof, we assume the buyer believes the car is low quality off the equilibrium path. Also as before, a low type can always make positive profit by telling the truth and charging v_B^L , so low types never withhold their cars from the market. We organize the proof around the number of high types present.

(I) Consider a strategy for the seller where both high types withhold their cars from the market.

The buyer therefore believes that the car is low quality both on and off the equilibrium path. The equilibrium prices must therefore be $p^{\psi L} = p^{0L} = v_B^L$. There is no reason to lie so $m^{\psi L} = L$ to avoid incurring the deception cost but the dishonest low type can lie or tell the truth in equilibrium.

(II) Now consider a strategy for the seller where exactly one high type withholds. This cannot be the dishonest high type, who can always enter with the same strategy as the honest high type. Furthermore, we cannot have $m^{0H} = H$ because the honest high type could then enter with the same strategy. For such an equilibrium to exist we must therefore have $p^{0H} = p > v_S^H$, $m^{0H} = L$, and the honest high type withholds, which requires $p - v_S^H - \psi \leq 0$. In that case in equilibrium both low types will pool with the dishonest high type: $p^{0H} = p^{0L} = p^{\psi L} = p$ and $m^{0H} = m^{0L} = m^{\psi L} = L$. The buyer's posterior belief on the equilibrium path is that q^A is the probability that the car is low quality so $v_S^H < p \leq p^A$. This equilibrium does not satisfy the intuitive criterion because the honest high type could enter, announce that he is a high type, and price slightly below p . This deviation is equilibrium-dominated for all other types: the payoff from this deviation is less than their equilibrium payoffs assuming the buyer buys from the deviator. The buyer should therefore deduce that the deviator is the honest high type rather than a low type.

(III) Now consider a strategy for the seller where both high types are offered for sale in the market.

We cannot have $p^{0H} < p^{\psi H}$ because the dishonest high type can always mimic the honest high type. Furthermore, we cannot have $p^{\psi H} < p^{0H}$ and $m^{0H} = H$ because the honest high type could then mimic the dishonest high type. So the only possibilities are (A) $p^{\psi H} < p^{0H}$ and $m^{0H} = L$ or (B) $p^{\psi H} = p^{0H}$. We consider each case in turn.

(A) As in (II) both low types will pool with the dishonest high type: $p^{0H} = p^{0L} = p^{\psi L} = p$ and $m^{0H} = m^{0L} = m^{\psi L} = L$. In equilibrium we cannot have $m^{\psi H} = L$ because the

honest high type would deviate and pool with the others. To be an equilibrium we must therefore have $m^{\psi H} = H$,

$$v_S^H < p^{\psi H} < p \leq p^A, \quad (\text{A97})$$

and

$$p^{\psi H} - v_S^H \geq p - v_S^H - \psi \quad (\text{A98})$$

so the honest high type does not deviate. This equilibrium does not survive the intuitive criterion either because the honest high type could increase his price slightly and continue telling the truth.

(B) Finally, we consider the case $p^{\psi H} = p^{0H} = p$.

(1) If $m^{\psi H} = m^{0H} = L$ the equilibrium is pooling: $p^{jk} = p$ and $m^{jk} = L$ for all $j \in \{\psi, 0\}$ and $k \in \{H, L\}$. This is an equilibrium if $p \leq p^P$ and the honest high type prefers not to exit $p - v_S^H - \psi > 0$. This does not survive the intuitive criterion because the honest high type could reduce his price slightly and save on lying costs by telling the truth.

(2) If $m^{\psi H} = H$ and $m^{0H} = L$ the honest low type pools with the dishonest high type in equilibrium: $p^{\psi L} = p$ and $m^{\psi L} = L$.

(a) If the dishonest low type also pools with the dishonest high type then the seller's strategy is for all types to price at p , the honest high type tells the truth $m^{\psi H} = H$, while all other types send the message $m^{0H} = m^{\psi L} = m^{0L} = L$. When the buyer observes p and L she believes the car is low quality with probability q^A . When the buyer observes p and H she believes the car is high quality with probability one. This is an equilibrium if $v_S^H < p \leq p^A$.

