Exposure to the Unconventional, Mandatory Disclosure, and Contract Design*

Alessandro Pavan† and Jean Tirole‡

June 25, 2024

Abstract

We introduce the concept of "relative exposure to the unconventional " and show that, when parties covertly acquire information about the need for an unconventional contract design prior to signing the contract, the concept underlies a variety of phenomena such as expectation conformity (the parties' tendency to conform to the intensity of information gathering that is expected of them), excessive investment in information acquisition, and the welfare merits of mandatory disclosure laws and other regulations. The paper develops a simple framework that captures the above phenomena and draws policy implications.

Keywords: information acquisition, contracts, endogenous adverse selection, caveat emptor, mandatory disclosures, expectation conformity.

JEL numbers: C72; C78; D82; D83; D86.

1 Introduction

A key activity of public and private decision-makers is to design, negotiate, and enter contractual agreements, such as private contracts, laws, or international treaties. To this purpose, they hire engineering, financial, or legal experts, and set aside other activities in order to gather information about the implications of alternative designs. Information gathering influences transactional frictions that arise from asymmetric information. It is therefore central to the functioning of markets, regulation, and political decisions.

This paper studies a simple contracting environment in which the parties covertly engage in information acquisition prior to contracting. Its contribution is two-fold. First, it identifies a sufficient statistic, the "relative exposure to the unconventional," and shows that the latter underlies a variety

*For useful feedback, we thank participants at various seminars and conferences where the paper was presented. Amirreza Ahmadzadeh provided excellent research assistance.

†Department of Economics, Northwestern University, and CEPR. Email: alepavan@northwestern.edu.

‡Toulouse School of Economics (TSE) and Institute for Advanced Study in Toulouse (IAST), University of Toulouse Capitole. Email: jean.tirole@tse-fr.eu.

of phenomena that are relevant for this type of situations. Second, it analyzes the welfare implications of mandatory disclosure laws and other regulations aimed at increasing the efficiency of contractual relationships.

In the model, described in Section 2, parties can opt for a standard design or an unconventional one. The standard design is favored in the absence of information proving the need to switch to the unconventional one. The standard design, when inadequate, exposes the parties to an efficiency loss, whose relative incidence to the players, which we label "relative exposure to the unconventional," plays a key role both in the early negotiations leading to the signing of the contract and in subsequent contract renegotiations. For example, under unconventional circumstances, the product specification under the standard design may be inappropriate for the buyer's needs or unusually costly for the seller to produce. Information gathering prior to the signing of the contract can allow the parties to identify contingencies under which it is efficient to switch to an unconventional design, thus avoiding such welfare losses and permitting the parties to write a better contract. However, in addition to its effect on efficiency, information also involves rent seeking. Depending on the circumstances, the parties may over- or under-invest in information acquisition relative to what is efficient, and the analysis reveals when each of the two cases arises.

For simplicity, we assume that only one party acquires information. We discuss the case of two-sided information acquisition in the Appendix. Section 3 analyses the case of voluntary disclosure. The information that is acquired is "hard" and hence verifiable. We show that both the incentives to acquire information and to disclose it increase with the information acquirer's *relative exposure to the unconventional*. The latter is a sufficient statistics of the primitives of the contractual problem under consideration that captures the losses to a party due to the writing of a contract specifying an inefficient design, net of the benefit of such contractual inefficiencies stemming from speculative considerations.

We show that expectation conformity (namely, a player's incentives to conform to what is expected out of them when it comes to information gathering), and its corollary (the possibility of multiple equilibria) obtains if and only if the information acquirer is relatively more exposed to the unconventional than the other party; in this case, the party gathering information is always better off in the equilibrium with the lowest intensity of information acquisition.

Section 4 uses the characterization in the previous section to study mandatory disclosure laws. The notion of mandatory disclosure is complex, and has been the object of tensions in contract law for a long time.[1] For example, in Macquarie International Health Clinic Pty Ltd vs Sydney South West Area Health Service (2010, NSWCA 268), the Court held that the obligation of "good faith" does not require parties to compromise their own commercial interests, but that parties must cooperate, including disclosing information, in a reasonable way to achieve the contract's objectives. The Macquarie decision allows for the possibility of delay in disclosure; in some cases, indeed, a party may refrain from disclosing at the contractual stage, but then disclose after the initial contract is signed

[1] See Kronman (1978) seminal paper on the topic.

and renegotiate before news about contractual inefficiencies publicly accrue. Our results identify conditions under which a party has incentives to delay disclosure and show that they are related to a party's relative exposure to the unconventional. The possibility of delay in disclosure raises the issue of the welfare merits of making disclosure at the signing of a contract a legal requirement, which we also investigate in Section 4.

Specifically, Subsection 4.1 shows that, in the absence of disclosure regulation, strategic dissimulation of information at the contracting stage occurs when the other party to the contract is relatively more exposed to the unconventional and post-contract renegotiation does a good job at limiting the damages associated with a wrong design. In this case, mandatory disclosure, studied in Section 4.2, has both positive and negative welfare effects. On the positive side, it prevents efficiency losses associated with delayed voluntary disclosure (e.g., the bearing of sunk costs associated with irreversible investments related to a wrong design). On the negative side, it involves two costs. First, the party gathering information, having fewer options on what to do with it, is less keen on gathering socially useful information in the first place (we show that late disclosures occur only when information gathering is inefficiency low from a social standpoint). Second, the information acquirer is deterred from disclosing information that is acquired after the signing of the contract whenever, as is likely, it cannot be proven whether this information was acquired prior to or after the signing of the contract. So, while mandatory disclosure is always optimal for exogenous information, its optimality when information is endogenous requires strong conditions. In that respect, the optimal treatment of contract-relevant information bears resemblance to intellectual property law.[2]

Section 5 investigates the optimal design of penalties when the (balanced-budget) court (a) either observes whether a party discloses information post contract, (b) or observes that the party concealed information prior to contracting (observing only that the contract is renegotiated does not alter the equilibrium outcomes, as the parties can undo any penalty that one pays to the other because of renegotiation). We show that, in general, optimally-designed penalties do better than simple mandatory disclosure laws, but the key trade-offs in their design are similar to those associated with the choice of whether or not to make disclosure mandatory.

Finally, Section 6 concludes by discussing a few venues for future work.

Relationship to the literature. The paper is related to several strands of the literature. The first one is the legal literature on *caveat emptor* ("Let the buyer beware"). Caveat emptor, which has a long tradition dating back to the Roman times, provides in common law a safe harbor for a seller not to disclose information to the buyer.[3] Several arguments have been made in its favor. The first is that, under symmetric information, the seller's liability may alter consumer choices when the buyer's relative tastes for price and defects are heterogenous (Buchanan (1970)). The main

[2] The latter specifies that an inventor is entitled to benefit from their innovation if the latter is novel, non-obvious, and useful. The goal of intellectual property law is to reward inventors without generating socially costly "underserved" rents.

[3] French law, by contrast, tends to view dissimulation as contrary to good faith bargaining.

justification is to avoid frivolous lawsuits by having buyers bear the risk of loss and thereby imposing upon them a duty to inspect. In particular, caveat emptor holds it that the seller has no duty to disclose patent or obvious defects to the buyer. The possibility of asymmetric information has over time led courts and legislative enactments to what Johnson (2008) calls *"caveat emptor light"*, more in line with Kronman (1978)'s influential theory of information as a property right. Kronman (1978) makes a distinction between casually and deliberately acquired information. Information acquired by the homeowner as a by-product of living in the house (the presence of termites, the occasional flooding of the basement) should be disclosed, while that deliberately acquired by the seller is akin to a property and should not be subject to a disclosure obligation. If the presence of termites or the occasional flooding are just redistributive aspects (they affect the sale price, but not who should own the house for what purpose), this precept runs counter Cooter and Ulen (2016), who distinguish between "productive" and "redistributive" facts, and argue that the redistributive facts should not be subject to a disclosure duty. Our paper offers a formal framework capturing some of the relevant tradeoffs in which this legal debate can be analyzed. It considers a situation that is more general than a sale (in the model, both parties have a post-contractual stake, and may want to renegotiate the contract to their mutual advantage), and it shows the role played by a sufficient statistic (a player's relative exposure to the unconventional) in shaping the incentives for information gathering and dissimulation, and in assessing the merits of alternative regulations.

The second strand is the literature on disclosure games, in which a sender holds hard (verifiable) information and decides whether to reveal it to a receiver who then takes an action affecting both parties. See Sobel (2013) for a survey and Dekel et al (2018) for some of the recent developments. Most papers in this literature assume the information structure is exogenous; exceptions include Matthews and Postlewaite (1985), Shavell (1994), Dang (2008), and Hoffmann et al (2020). Our contribution is in analyzing the welfare merits of mandatory disclosure and other regulations.

The third strand is the literature on information acquisition in contracting games. A rich literature discusses the implications of the possibility of acquiring information after a contract offer is on the table. In Cremer and Khalil (1992), a contract is designed so as to alter the incentives to the other party's information acquisition (see also Lewis and Sappington (1997), and Szalay (2009) for a more general treatment). In these papers, information acquisition is purely wasteful, and the optimal contract deters it. Information acquisition prior to contracting, instead, is investigated in Spier (1992), Cremer and Khalil (1994), Cremer et al. (1998a,b), Gabaix and Laibson (2006), Tirole (2009), and Bolton and Faure-Grimaud (2010), among others. The contribution of the present paper vis-a-vis this body of work is twofold. First, it analyses the welfare implications of mandatory disclosure laws and other policy interventions. Second, it identifies a summary statistic, the relative exposure to the unconventional, and shows the role the latter plays for information acquisition, and the dissimulation of information at the contracting stage.

2 Model

2.1 Description

Players and contingencies. Two risk-neutral players engage in a contractual relationship with unknown payoffs. The state space is binary, with $\Omega = \{\omega, \widehat{\omega}\}$, and it is common knowledge that each party assigns prior probability q and $\widehat{q}$ to ω and $\hat{\omega}$, respectively. As anticipated above, we assume that only one of the two players acquires information and refer to this player as player 1 (we discuss a few properties of two-sided information acquisition in Appendix B). In state ω, player 1's initial (pre-search) and final (post-search) information is $\varnothing$, regardless of the intensity of information acquisition. In state $\widehat{\omega}$, instead, player 1 learns the state $\widehat{\omega}$ with probability ρ, whereas, with probability $1 - \rho$, she learns nothing (i.e., her information remains equal to $\varnothing$), where $\rho \in [0, 1]$ measures the intensity of information acquisition. The cost of information acquisition is $C(\rho)$, with $C'(\rho) > 0$ for $\rho > 0$, $C''(\rho) > 0$ for all ρ, $C'(0) = C(0) = 0$, and $C'(1) = \infty$. The information that player 1 receives in state $\widehat{\omega}$ proving that the state is $\widehat{\omega}$ is *hard* and therefore can be disclosed in a verifiable manner to player 2 if player 1 decides to do so.

Actions and payoffs. Contracts between the two parties can specify one of two non-monetary actions, a and $\widehat{a}$. Think of each of these actions as the specification of the type of product or service to be exchanged. In state ω, the efficient (i.e., gross total-surplus maximizing) action is a, whereas in state $\widehat{\omega}$ the efficient action is $\widehat{a}$. The players can contract on which of these two actions to take and transfer money between themselves (more below).

Let U_i (alternatively, $\widehat{U}_i$) denote player i's *gross* surplus in state ω (alternatively, $\widehat{\omega}$) when the optimal action for that state is taken (a when the state is ω and $\hat{a}$ when the state is $\hat{\omega}$). Denote by $U = \Sigma_i U_i$ and $\widehat{U} = \Sigma_i \widehat{U}_i$ the total surplus under the efficient actions and by $\delta \geq 0$ (alternatively, $\hat{\delta} \geq 0$) the deadweight loss associated with choosing the wrong action (that is, action $\hat{a}$ in state ω, or action a in state $\hat{\omega}$). Such losses can be decomposed into the respective losses to the two players, δ_i and $\hat{\delta}_i$, $i = 1, 2$, with $\Sigma_i \delta_i = \delta$ and $\Sigma_i \hat{\delta}_i = \hat{\delta}$. We assume that, in the absence of evidence proving that the state is $\widehat{\omega}$, the action specified in the contract is a. We then interpret state ω as "business as usual," action a as the default/standard action, state $\widehat{\omega}$ as "unconventional circumstances," and action $\hat{a}$ as the unconventional action. Consistently with this interpretation, one can assume that, when the state is $\widehat{\omega}$, an unconventional "design" is needed. The appropriate version of such a design, x, is drawn uniformly from $[0, 1]$. Action $\widehat{a}$ then corresponds to selecting the appropriate design x in state $\widehat{\omega}$, and knowing the state $\widehat{\omega}$ comes with the knowledge of the appropriate design x. Selecting any unconventional design in state ω, or any inappropriate design $x' \neq x$ in state $\widehat{\omega}$ in the absence of information (i.e., under $\emptyset$), results in a loss to each party large enough to dissuade them from specifying in their contract any unconventional design in the absence of any disclosure.

The above payoffs should be interpreted as post-renegotiation payoffs in case the initial contract is eventually renegotiated, in which case the losses δ_i and $\hat{\delta}_i$ can be interpreted as "adjustment costs," which are incurred in case the parties fail to specify the right action upfront at the initial contractual stage. These payoffs are gross of monetary transfers between the two players and of any information-gathering costs.The assumption that payoffs are renegotiation-inclusive deserves some comments. An improper design, by definition, leads to a higher cost to the seller or a lower value to the buyer (or both). When the state is realized, it may be too late to change the design, and the deadweight loss is fully incurred (the "no-renegotiation case"). Alternatively, the loss may be reduced, or even eliminated, by altering the design specified under the initial contract, incurring some associated adjustment cost (the "renegotiation case"). One would then expect that the earlier the state is publicly revealed, the lower the adjustment cost (for example, fewer investments will be sunk by the seller and the buyer).

Figure 1 represents the players' joint payoffs as a function of the state and the action specified at the contractual stage.

		state of nature	
		ω	$\widehat{\omega}$
action	a	U	$\widehat{U} - \hat{\delta}$
	$\widehat{a}$	$U - \delta$	$\widehat{U}$

Figure 1: **Joint surplus**

We assume that each player's outside option (that is, their payoff in case of no trade with the other party) is equal to zero. Finally, we assume that $U, \hat{U} \geq 0$, which means that, under the appropriate actions, there are gains from trade (at least weakly) in either state.

Transfers. Let $w_i \in [0, 1]$ denote player i's bargaining power, or weight, in any negotiation between the two players over the transfers, with $\sum w_i = 1$. Each player reaps a fraction w_i of the gains from trade. Specifically, when player 1 discloses information proving that the state is $\hat{\omega}$, the action specified in the contract is $\hat{a}$ and the transfer to each player $i = 1, 2$ is given by the unique solution to

$$\widehat{U}_i + t_i = w_i \widehat{U}. \tag{1}$$

When, instead, player 1 does not disclose information (either because she did not receive it, or because she conceals it), the action specified in the contract is a and the transfer t_i to each player $i = 1, 2$ is as follows. Suppose that, in equilibrium, player 1 invests ρ in information acquisition and discloses with probability d in state $\hat{\omega}$ (as explained above, there is nothing to disclose in state ω). Let q' (alternatively, $\hat{q}'$) denote the two players' on-path posterior beliefs that the state is ω

(alternatively, $\hat{\omega}$) in the absence of any disclosure.[4] Using Bayes' rule

$$q' = \frac{q}{q + \hat{q}(1-\rho_i d_i)} = 1 - \hat{q}'.$$

The transfer t_i to each player i is given by the unique solution to

$$q' U_i + \hat{q}' \big(\widehat{U}_i - \delta_i\big) + t_i = w_i \Big[q' U + \hat{q}' \big(\widehat{U} - \delta\big)\Big]. \tag{2}$$

Note that the term in square brackets in the right-hand side of (2) is the total surplus expected in the absence of any disclosure, under the equilibrium strategies. The same division of surplus is used to determine the transfers ex-post, in case the parties renegotiate the initial contract. That is, ex-post transfers are determined so that each player i receives a fraction w_i of the total surplus from renegotiating the initial contract. We also assume that the gross payoffs in each of the two states are such that, under the transfers described above, each player prefers contracting with the other player to her outside option (accounting for the fact that, off path, player 1's beliefs may differ from $(q', \hat{q}')$). In Appendix A, we identify the precise conditions that guarantee that this is the case and show that these conditions are always met when, given $\hat{\delta}$ and $U_i - \hat{U}_i$, the gross surplus U_i is large enough for all i.

The transfers above coincide with those under the familiar Rubinstein-Stahl sequential bargaining game when (a) offers are frequent (i.e., when the delay between offers vanishes), (b) the players' participation constraints under the above protocol are satisfied (which is the case under the conditions in Appendix A), and (c) players hold passive beliefs.[5] The last assumption, which amounts to the refinement that players do not change their beliefs over the information held by the opponent when they receive an off-path offer, is justified in our setting by the fact that all types of player 1 have the same preferences over the negotiated price, which makes signaling implausible.

Definition 1. Player i's ***relative exposure to the unconventional*** is given by

$$\sigma_i \equiv \Big[U_i - \big(\widehat{U}_i - \hat{\delta}_i\big)\Big] - w_i \Big[U - \big(\widehat{U} - \hat{\delta}\big)\Big].$$

Player i is *relatively more exposed to the unconventional* if $\sigma_i > 0$.

Intuitively, player i loses (or gains) gross surplus $U_i - \big(\widehat{U}_i - \hat{\delta}_i\big)$ when the default action a is specified in the original contract and the realized state is $\widehat{\omega}$ rather than ω. At the same time, from an ex-ante viewpoint, the player may be able to appropriate a fraction of the total loss $U - \big(\widehat{U} - \hat{\delta}\big)$ due to an improper design, the magnitude of which depends on the player's bargaining weight w_i. The second component of σ_i is thus a speculative one which captures player i's ability to take advantage of any possible mis-pricing at the contractual stage. Note that the measure σ_i is indeed a relative one as $\Sigma_i \sigma_i = 0$. Accordingly, we say that player i is relatively more exposed if $\sigma_i > 0$.

[4] Hereafter, we use the "prime" sign to denote the on-path posterior beliefs, in the absence of disclosure.

[5] The proof follows from familiar arguments and is thus omitted; it is available upon request.

The measure σ_i will play an important role as a sufficient statistic underlying our results. It allows us to give a formal meaning to Cooter and Ulen (2016)'s distinction between "productive and redistributive facts". The authors acknowledge that information acquisition usually unveils both productive and redistributive elements. In our model, σ_i has a clear redistributive/zero-sum nature, whereas $\widehat{q}\hat{\hat{\delta}}$ captures the productive stake in information acquisition (equivalently, the expected losses that the two players can avoid by discovering that the state is $\hat{\omega}$ and writing a contract specifying the appropriate action $\hat{a}$ for that state).

Timing. In Section 3, we assume that disclosure occurs either prior to contracting or never until the state is publicly realized. This assumption does not rule out renegotiation *after* the state is publicly disclosed, as shown by the two illustrations discussed below in Subsection 2.2. By contrast, the case of delayed disclosure is studied in Section 4. The timing, in the case of pre-contractual disclosure, is summarized in Figure 2 and goes as follows:

(1) Player 1 secretly chooses how much information to acquire (formally captured by the probability ρ of learning the state $\widehat{\omega}$, when relevant);

(2) Player 1 either learns that the state is $\widehat{\omega}$ or does not receive any information (i.e., receive the null signal $\varnothing$);

(3) Player 1 chooses whether to disclose hard information proving to the other party that the state is $\widehat{\omega}$, when this is the case;

(4) In the absence of any disclosure, the negotiations between the two parties lead to a contract specifying action a and a transfer t_i to each party determined according to (2).If, instead, player 1 discloses information, proving that the state is $\widehat{\omega}$, the negotiations between the two parties lead to a contract specifying action $\widehat{a}$ and a transfer t_i to each party determined according to (1). After the negotiations are over, parties can still leave the relationship if thew want so (in other words, the outside options are exerted at stage (4)).

(5) The state is publicly realized.[6]

2.2 Examples

Symmetric Buyer-Seller game. In this example, player 1 is a seller and player 2 a buyer. The two actions correspond to different product designs. The seller's cost of supplying the buyer is known and equal to c, irrespective of the design. The buyer's gross value for the good is B if the correct design is selected (a when the state is ω, $\hat{a}$ when the state is $\hat{\omega}$) but only $b < B$ if the wring design

[6]As noted above, once the state is publicly revealed, the parties can still renegotiate to their mutual advantage. This is the case if action a is specified in the original contract, the state of nature is $\widehat{\omega}$, and the adjustment cost to replace action a with action $\widehat{a}$ is not too large: see the examples in Section 2.2.