(b) If the dishonest low type pools with the honest high type then all types charge p and $m^{\psi H} = m^{0L} = H$ and $m^{0H} = m^{\psi L} = L$. On the equilibrium path the buyer maintains her prior so this is an equilibrium when $v_S^H < p \leq p^P$.

(3) The case $m^{\psi H} = L$ and $m^{0H} = H$ cannot be an equilibrium.

(4) If $m^{\psi H} = m^{0H} = H$ the dishonest low type will pool with the high types.

(a) If the honest low type pools with the others then the seller's strategy is for all types to charge p and send the message H . On the equilibrium path the buyer maintains her prior with maximum willingness to pay p^P . The honest low type

will deviate and charge $p^{\psi L} = v_B^L$ and tell the truth $m^{\psi L} = L$ unless

$$p - v_S^L - \psi \geq v_B^L - v_S^L. \quad (\text{A99})$$

We therefore have an equilibrium when $v_S^H < p \leq p^P$ and $p \geq v_B^L + \psi$.

- (b) If the honest low type separates with $p^{\psi L} = v_B^L$ and $m^{\psi L} = L$ and the other types charge p and send the message H then the buyer believes that the car is low quality with probability one when she observes the former and q^E when she observes the latter. This is an equilibrium provided that $v_S^H < p \leq p^S$ and $p \leq v_B^L + \psi$.

This completes the proof. ■

Proof of Proposition 7. We first observe that $p^A < p^P < p^S$ because $q^E < \rho < q^A$. We first prove (i) where $p^P > v_S^H$. If $\psi = 0$ the optimistic equilibrium in Proposition 5 is the pooling equilibrium with $p = p^P$ where expected profit is first best R^F . If $\psi > 0$ then (i) and (ii) in Proposition 6 provide less than first best expected profit. The others (iii)-(v) do achieve the first best expected profit but (iv) entails deception costs and all three entail socialization costs. The optimal choice for the parent is therefore $\psi = 0$. We now prove (ii), where $p^A < p^P \leq v_S^H < p^S$. If $\psi = 0$ only the lemons equilibrium is available in Proposition 5. If $\psi > 0$ only (i) and (v) are available in Proposition 6. We now compare (v) with the lemons equilibrium in Proposition 5 with $\psi = 0$. If (65) holds the equilibrium in (v) with the highest expected profit for the seller is the one where all types other than the honest low type charge $p = v_B^L + \psi$. The expected payoff of the parent is

$$\rho(1 - \nu)v_B^L + [\rho\nu + (1 - \rho)]p - \rho v_S^L - (1 - \rho)v_S^H - c\psi. \quad (\text{A100})$$

Note that the above expression is linear in ψ . If $\rho\nu + (1 - \rho) > c$ the optimal ψ within this class of equilibria is the maximum $\psi^S = p^S - v_B^L$ with $p = p^S$. Since this equilibrium achieves the first best expected profit R^F , the parent prefers it over the lemons equilibrium with $\psi = 0$ when

$$R^F - c\psi^S \geq \rho(v_B^L - v_S^L) \iff (1 - \rho)(v_B^H - v_S^H) \geq c\psi^S. \quad (\text{A101})$$

If $\rho\nu + (1 - \rho) \leq c$ the expression in (A100) is nonincreasing in ψ so we compare the parent's expected payoff at the left endpoint where $\psi = v_S^H - v_B^L$ and $p = v_S^H$ with the parent's expected payoff from the lemons equilibrium with $\psi = 0$. The latter is higher when $c > \rho\nu$ which is implied

by $\rho\nu + (1 - \rho) \leq c$. If $v_S^H \geq p^S$ the only available equilibrium is the lemons equilibrium and the parent's optimal choice is $\psi = 0$. ■

6 References

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