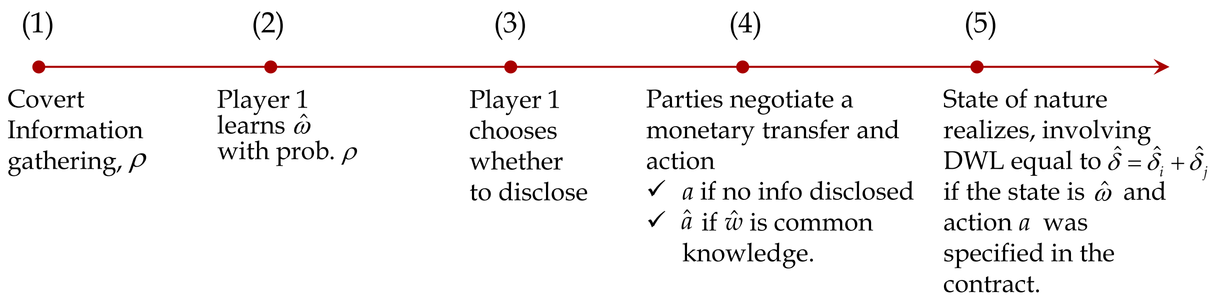

Figure 2: **Timing**

is selected ($\hat{a}$ when the state is ω, a when the state is $\hat{\omega}$). If wrong design is selected, after the state is publicly revealed, the buyer can still enjoy the full surplus B but only if the seller incurs some adjustment cost $\alpha \geq 0$ (such a cost may reflect the changes to the product necessary to deliver the value B to the buyer). Figures 3 and 4 summarize the gross payoffs of the two parties without and with renegotiation, respectively.

1. *No renegotiation* (the ex-post adjustment cost is large: $\alpha \geq B - b$).

	ω	$\widehat{\omega}$
a	$B, -c$	$b, -c$
$\hat{a}$	$b, -c$	$B, -c$

Figure 3: **Buyer-seller game in the absence of ex-post renegotiation**

That the default design a is selected in the absence of disclosure is then guaranteed, for example, by assuming that $\hat{q}B + qb - c < 0$, which implies that, under the unconventional design $\hat{a}$, expected surplus is negative no matter the strategy of player 1.[7] In this case, the gross payoffs satisfy the following conditions

$$U = \widehat{U} = B - c, \quad \delta_2 = \hat{\delta}_2 = B - b, \quad \delta_1 = \hat{\delta}_1 = 0, \quad \delta = \hat{\delta} = B - b.$$

As a result, in this example,

$$\sigma_2 = \hat{\delta}_2 - w_2\hat{\delta} = w_1\hat{\delta} = w_1(B - b) > 0,$$

implying that the buyer (player 2) is relatively more exposed to the unconventional.

2. *Ex-post renegotiation* (adjustment cost $\alpha < B - b$).

[7]This is because posterior belief in the absence of any disclosure satisfy $\hat{q}' \leq \hat{q}$.

	ω	$\widehat{\omega}$
a	$B, -c$	$b + w_B(B - b - \alpha)$, $-c + w_S(B - b - \alpha)$,
$\hat{a}$	$b + w_B(B - b - \alpha)$, $-c + w_S(B - b - \alpha)$,	$B, -c$

Figure 4: **Buyer-seller game with ex-post renegotiation**

Compared to the case of large adjustment costs, the deadweight loss is smaller, but the relative exposure is the same. To see this, note that

$$\hat{\delta}_2 = (B - b) - w_2[(B - b) - \alpha] = w_1(B - b) + w_2\alpha$$

and

$$\hat{\delta}_1 = -w_1(B - b - \alpha) = \alpha - \hat{\delta}_2$$

and hence

$$\hat{\delta} = \alpha \quad \text{and} \quad \sigma_2 = w_1(B - b).$$

That action a is selected in the absence of any disclosure is then guaranteed, for example, by assuming that $\hat{q}B + q(B - \alpha) - c < 0$. Note that, for $\alpha = B - b$, the expressions are the same as for the no-renegotiation case.

Shrouded attributes and ex-post distortions due to private information. In this example too player 1 is a seller and player 2 a buyer. The seller may discover that the good may require an add-on, also provided by the seller. The cost to the seller of providing the basic good is equal to c, wheres the cost of the add-on is $\hat{c}$. Let ω correspond to the state in which the add-on is not needed and $\hat{\omega}$ the state in which it is. Gabaix and Laibson (2006) consider a version of this model in which the seller is perfectly informed of the state. The focus here, instead, is on the seller's endogenous acquisition of information.

For simplicity, assume that, in state $\widehat{\omega}$ in which the add-on is needed, the basic version of the good brings no value to the buyer. The value the buyer assigns to the good (in its basic configuration in state ω or together with the add-on in state $\widehat{\omega}$) is v, with the latter drawn from $\mathbb{R}_+$ according to the distribution F and privately observed by the buyer ex-post, i.e., at stage (5). In this example, v is thus the buyer's value for the "satisfactory" version of the good, which coincides with the basic specification in state ω and to the combination of the basic configuration with the add-on in state $\widehat{\omega}$. That v is learned ex-post generates a downward-sloping demand (and hence a monopoly distortion) in case of ex-post renegotiation (i.e., in case the need for the add-on is disclosed only after the initial contract is signed) without introducing adverse selection on the buyer side at the contracting stage. Let r^m denote the monopoly price for the add-on in state $\hat{\omega}$ when the state is revealed only

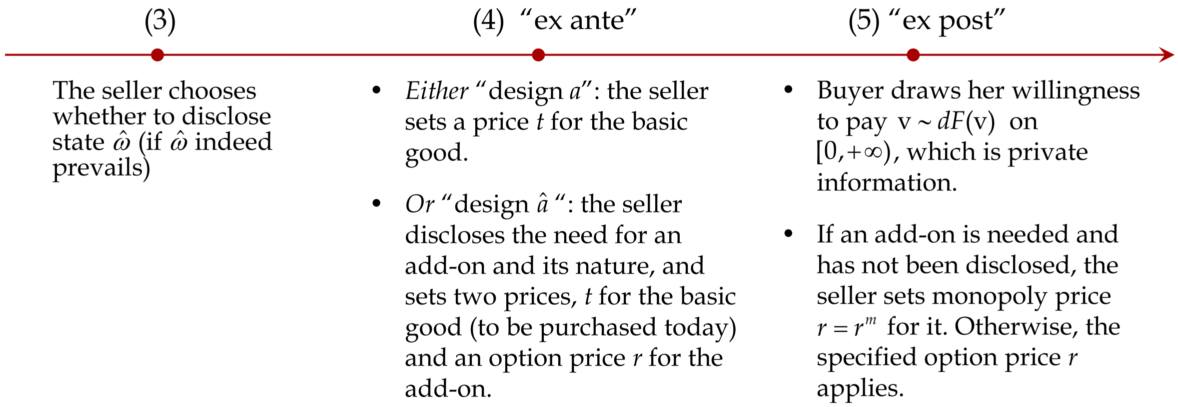

Figure 5: **Shrouded-attributes model**

ex-post, after the initial contract is signed. The ex-post monopoly price r^m is the value of r for which $(r-\widehat{c})[1-F(r)]$ is the highest. The lack of ex-ante adverse selection implies that, if the need for the add-on is disclosed at the initial contracting stage, then it is optimal for the seller to price it at marginal cost, in which case there is no ex-post distortion. Let $\mathcal{S}(r) = \int_r^{\infty} (\mathrm{v}-r)dF(\mathrm{v})$ denote the buyer's expected surplus when the price for the add-on is r, gross of the price of the basic good. The most relevant events are summarized in Figure 5 whereas the players' payoffs (gross of the price paid by the buyer for the basic good) are represented in Figure 6.

	ω	$\widehat{\omega}$
a	$\int_0^{\infty} \mathrm{v} dF(\mathrm{v}), -c$	$\int_{r^m}^{\infty} (\mathrm{v}-r^m) dF(\mathrm{v}),$ $-c + (r^m - \hat{c})[1-\mathrm{F}(r^m)]$
$\hat{a}$	$\int_0^{\infty} \mathrm{v} dF(\mathrm{v}), -c$	$\int_{\hat{c}}^{\infty} (\mathrm{v}-\hat{c}) dF(\mathrm{v}) - \hat{c}$

Figure 6: **Payoffs in the shrouded-attributes model (gross of the ex-ante transfer)**

This situation thus corresponds to a special version of the model in which the following conditions hold:

- $w_1 = 1$ (the seller is a price setter);
- $\hat{\delta} = \left[\mathcal{S}(\hat{c}) - \mathcal{S}(r^m)\right] - (r^m - \hat{c})\left[1 - F(r^m)\right]$ is the deadweight loss associated with non-disclosure of the need for the add-on and ex-post monopoly pricing (the "wrong design" in this situation corresponds to a contractual failure in which the seller, by not disclosing, fails to commit to the cost-based add-on price);

- $\sigma_B = \displaystyle\int_0^{r^m} \mathrm{v}\, dF(\mathrm{v}) + \big[1 - F(r^m)\big] r^m$ (the buyer's relative exposure to the unconventional is equal to the buyer's loss of utility under ex-post monopoly pricing and combines the loss from foregone consumption (in case $v \in [0, r^m]$) and the extra payment (in case $\mathrm{v} > r^m$).

3 Voluntary disclosure

As explained above, the primary purpose of the analysis is to identify the merits and limits of mandatory disclosure laws and other regulatory interventions. The first step in this direction is the characterization of the equilibria in the laissez-faire economy in which disclosure is voluntary. We first examine the disclosure decision and then the acquisition of information.

3.1 Disclosure decision

In this subsection, we fix the investment in information gathering at $\rho = \rho^*$ and investigate player 1's incentive to disclose.

When player 1 is expected to disclose with probability $d^* \in (0, 1)$, the posterior probability that player 2 assigns to the state being ω in the absence of any disclosure is equal to

$$q'(\rho^*, d^*) = \frac{q}{1 - (1 - q)\rho^* d^*}. \tag{3}$$

Suppose for a moment that player 1 is expected to disclose with certainty when she finds that the state is $\widehat{\omega}$ (i.e., $d^* = 1$) (anticipating the analysis in the next subsection, note that this is necessarily the case when information is endogenous and costly to acquire because there is no point in acquiring information if it is weakly suboptimal to disclose it).[8]

Suppose player 1 learns that the state is $\widehat{\omega}$. By disclosing this information, she obtains a payoff, net of the transfer t_1 of Condition (1), equal to $w_1 \widehat{U}$, that is, her share w_1 of the (complete-information) total surplus $\widehat{U}$. By not disclosing, instead, she obtains

$$\widehat{U}_1 - \hat{\delta}_1 + t_1,$$

where t_1 is the transfer associated with the default design a, as given in Condition (2). Simple algebra reveals that player 1 prefers disclosing to not disclosing if and only if

$$w_1 \hat{\delta} \geq q'(\rho^*, 1)\sigma_2, \tag{4}$$

where σ_2 is player 2's relative exposure to the unconventional. Condition (4) says that player 1 prefers to disclose whenever her share of the deadweight loss, $w_1 \hat{\delta}$, exceeds the cross-subsidy embodied in

[8] There are in general two possible motivations for player 1 to acquire information. The first one (on which we focus here) is to disclose it so as to avoid the deadweight loss of a wrong contract design. The second is to decide whether or not to trade with player 2 (this alternative motivation is ruled out by the assumption that, given the equilibrium transfer t_1 , player 1's expected surplus is higher than her outside option, no matter her posterior beliefs). See also the discussion in the Appendix.

the transfer t_1, namely $q'(\rho^*, 1)\sigma_2$. This cross-subsidy is proportional to the posterior probability $q'(\rho^*, 1)$ that player 2 assigns to the erroneous state, ω, in the absence of disclosure, when player 1 is expected to acquire information with intensity ρ^* and disclose with certainty. The right-hand-side of (4) is thus a rent that player 1 obtains thanks to player $2's$ incorrect beliefs (which shape the price t_1 that player 1 can obtain in the absence of disclosure).

If Condition (4) is violated, disclosing information when expected to do so is not sequentially rational for player 1. In particular, when $w_1\hat{\delta} \leq q\sigma_2$, because, for any intensity ρ^* of information gathering and any probability $d^* > 0$ by which player 1 discloses, $q'(\rho^*, d^*) > q$, there is no equilibrium in which player 1 discloses information with positive probability after learning that the state is $\widehat{\omega}$. If, instead,

$$q\sigma_2 < w_1\hat{\delta} < q'(\rho^*, 1)\sigma_2,$$

then, while disclosing with certainty cannot be part of an equilibrium, disclosing with probability $d^* \in (0, 1)$, with the latter appropriately defined, can be consistent with player 1's rationality. In fact, using again Condition (2), we have that, when player 2 expects player 1 do disclose with probability d^*, player 1 is indifferent between disclosing and not disclosing if and only if $q'(\rho^*, d^*)\sigma_2 = w_1\hat{\delta}$, which implies that d^* must be equal to the unique solution to[9]

$$\frac{q}{1 - (1 - q)\rho^* d^*} = \frac{w_1\hat{\delta}}{\sigma_2}. \tag{5}$$

We summarize these observations in the following lemma:

Lemma 1. ***[incentive to disclose prior to contracting]*** *Suppose that the intensity of player 1's information gathering is fixed at $\rho = \rho^*$. In the voluntary disclosure game, player 1's disclosure behavior is unique.*

1. *Player 1 discloses with certainty if $w_1\hat{\delta} > q'(\rho^*, 1)\sigma_2$;*

2. *Player 1 does not disclose if $w_1\hat{\delta} \leq q\sigma_2$;*

3. *Player 1 randomizes between disclosing and not disclosing if $q\sigma_2 < w_1\hat{\delta} \leq q'(\rho^*, 1)\sigma_2$. In this case, the probability d^* with which player 1 discloses is given by the unique solution to (5).*

The following examples illustrate.

- *Full bargaining power.*

In some applications, the informed player has full bargaining power so that $w_1 = 1$. Condition (4) then simplifies to

$$\hat{\delta} \geq q'(\rho^*, 1)\big[U_2 - (\widehat{U}_2 - \hat{\delta}_2)\big].$$

[9] In this case, the ex-ante expected deadweight loss is equal to

$$DWL \equiv \widehat{q}(1 - \rho^* d^*)\hat{\delta} = q\Big[\frac{\sigma_2}{w_1\hat{\delta}} - 1\Big]\hat{\delta}.$$

The left-hand side is the total deadweight loss from not changing the design when it is optimal to do so, whereas the right-hand side is the surplus that 1 can extract from 2 because of the latter's incorrect beliefs. In turn, this is equal to the extra utility $U_2 - (\widehat{U}_2 - \hat{\delta}_2)$ that 2 expects to derive from the state being ω instead of $\widehat{\omega}$, scaled by the probability $q'(\rho^*, 1)$ that 2 assigns to the state being ω when 1 is expected to disclose with certainty. In other words, the left-hand side is the efficiency gain from taking the correct action in state $\widehat{\omega}$ whereas the right-hand side is the speculative gain from taking advantage of the opponent's misperception of the state.

- *Symmetric buyer-seller game.*

In Example 1, $\sigma_2 = w_2(B - b)$. In the absence of renegotiation (i.e., when the adjustment costs α are high), Condition (4) boils down to $w_1 \geq q'(\rho^*, 1)w_1$. Hence, player 1 always discloses, no matter her bargaining power (i.e., the weight w_1). In the presence of renegotiation, instead, player 1 (the seller) discloses only if the deadweight loss (equal to the adjustment cost α) is large enough: $\alpha \geq q'(\rho^*, 1)(B - b)$.

- *Shrouded attributes and ex-post distortions due to private information.*

In this example, the seller opts for shrouded attributes (that is, does not disclose the need for the add-on when the latter is needed) if $w_1\hat{\delta} \leq q\sigma_2$, which is equivalent to

$$\int_{\hat{c}}^{r^m} (\mathrm{v} - \hat{c})dF(\mathrm{v}) \leq q\Big[\int_0^{r^m} \mathrm{v}dF(\mathrm{v}) + \big[1 - F(r^m)\big]r^m\Big]. \tag{6}$$

As explained above, the left-hand side of (6) is the deadweight loss associated with non-disclosure and the concomitant monopoly pricing; this loss is entirely borne by the seller who, in this example, has full bargaining power as a price setter. The right-hand side is the product of the posterior probability of the state being the one in which the add-on is not necessary (which is equal to the prior probability in a no-disclosure equilibrium) and the buyer's loss of utility when the add-on is needed (i.e., when the state is $\widehat{\omega}$ instead of ω).

3.2 Information gathering

We now turn to player 1's information-gathering. Let $t_1(\rho^*, d^*)$ be the transfer that player 1 obtains in the absence of any disclosure when she is expected to acquire information with intensity ρ^* and disclose with probability d^*. Using Condition (2), we have that

$$t_1(\rho^*, d^*) = w_1 U - U_1 + \hat{q}'(\rho^*, d^*)\sigma_1, \tag{7}$$

where $\hat{q}'(\rho^*, d^*) \equiv 1 - q'(\rho^*, d^*)$.

First consider equilibria in which player 1 does not acquire information, i.e., $\rho^* = 0$. Because $C'(0) = 0$, such equilibria exist if and only if there is no net gain from disclosure: $w_1\hat{\delta} \leq q\sigma_2$ (see Lemma 1).

Next consider the more interesting case in which, in equilibrium, player 1 acquires information with intensity $\rho^* > 0$ and discloses with certainty upon learning that the state is $\widehat{\omega}$. Note that the situation in part 3 of Lemma 1 in which player 1 discloses with probability $d^* \in (0,1)$ can exist only when information is exogenous: As explained above, player 1 puts zero effort in acquiring information if the latter is costly and if it is weakly optimal ex-post not to disclose.

Let $V_1(\rho, \rho^*)$ denote player 1's gross payoff when she acquires information with intensity ρ and is expected to acquire it with intensity ρ^* and disclose with certainty in case she finds that the state is $\hat{\omega}$. Using Lemma 1, for player 1 to strictly prefer to disclose after learning that the state is $\hat{\omega}$, it must be that $w_1\hat{\delta} > q'(\rho^*, 1)\sigma_2$. Clearly, the same condition also implies that player 1 strictly prefers to disclose when her investment in information acquisition is ρ (recall that information gathering is covert). Hence, when $w_1\hat{\delta} > q'(\rho^*, 1)\sigma_2$,

$$V_1(\rho, \rho^*) = \hat{q}\Big[\rho w_1 \widehat{U} + (1-\rho)\big(\hat{U}_1 - \hat{\delta}_1 + t_1(\rho^*, 1)\big)\Big] + q\big[U_1 + t_1(\rho^*, 1)\big]. \tag{8}$$

For ρ^* to be selected in equilibrium, it must be that

$$\rho^* \in \arg\max_{\rho \in [0,1]} \{V_1(\rho, \rho^*) - C(\rho)\}$$

and hence ρ^* must satisfy the first-order-condition

$$C'(\rho^*) = \hat{q}\Big[w_1\widehat{U} - \big(\widehat{U}_1 - \hat{\delta}_1 + t_1(\rho^*, 1)\big)\Big].$$

Equivalently, using the formula for $t_1(\rho^*, 1)$ in (7) and the fact that $\sigma_1 = -\sigma_2$, we have that ρ^* must satisfy

$$C'(\rho^*) = \hat{q}\Big[w_1\hat{\delta} - q'(\rho^*, 1)\sigma_2\Big]. \tag{9}$$

As explained above, the right-hand side of Condition (9) is the benefit of disclosing information, net of its opportunity cost. Consistently with the result in Lemma 1, Condition (9) admits a solution $\rho^* > 0$ if and only if $w_1\hat{\delta} > q\sigma_2$, as $q'(\rho^*, 1)$ is increasing in ρ^* and is such that $q'(0,1) = q$. Furthermore, in this case, ρ^* is unique if $\sigma_2 \geq 0$, as $q'(\rho^*, 1)$ is strictly increasing in ρ^*.

Comparing the equilibrium intensity of information gathering to its efficient counterpart, we have that player 1 over-invests in information gathering if the private benefit of acquiring information (the right-hand side of (9)) exceeds the social benefit. $\widehat{q}\hat{\delta}$. This happens if and only if player 1 is heavily exposed to the unconventional, in the sense that

$$q'(\rho^*, 1)\sigma_1 > w_2\hat{\delta}. \tag{10}$$

Proposition 1. ***[over-investment in information gathering]*** *Player* 1 *over-invests in information acquisition (relative to what is socially efficient) only if she is relatively more exposed to the unconventional, that is, only if* $\sigma_1 > 0$.

Next, we turn to expectation conformity, which we define as follows. Consider two investment levels ρ and ρ'. We say that expectation conformity holds if player 1 has more incentives to choose ρ' than ρ when expected to do so.[10] That is, expectation conformity holds if and only if

$$\Gamma_1^{EC}(\rho,\rho') \quad \equiv \quad \left[V_1(\rho',\rho') - V_1(\rho,\rho')\right] - \left[V_1(\rho',\rho) - V_1(\rho,\rho)\right] > 0.$$

Now suppose that player 1 finds it optimal to disclose both when she is expected to choose ρ and when she is expected to choose ρ' (recall that there is no point for 1 to acquire information if she then conceals it). Simple computations then reveal that

$$\Gamma_1^{EC}(\rho,\rho') = q\hat{q}(\rho' - \rho)\left[\frac{1}{1-\hat{q}\rho'} - \frac{1}{1-\hat{q}\rho}\right]\sigma_1.$$

Thus expectation conformity holds if and only if player 1 is relatively more exposed to the unexpected, i.e. $\sigma_1 \geq 0$. In this case, the higher the investment in information acquisition expected from her, the lower the probability of state $\hat{\omega}$ in the absence of disclosure and so the less favorable is the bargaining outcome to player 1 whenever she does not disclose any information.[11] This raises player 1's incentives to acquire information.

Finally, note that the exposure to the unconventional is also the key to the existence of multiple equilibria and to the possibility that player 1 is better off in a low information-intensity equilibrium. To see this, first note that, when $\Gamma_1^{EC} < 0$, i.e., when $\sigma_1 < 0$, the equilibrium effort is unique.[12] Next, observe that, when $\Gamma_1^{EC} > 0$, i.e., when $\sigma_1 > 0$, for any pair (ρ,ρ'), one can construct cost functions such that both ρ and ρ' are equilibrium levels. Finally, observe that, when multiple equilibria are possible (which is the case only if $\sigma_1 > 0$), player 1 is better off in the low-effort equilibrium:

$$\frac{dV_1(\rho^*,\rho^*)}{d\rho^*} \overset{sgn}{=} \frac{dt_1(\rho^*)}{d\rho^*} \overset{sgn}{=} -\sigma_1.$$

Summarizing, we have the following result:

Lemma 2. ***[equilibrium investment in information acquisition]***
(i) Investment $\rho^* > 0$ in information acquisition can be sustained in equilibrium if and only if it satisfies Condition (9).[13]
(ii) In any equilibrium in which $\rho^* > 0$, disclosure occurs with certainty.
(iii) If and only if player 1 is relatively more exposed to the unconventional (i.e.,$\sigma_1 > 0$), then player 2's anticipation of more investment in information acquisition by player 1 increases player 1's value to acquire more information (expectation conformity), thus generating the possibility of multiple equilibria.
(iv) In case of multiple equilibria, player 1 is better off in a low information-intense equilibrium.

[10]See Pavan and Tirole (2022) for a more general analysis of expectation conformity in strategic cognition.

[11]Use (7) to verify that, when $\sigma_1 > 0$, in case of no disclosure, the transfer $t_1(\rho^*, 1)$ to player 1 is decreasing in the intensity ρ^* of information acquisition expected from 1 by player 2.

[12]As anticipated above, when $\sigma_1 < 0$ (equivalently, when $\sigma_2 > 0$, meaning that player 2 is relatively more exposed), Condition (9) has a unique solution.

[13]Note that, given ρ^*, the function $V_1(\rho,\rho^*) - C(\rho)$ is globally concave in ρ.

4 Strategic delay and mandatory disclosure

So far, we have assumed that the party acquiring information either discloses it before contracting or does not disclose it at all. As a result, in the absence of intent of pre-contractual disclosure, the party does not acquire any information. This property no longer holds if the information can be withheld and disclosed at some stage between the contracting date and the date at which the state is publicly revealed. In this section, we first consider an environment in which there is no penalty for withholding information other than the deadweight loss of embarking on the wrong contract design. We then compare the equilibrium outcomes of such an environment with those in one in which delayed disclosure is interpreted as speculative, and hence forbidden (mandatory early disclosure). The comparison permits us to identify the merits and limitations of mandatory disclosure laws.

4.1 Voluntary (early vs late) disclosure

We modify the course of events in Figure 2 by allowing for interim renegotiation at stage (5).[14] If the state of nature is $\widehat{\omega}$ and action a specified in the contract is renegotiated into $\widehat{a}$ at stage (5), the total deadweight loss is only $\beta\hat{\delta}$, where $\beta \in [0, 1]$: Some useless investments can be avoided if the contract is renegotiated early, while others are sunk. We do not need to specify whose investments are sunk by stage (5) because, as we show below, only the total deadweight loss $\beta\hat{\delta} = \beta_1\hat{\delta}_1 + \beta_2\hat{\delta}_2$ plays a role in the analysis.

The possibility of interim renegotiation raises the informed party's incentive to conceal information at the contracting stage after learning that the state is $\widehat{\omega}$; by concealing, player 1 is can take advantage of the mis-pricing at stage (4) when player 2 is relatively more exposed (i.e., $\sigma_2 > 0$) while expecting a more limited deadweight loss thanks to the earlier renegotiation.

To make things more interesting (but also to set the stage for the analysis of mandatory disclosure in the next subsection), we also allow party 1 to receive exogenous information at stage (5): when the state is $\widehat{\omega}$, player 1 learns it at stage (5) with probability μ, if she has not learnt it earlier.[15] Namely, we assume that, when the state is $\widehat{\omega}$, player 1 receives information proving that the state is $\widehat{\omega}$ at stage (2) with probability ρ and at stage (5) with probability μ, with $\rho \in [0, 1 - \mu]$. The cost of learning the state at stage (2) is given by a function C satisfying the same properties introduced above, with the exception that now $\lim_{\rho \to 1-\mu} C'(\rho) = +\infty$. hence, when the state is $\widehat{\omega}$ player 1 learns the state with total probability $\rho + \mu$.[16] As we show below, the possibility of receiving fortuitous information

[14] Such interim renegotiation is not to be confused with the ex-post renegotiation. The latter occurs after the state is publicly revealed (the case considered in the examples of Subsection 2.2).

[15] In a multi-period extension, one would expect the probability of receiving information, μ, and the remaining deadweight loss, β, to be positively correlated: As time elapses, more information is acquired and more investments are sunk, thus making the deadweight loss larger.

[16] Alternatively, one can assume independence between the two events, with the total probability of learning the state equal to $\rho + (1 - \rho)\mu$, or various other forms of positive or negative correlation between the two events, without any significant change in the qualitative results. One can also assume that the stage-(5) information acquisition, which here

after signing the initial contract plays a role in determining the structure of the optimal regulation. We represent the changes in the environment introduced above in Figure 7, which describes only the contractual/post-contractual events (the pre-contractual ones are the same as in the previous sections).

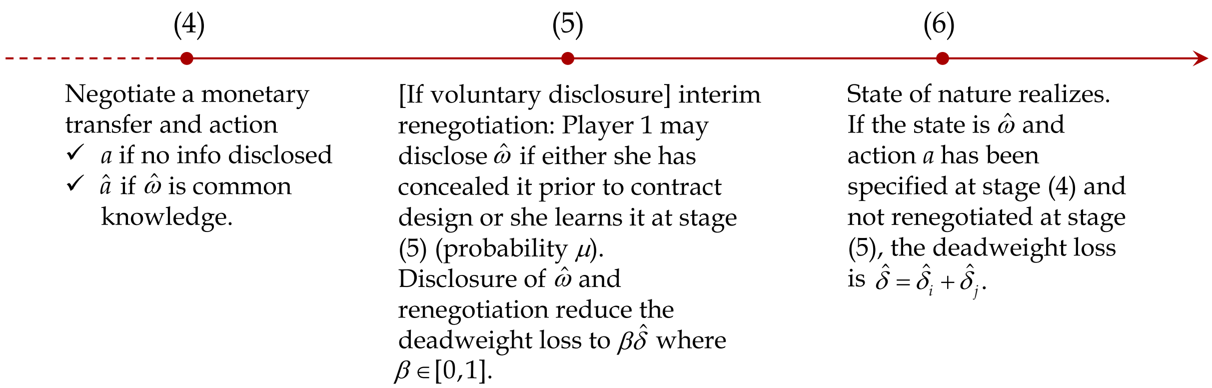

Figure 7: **Interim renegotiation**

Suppose that party 1 is expected to invest ρ^* in information acquisition and disclose with probability d^* at stage (3). When, at stage (2), party 1 learns that the state is $\widehat{\omega}$ but does not disclose this information till stage (5), she receives a payoff equal to

$$\left(\widehat{U}_1 - \hat{\delta}_1\right) + t_1 + w_1(1-\beta)\hat{\delta},$$

where $t_1 = t_1(\rho^*, d^*)$ now solves

$$\begin{aligned} t_1 + q'(\rho^*, d^*)U_1 + \widehat{q}'(\rho^*, d^*)\left[\widehat{U}_1 - \hat{\delta}_1 + \frac{\mu + \rho^*(1-d^*)}{1-\rho^* d^*} w_1(1-\beta)\hat{\delta}\right] \\ = w_1 \left\{ q'(\rho^*, d^*)U + \widehat{q}'(\rho^*, d^*)\left[(\widehat{U} - \hat{\delta}) + \frac{\mu + \rho^*(1-d^*)}{1-\rho^* d^*}(1-\beta)\hat{\delta}\right] \right\}, \end{aligned} \tag{11}$$

with $q'(\rho^*, d^*) = 1 - \widehat{q}'(\rho^*, d^*)$ defined as in the previous section. One can verify that the transfer t_1 that solves (11) is the same as the one in the previous section (the one given by (2) or, equivalently, by (7)). The condition for player 1 to disclose for sure at stage (3) ($d^* = 1$) then becomes

$$w_1\widehat{U} \geq \widehat{U}_1 - \hat{\delta}_1 + t_1 + w_1(1-\beta)\hat{\delta},$$

which, after substituting for $t_1 = t_1(\rho^*, 1)$, we can rewrite as

$$w_1\beta\hat{\delta} \geq q'(\rho^*, 1)\sigma_2, \tag{12}$$

where, as earlier, $\sigma_2 \equiv U_2 - (\widehat{U}_2 - \hat{\delta}_2) - w_2[U - (\widehat{U} - \hat{\delta})]$ denotes player 2's relative exposure to the unconventional.

is assumed to be exogenous, is partially endogenous and covert, again without any significant effect on the insights.

Player 1's equilibrium investment in information gathering, ρ^*, when the latter is strictly positive and player 1 discloses with certainty at stage (3), then continues to be given by the solution to the following optimality condition[17]

$$C'(\rho^*) = \widehat{q}[w_1\hat{\delta} - q'(\rho^*, 1)\sigma_2]. \tag{13}$$

In the special case in which renegotiation at stage (5) is costless, in the sense that it permits the players to avoid all deadweight losses due to the early inappropriate contract design (i.e., $\beta = 0$, meaning that no initial investments in contract design are sunk), it is optimal for player 1 to disclose prior to contracting if and only if she is relatively more exposed to the unconventional (i.e., if and only if $\sigma_1 \geq 0$). In this case, the specification of the contractual terms is just a zero-sum game. More generally, we have the following result:

Lemma 3. *[**early vs delayed disclosure**] Assume that the information-acquiring player can disclose early (i.e., at stage (3), prior to signing the contract) or late (at stage (5) after signing the contract but before the state is publicly revealed). Let $\rho^{ND}(\beta)$ and ρ^D solve $C'(\rho^{ND}) = \widehat{q}w_1(1-\beta)\hat{\delta}$ and $C'(\rho^D) = \widehat{q}[w_1\hat{\delta} - q'(\rho^D, 1)\sigma_2]$, respectively.*[18] *There exist thresholds $\beta^*, \beta^{**} \in [0, 1]$, with $\beta^* \leq \beta^{**}$, such that the following are true:*

1. *when $\beta \leq \beta^*$, the equilibrium intensity of information gathering is $\rho^* = \rho^{ND}(\beta)$, and disclosure at stage (3) occurs with probability zero;*

2. *when $\beta^* < \beta < \beta^{**}$, the equilibrium intensity of information gathering is $\rho^* = \rho^{ND}(\beta)$ and disclosure at stage (3) occurs with probability $d^*(\beta) \in (0, 1)$ given by the unique solution to $q\sigma_2/[1 - (1 - q)\rho^{ND}(\beta)d^*] = w_1\beta\hat{\delta}$;*

3. *when $\beta \geq \beta^{**}$, the equilibrium intensity of information gathering is $\rho^* = \rho^D$ and disclosure at stage (3) occurs with certainty.*[19]

Proof of Lemma 3. From the discussion preceding the proposition, we have that, when $w_1\beta\hat{\delta} \leq q\sigma_2$, player 1 never discloses at stage (3). That, in this case, the equilibrium investment in information gathering is given by $\rho^{ND}(\beta)$ follows from the fact that the benefit of information acquisition comes from the possibility to disclose at stage (5), thus reducing the deadweight loss from $\hat{\delta}$ to $\beta\hat{\delta}$ (the marginal benefit of information acquisition is thus equal to $\widehat{q}w_1(1 - \beta)\hat{\delta}$).

[17] The reason why the condition for the equilibrium value of ρ^* is unaffected by the possibility of a late disclosure is that the increase in the probability of finding information at stage (3) comes with a reduction in the probability of not finding any information at all (the probability μ of receiving information exogenously at stage (5) is fixed). Note also that, for a given d^*,

$$\begin{aligned} V(\rho, \rho^*) = \quad & q[U_1 + t_1(\rho^*, d^*)] + \widehat{q}\big[(1 - \mu - \rho)[\widehat{U}_1 - \hat{\delta}_1 + t_1(\rho^*, d^*)] \\ & + \rho d^* w_1 \widehat{U} + [\mu + \rho(1 - d^*)][\widehat{U}_1 - \hat{\delta}_1 + t_1(\rho^*, d^*) + w_1(1 - \beta)\hat{\delta}]\big]. \end{aligned}$$

[18] The assumption that $\lim_{\rho \to 1-\mu} C'(\rho) = +\infty$ implies that $\rho^{ND}(\beta), \rho^D < 1 - \mu$ for all $\beta \in [0, 1]$.

[19] As discussed above, equation $C'(\rho^D) = \widehat{q}[w_1\hat{\delta} - q'(\rho^D, 1)\sigma_2]$ can have multiple solutions only when $\sigma_2 < 0$. In this case, $\beta^* = \beta^{**} = 0$ as shown in the proof of the proposition.

When, instead, $w_1\beta\hat{\delta} > q\sigma_2$, disclosure at stage (3) occurs with positive probability in any equilibrium. In particular, when $q\sigma_2 < w_1\beta\hat{\delta} < q'(\rho^{ND}(\beta), 1)\sigma_2$, which requires that player 2 is relatively more exposed (i.e., $\sigma_2 > 0$), in the unique equilibrium, player 1 invests $\rho^{ND}(\beta)$ and then discloses with probability $d^*(\beta) \in (0, 1)$ given by the unique solution to $q\sigma_2/[1 - (1 - q)\rho^{ND}(\beta)d] = w_1\beta\hat{\delta}$. To see why this is the case, note that, when $\rho = \rho^{ND}(\beta)$, if player 1 were expected to disclose with certainty, the net benefit of disclosing at stage (3) would be equal to $w_1\beta\hat{\delta} - q'(\rho^{ND}(\beta), 1)\sigma_2 < 0$, whereas, if she were expected to disclose with probability zero, the net benefit of disclosing at stage (3) would be equal to $w_1\beta\hat{\delta} - q\sigma_2 > 0$, implying that, in either case, player 1 would have a profitable deviation. Hence, when $q\sigma_2 < w_1\beta\hat{\delta} < q'(\rho^{ND}(\beta), 1)\sigma_2$, in any equilibrium in which $\rho^* = \rho^{ND}(\beta)$, the equilibrium probability of disclosure, $d^*(\beta)$, is given by the unique solution to $w_1\beta\hat{\delta} - q'(\rho^{ND}(\beta), d^*)\sigma_2 = 0$. Note that the last condition implies that, when player 2 expects player 1 to invest $\rho^{ND}(\beta)$ in information gathering and disclose with probability $d^*(\beta)$, player 1 is indifferent between disclosing and not disclosing at stage (3). Also note that, because $\rho^{ND}(\beta)$ is decreasing in β, $d^*(\beta)$ is increasing in β.

To see that, when $q\sigma_2 < w_1\beta\hat{\delta} < q'(\rho^{ND}(\beta), 1)\sigma_2$, there exists no equilibrium in which ρ is different from $\rho^{ND}(\beta)$, first recall that, because $q\sigma_2 < w_1\beta\hat{\delta}$, in any equilibrium, disclosure at stage (3) must occur with positive probability. Next, observe that, in any equilibrium in which player 1 discloses at stage (3) with probability less than 1, player 1 must be indifferent between disclosing and concealing at stage (3), implying that the marginal benefit from information acquisition is equal to $\widehat{q}w_1(1 - \beta)\hat{\delta}$.[20] Because player 1's net payoff is strictly concave in ρ, player 1's investment in information gathering must necessarily be equal to $\rho^{ND}(\beta)$. Finally, observe that there exists no equilibrium in which disclosure occurs with certainty. To see this, note that, if such an equilibrium existed, then player 1's equilibrium investment in information gathering ρ^D would have to solve $C'(\rho^D) = \widehat{q}[w_1\hat{\delta} - q'(\rho^D, 1)\sigma_2]$, with $q'(\rho^D, 1)\sigma_2 \leq w_1\beta\hat{\delta}$. Because $q'(\rho, 1)$ is increasing in ρ, and because $w_1\beta\hat{\delta} < q'(\rho^{ND}(\beta), 1)\sigma_2$, it must be that $\rho^D < \rho^{ND}(\beta)$. However, the definitions of ρ^D and $\rho^{ND}(\beta)$ imply that

$$C'(\rho^D) = \widehat{q}[w_1\hat{\delta} - q'(\rho^D, 1)\sigma_2] \geq \widehat{q}[w_1\hat{\delta} - w_1\beta\hat{\delta}] = C'(\rho^{ND}(\beta)),$$

which is inconsistent with $\rho^D < \rho^{ND}(\beta)$. Hence, when $q\sigma_2 < w_1\beta\hat{\delta} < q'(\rho^{ND}(\beta), 1)\sigma_2$, in equilibrium, disclosure at stage (3) occurs with probability less than 1.

Lastly, suppose that $w_1\beta\hat{\delta} \geq q'(\rho^{ND}(\beta), 1)\sigma_2$. Then the arguments above imply that, in equilibrium, $\rho^* = \rho^D$ and disclosure occurs with certainty at stage (3).

The lemma follows from the arguments above by observing that, when $\sigma_2 \leq 0$, $\beta^* = \beta^{**} = 0$. When, instead, $\sigma_2 > 0$, β^* is given by the unique solution to $w_1\beta^*\hat{\delta} = q\sigma_2$, whereas $\beta^{**} \geq \beta^*$ is given by the unique solution to

$$w_1\beta^{**}\hat{\delta} = q'\left(\rho^{ND}(\beta^{**}), 1\right)\sigma_2.$$

[20] Note that this is the marginal benefit in case player 1 conceals at stage (3).

Note that, for $\beta = \beta^{**}$, $\rho^{ND}(\beta^{**}) = \rho^D$. That $\rho^{ND}(\beta)$ is strictly decreasing in β then implies that, for $0 \leq \beta < \beta^{**}$, $\rho^{ND}(\beta) > \rho^D$. Q.E.D.

4.2 Mandatory (early) disclosure

Equipped with the above results, we are now in a position to investigate the welfare effects of mandatory disclosure laws, by which we mean policies that severely punish any late disclosure. We assume that the court is unable to determine whether information disclosed at stage (5) was received at stage (5) or it was received at stage (2) and disclosed only at stage (5) for strategic/opportunistic reasons. Disclosures at stage (5) are severely punished, no matter when the information was received. Hence, under mandatory disclosure laws, player 1 either discloses at stage (3) or never.

Note that mandatory disclosure is irrelevant in the absence of interim renegotiation (that is, when delayed disclosure at stage (5) is either not feasible or not useful to reduce the welfare losses). This is because, as stated in Lemma 2, in that case, in equilibrium, player 1 either acquires no information or discloses it with certainty at stage (3) prior to contracting. Things are different when interim renegotiation is possible. As shown in Lemma 3 above, in this case, player 1, in the absence of any legislation prohibiting late disclosure, may find it optimal to acquire information with the intent of concealing it till stage (5). Mandatory disclosure laws then have a bite, as they affect both the incentives for player 1 to disclose information at stage (3) and the incentives to acquire information in the first place. Our next result summarizes the welfare implications of mandatory disclosure. Let ρ^M and d^M denote the equilibrium investment in information acquisition and the probability of disclosure under mandatory disclosure laws.

Proposition 2. *[**mandatory disclosure**] Under mandatory disclosure, if $w_1\hat{\delta} \leq q\sigma_2$, then $\rho^M = d^M = 0$, whereas, if $w_1\hat{\delta} > q\sigma_2$, then $\rho^M = \rho^D$ and $d^M = 1$, with ρ^D satisfying $C'(\rho^D) = \widehat{q}[w_1\hat{\delta} - q'(\rho^D, 1)\sigma_2]$. If the equilibrium in the laissez-faire economy involves early disclosure at stage (3) with probability less than one (i.e., if the welfare losses due to inefficient design are small, namely if $\beta < \beta^{**}$, where β^{**} is the threshold in Lemma 3), then under mandatory disclosure, the investment in information acquisition is reduced.[21] There exists a critical threshold μ^* on the probability of receiving information exogenously at stage (5) such that, for all $\mu \geq \mu^*$, mandatory disclosure reduces welfare. Similarly, when the fraction β of the deadweight losses that cannot be recouped via early renegotiation is either small or close to (but smaller than) β^{**}, mandatory disclosure is welfare reducing.*

Proof of Proposition 2. When disclosure is mandatory, the equilibrium investment in information acquisition is the same as in the game of Section 3 in which interim disclosure (i.e., at stage (5), after the contract is signed but before the state is publicly revealed) is not feasible. This means that $\rho^M = 0$ if $w_1\hat{\delta} \leq q\sigma_2$ and $\rho^M = \rho^D$, with ρ^D satisfying $C'(\rho^D) = \widehat{q}[w_1\hat{\delta} - q'(\rho^D, 1)\sigma_2]$ if $w_1\hat{\delta} > q\sigma_2$, as shown in Lemma 2. Because, when $\beta < \beta^{**}$, $\rho^M < \rho^{ND}(\beta)$, we have that, in this case, mandatory

[21] Note that $\beta^{**} > 0$ only when $\sigma_2 > 0$, in which case ρ^D is unique.

disclosure reduces the investment in information acquisition. The net benefit of mandatory disclosure on welfare (when it has bite, i.e., when $\beta < \beta^{**}$) is the difference ΔW between the welfare deadweight loss under voluntary disclosure and the welfare deadweight loss under mandatory disclosure:

$$\begin{aligned}\Delta W(\beta,\mu) &= \widehat{q}\hat{\delta}\big[\left(1-\rho^{ND}(\beta)-\mu\right)+\mu\beta+\rho^{ND}(\beta)\left(1-d^{*}(\beta)\right)\beta-\left(1-\rho^{M}\right)\big]\\ &= \widehat{q}\hat{\delta}[\rho^{ND}(\beta)\left(1-d^{*}(\beta)\right)\beta-(\rho^{ND}(\beta)-\rho^{M})-(1-\beta)\mu]. \qquad (14)\end{aligned}$$

The benefit of mandatory disclosure is to avoid the deadweight loss $\beta\hat{\delta}$ from delay when, under voluntary disclosure, early disclosure happens with probability $d^{*}(\beta) < 1$, where $d^{*}(\beta)$ is the value in part 2 of Lemma 3.

Mandatory disclosure, however, has two costs. The first one is that it reduces the investment in information acquisition from $\rho^{ND}(\beta)$ to $\rho^{M} < \rho^{ND}(\beta)$. The second one is that it deters player 1 from disclosing information that is received exogenously, post-contract, at stage (5) with probability μ.[22]

Because $\Delta W(\beta,\mu)$ is decreasing in μ, there exists μ^{*} such that, for all $\mu \geq \mu^{*}$, $\Delta W(\beta,\mu) < 0$.[23] It is also easy to see that, when $\beta = 0$, $\Delta W(\beta,\mu) = -\widehat{q}\hat{\delta}[\rho^{ND}(0)-\rho^{M}+\mu] < 0$. In this case, interim renegotiation entails no deadweight loss and mandatory disclosure reduces welfare by disincentivizing information acquisition (it also makes player 1 conceal information received exogenously after signing the contract, but, as we argued earlier, μ is likely to be close to 0 if β is). By continuity of $\Delta W(\beta,\mu)$ in β, mandatory disclosure reduces welfare for β strictly positive but small. Lastly, observe that, when $\beta = \beta^{**}$, $d^{*}(\beta) = 1$, in which case $\Delta W(\beta,\mu) < 0$. By continuity, $\Delta W(\beta,\mu) < 0$ also for β strictly below β^{**} but close to β^{**}. Q.E.D.

Figure 8 summarizes the analysis in Lemma 3 and Proposition 2 for the case in which $0 < \sigma_2 < w_1\hat{\delta}/q$. Note that this case is the most interesting one. When $\sigma_2 \leq 0$, there is always disclosure, whether mandated or not (i.e., $\beta^{*} = \beta^{**} = 0$) and hence mandatory disclosure has no bite. When, instead, $\sigma_2 \geq w_1\hat{\delta}/q$, then a fortiori $\sigma_2 \geq w_1\beta\hat{\delta}/q$ and, hence, when disclosure is voluntary, there is no disclosure at stage (3) ($\beta^{*} = \beta^{**} = 1$). Furthermore, in this case, there is no information acquisition under mandatory disclosure ($\rho^{M} = 0$) in which case mandatory disclosure is clearly welfare-reducing as it discourages player 1 from disclosing information received exogenously at stage (5).

The corollary below summarizes the implications of the above results for the debate in law and economics about the merits of mandatory disclosure and the structure of the optimal disclosure regime. To relate the results to the policy debate, we amend our maintained assumption about the cost of information acquisition as follows: there exists $\rho^{ex} \in [0,1)$ such that $C(\rho) = 0$ for all $\rho \leq \rho^{ex}$,

[22] Recall that the court is unable to distinguish between information disclosed at stage (5) that is received at stage (5) and information disclosed at stage (5) that is received at stage (3) and concealed for strategic reasons. As a result, under mandatory disclosure, any late disclosure at stage (5) is punished by the court, no matter when the information was received, in which case player 1 never discloses at stage (5), i.e., post contract.

[23] Recall that, because $\lim_{\rho\to 1-\mu} C'(\rho) = +\infty$, $\rho^{M}, \rho^{ND}(\beta) \leq 1-\mu$.

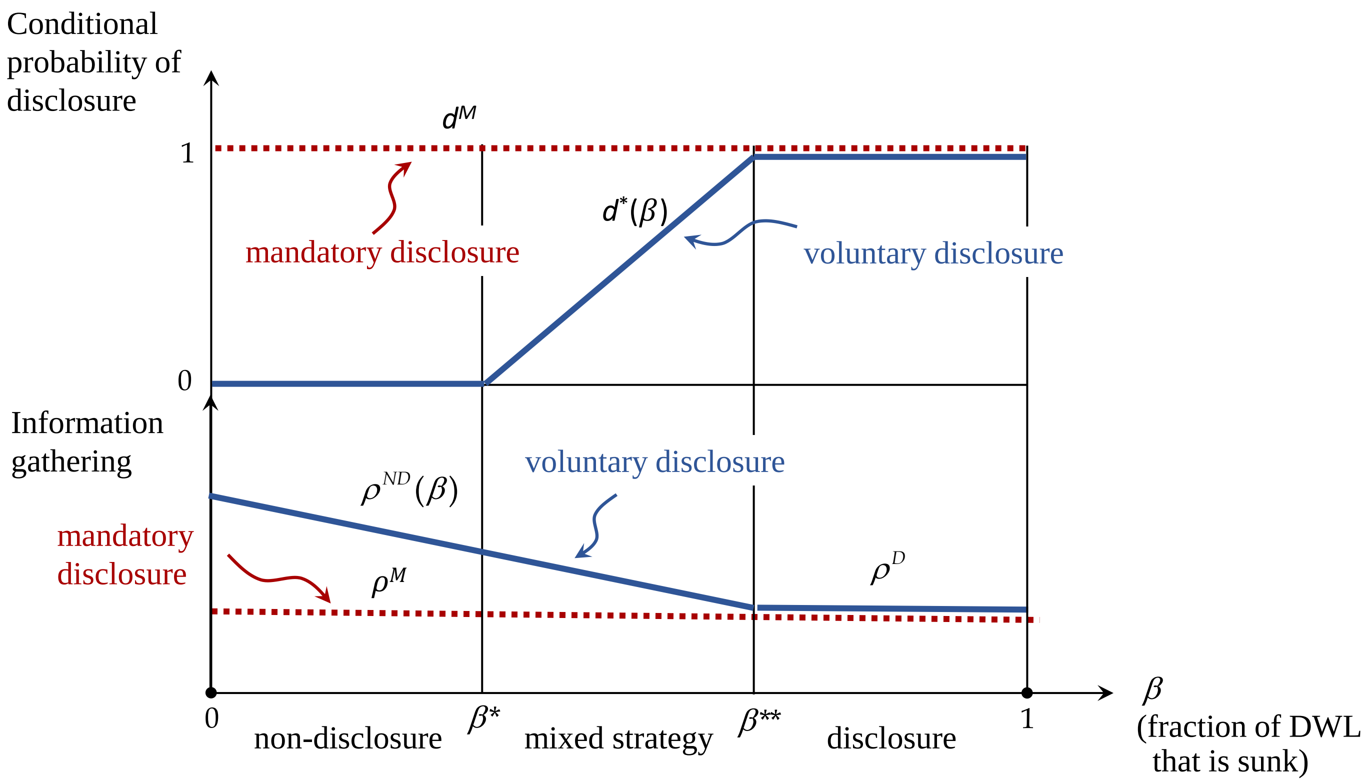

Figure 8: **Voluntary vs mandatory disclosure (for** $0 < \sigma_j < w_i\hat{\delta}/q$**)**

$C'(\rho), C''(\rho) > 0$ for all $\rho > \rho^{ex}$, $C'(\rho^{ex}) = 0$, and $\lim_{\rho\to 1-\mu} C'(1-\mu) = +\infty$ (the baseline model is nested with $\rho^{ex} = 0$). The idea is that player 1 may be able to collect some information for free prior to contracting. We then have the following result (the proof follows from inspection of the formula for ΔW in (14)):

Corollary 1. *[**optimal disclosure law**] The optimal disclosure law is:*

- ***mandatory disclosure** when the arrival of pre-contractual information is frequent (ρ^{ex} large), the arrival of post-contractual information is rare (μ small), and the deadweight losses due to improper design are intermediate (the fraction β of the welfare losses that cannot be recouped at the interim renegotiation stage is close to β^*);*

- ***voluntary disclosure** when the arrival of exogenous pre-contractual information is rare (ρ^{ex} small), the arrival of post-contractual information is frequent (μ large), and the deadweight losses due to improper design are either small or large (the fraction β of the welfare losses that cannot be recouped at the interim renegotiation stage is either close to zero or to β^{**}).*

The corollary formalizes Kronman (1978)'s and Eisenberg (2003)'s informal argument that mandatory-disclosure laws must distinguish between the cases of information casually acquired prior to contracting and information that results from deliberate search (which, according to Kronman (1978), must benefit from a legal no-disclosure privilege, in effect a property right). When player 2 is relatively more exposed to the unconventional (i.e., $\sigma_2 > 0$) in which case mandatory disclosure has bite, mandatory disclosure reduces the incentive of player 1 to acquire information. It may also make player 1 conceal information received exogenously post contracting.

It would seem reasonable to protect particularly exposed parties (those for whom $\sigma_2 > 0$) against concealment of contract-relevant information; that insight is indeed correct when information is exogenous (a person skilled in the art has casually acquired information prior to contracting through the unfolding of past professional relationships), but not if information is endogenous: When σ_2 is large (party 2 is very exposed to the unexpected), the information-acquiring player does not acquire any information under mandatory disclosure, as she has to reveal the bad news prior to contracting. A mandatory disclosure law then de facto mandates disclosure of non-existing information. In contrast, it deters disclosure of information casually acquired after the contract is signed and it prevents the pre-contracting acquisition of useful information that would have occurred in the absence of a disclosure requirement.

5 Broader class of regulatory interventions

In this section, we discuss other regulatory interventions that may help making contracts more efficient. We start by discussing in more detail the policy maker's (i.e., the legislator's) objective function, and the information and instruments available to the court. We assume that the policy maker has no redistributive purposes and only aims at raising the efficiency of the relationship; the policy maker is preoccupied with the investment in information acquisition and the avoidance of deadweight losses, not the monetary transfers paid or received by the parties. In terms of instruments, the court can impose a penalty $p \geq 0$ on party i; the mechanism is balanced in that the penalty is paid to party j.

One can envision alternative information structures for the court, ranked by their fineness:

(a) At the very least, the court observes that the initial contract is renegotiated at stage (5) (in equilibrium, such an event reveals that player 1 has disclosed information proving that the state is $\hat{\omega}$ at that stage), but nothing more. In particular, the court does not know whether the information that gave rise to the renegotiation was received before the initial contract was signed (at stage (2)) or after the initial contract was signed (at stage (5)).

(b) The court can directly observe that party 1 disclosed relevant information at stage (5). However, it cannot determine whether the information disclosed at stage (5) was received at stage (2) or at stage (5). This is the information structure considered when studying mandatory disclosure laws.[24]

[24] In richer settings in which disclosure can occur over an interval of time, the policy maker could also set a deadline between the contracting date and the time at which information becomes public such that the party disclosing information is charged a penalty when disclosing after the contracting date but before the deadline. The optimal choice of such a deadline is then determined by the speed by which the deadweight loss from specifying a wrong design at the

(c) When player 1 conceals information at stage (3), the court receives evidence of this behavior with some strictly positive probability; in this case, p stands for the expected penalty paid by player 1 (nominal penalty times probability of detection) for non-disclosure at stage (3).

Below we consider the role of penalties under each of these information structures.

(a) Suppose that the court can only verify that renegotiation took place (the new contract differs from the initial one). In case renegotiation occurs, player 1 is charged a penalty p that is paid to player 2. Such a penalty is neutral (as in Tirole 1986) because its payment is passed through in the contract renegotiation. To see this, let $t_i^{'}$ denote the transfer received by party $i = 1, 2$ as part of the renegotiation; it is given by $(1-\beta_i)\hat{\delta}_i + t_i^{'} - p = w_i(1-\beta)\hat{\delta}$. Because the penalty is paid only when the two parties agree to renegotiate the initial contract, the negotiated ex-post transfer $t_i^{'}$ offsets one-for-one the penalty, making the latter irrelevant.

(b) Next, suppose that the court can directly observe that player 1 disclosed information at stage (5) that proves that the state is $\hat{\omega}$. It can then force player 1 to pay a penalty $p \geq 0$ to player 2 irrespective of whether renegotiation occurs. As a result, the penalty does not impact the renegotiation process. This implies that player 1's net benefit from disclosing information that is still private at stage (5) is, regardless of the stage of accrual, equal to $w_1(1-\beta)\hat{\delta} - p$. So if $p > w_1(1-\beta)\hat{\delta}$, there is never any disclosure at stage (5). The outcome is then the one under mandatory disclosure in Subsection 4.2. When, instead, $p = 0$, the outcome is the one under the voluntary disclosure regime in Subsection 3.

Clearly, any two levels of the penalty p and p' such that $p, p' > w_1(1-\beta)\hat{\delta}$ are equivalent (both in terms of payoffs and welfare) because they discourage player 1 from disclosing information at stage (5), no matter when it was received. Next, observe that, for any $p \leq w_1(1-\beta)\hat{\delta}$, when player 1 is expected to invest ρ^* in information acquisition, disclose at stage (3) with probability d^*, and disclose with certainty at stage (5) (both the information received and withheld at stage (3) and the one received exogenously at stage (5)), the transfer $t_1(\rho^*, d^*; p)$ that player 1 receives at stage (4) in the absence of any disclosure now solves

$$\begin{aligned} t_1 + q'(\rho^*, d^*)U_1 + \widehat{q}'(\rho^*, d^*)\left[\widehat{U}_1 - \hat{\delta}_1 + \tfrac{\mu+\rho^*(1-d^*)}{1-\rho^* d^*}[w_1(1-\beta)\hat{\delta} - p]\right] \\ = w_1\left\{q'(\rho^*, d^*)U + \widehat{q}'(\rho^*, d^*)\left[(\widehat{U} - \hat{\delta}) + \tfrac{\mu+\rho^*(1-d^*)}{1-\rho^* d^*}(1-\beta)\hat{\delta}\right]\right\}. \end{aligned}$$

That is, relative to the absence of the penalty (i.e., to $p = 0$), the stage-(4) transfer $t_1(\rho^*, d^*; p)$ to player 1 increases by $\widehat{q}'(\rho^*, d^*)\frac{\mu+\rho^*(1-d^*)}{1-\rho^* d^*}p$:

$$t_1(\rho^*, d^*; p) = t_1(\rho^*, d^*; 0) + \widehat{q}'(\rho^*, d^*)\frac{\mu + \rho^*(1-d^*)}{1-\rho^* d^*}p.$$

Player 1 then finds it optimal to disclose at stage (3) only if

$$w_1\widehat{U} \geq \widehat{U}_1 - \hat{\delta}_1 + t_1(\rho^*, d^*; p) + w_1(1-\beta)\hat{\delta} - p,$$

contracting date increases with time, relative to the speed by which exogenous information is expected to arrive after the contracting date.

which, using the expression for $t_1(\rho^*, d^*; p)$ derived above, can be rewritten as

$$w_1\beta\hat{\delta} \geq q'(\rho^*, d^*)\sigma_2 - \left[1 - \widehat{q}'(\rho^*, d^*)\frac{\mu + \rho^*(1-d^*)}{1-\rho^* d^*}\right] p. \tag{15}$$

Holding ρ^* and d^* fixed, we thus have that the net reduction of player 1's payoff due to the penalty, in case she withholds information at stage (3), is equal to

$$\left[1 - \widehat{q}'(\rho^*, d^*)\frac{\mu + \rho^*(1-d^*)}{1-\rho^* d^*}\right] p > 0.$$

Thus, for any $p \leq w_1(1-\beta)\hat{\delta}$, an equilibrium in which player 1 invests ρ^* in information acquisition, discloses with probability $d^* > 0$ at stage (3) and discloses with certainty at stage (5) (no matter when the information available at stage (5) was received) exists if and only if Condition (15) is satisfied (with the condition holding as an equality when $d^* \in (0, 1)$) and

$$C'(\rho^*) = \hat{q}\Big[w_1\hat{\delta} - q'(\rho^*, d^*)\sigma_2 - \widehat{q}'(\rho^*, d^*)\frac{\mu + \rho^*(1-d^*)}{1-\rho^* d^*} p\Big]. \tag{16}$$

Note that, when $d^* \in (0, 1)$, because player 1 is indifferent between disclosing and not disclosing at stage (3), the marginal benefit of information acquisition (the right-hand-side of (16)) is also equal to

$$\hat{q}\Big[w_1(1-\beta)\hat{\delta} - p\Big],$$

which is the benefit in case player 1 does not disclose at stage (3).

The following result then holds:

Proposition 3. *[**penalties when information dissimulation is not detectable**] Suppose that the court can verify whether or not player 1 discloses relevant information at stage (5) but cannot determine whether the information was received at stage (2) before signing the contract or at stage (5), after the contract is signed but before the state is publicly revealed.*

1. Small penalties for late disclosures (formally, $p \leq w_1(1-\beta)\hat{\delta}$) come with the same trade-offs as mandatory-disclosure laws (which are formally equivalent to large penalties $p > w_1(1-\beta)\hat{\delta}$): They increase the incentives for disclosure at stage (3) but reduce the marginal benefits to information acquisition.

2. Under the welfare-maximizing equilibrium, welfare is always higher under a penalty equal to $p = w_1(1-\beta)\hat{\delta}$ than under a mandatory-disclosure law, with the comparison strict when, under a mandatory-disclosure law, there is no information acquisition in equilibrium.

3. When, in the absence of any policy intervention, the equilibrium features disclosure with certainty at stage (3), the unique optimal penalty is $p^* = 0$.

Proof of Proposition 3. The result in part 1 follows from the discussion preceding the proposition. The result in part 2 follows from the fact that any equilibrium when $p > w_1(1-\beta)\hat{\delta}$ is also an equilibrium when $p = w_1(1-\beta)\hat{\delta}$. When, under a policy of mandatory disclosure, the unique equilibrium features no investment in information acquisition, then it must be that $w_1\hat{\delta} \leq q'\sigma_2$. In this case, when $p = w_1(1-\beta)\hat{\delta}$, an equilibrium exists in which there is no investment in information acquisition but player 1 discloses with certainty the information received exogenously at stage (5). The equilibrium when $p = w_1(1-\beta)\hat{\delta}$ then Pareto-dominates the one under a mandatory-disclosure law. The result in part 3 is an immediate implication of part 1: Any $p > 0$ reduces the investment in information acquisition without augmenting the probability of disclosure. Q.E.D.

(c) Finally, suppose that the court can detect with some strictly positive probability whether player 1 withheld information at stage (3) and, in case it receives evidence of such a behavior, charges the player a penalty. Then, interpret p as the penalty that player 1 expects to pay in case information is withheld at stage (3) (thus p is the product of the probability of detection and the fine). The probability the court finds out that player 1 withheld information at stage (3) is independent of whether or not the player discloses at stage (5). As a result, player 1 always discloses the information she possess at stage (5), irrespective of when it was received and the magnitude of p. This is the key difference with respect to scenario (b) considered above. Because of this difference, when player 1 is expected to invest ρ^* in information acquisition and disclose at stage (3) with probability d^*, the transfer that she receives at stage (4) in case of no disclosure at stage (3) now solves

$$\begin{aligned} t_1 + q'(\rho^*, d^*)U_1 + \widehat{q}'(\rho^*, d^*)\Big[\widehat{U}_1 - \hat{\delta}_1 + \tfrac{\mu+\rho^*(1-d^*)}{1-\rho^* d^*} w_1(1-\beta)\hat{\delta} - \tfrac{\rho^*(1-d^*)}{1-\rho^* d^*}p\Big] \\ = w_1\Big\{q'(\rho^*, d^*)U + \widehat{q}'(\rho^*, d^*)\Big[(\widehat{U} - \hat{\delta}) + \tfrac{\mu+\rho^*(1-d^*)}{1-\rho^* d^*}(1-\beta)\hat{\delta}\Big]\Big\}. \end{aligned}$$

Equivalently,

$$t_1(\rho^*, d^*; p) = w_1 U - U_1 - \hat{q}'(\rho^*, d^*)\sigma_2 + \widehat{q}'(\rho^*, d^*)\frac{\rho^*(1-d^*)}{1-\rho^* d^*}p.$$

For player 1 to find it optimal to disclose at stage (3) with strictly positive probability, it must be that

$$w_1\widehat{U} \geq \widehat{U}_1 - \hat{\delta}_1 + t_1(\rho^*, d^*; p) + w_1(1-\beta)\hat{\delta} - p.$$

Using the above expression for $t_1(\rho^*, d^*; p)$, we can rewrite the above condition for disclosure as follows:

$$w_1\beta\hat{\delta} \geq q'(\rho^*, d^*)\sigma_2 - \left[1 - \widehat{q}'(\rho^*, d^*)\frac{\rho^*(1-d^*)}{1-\rho^* d^*}\right]p. \tag{17}$$

An equilibrium in which player 1 invests ρ^* in information acquisition and discloses with probability $d^* > 0$ at stage (3) then exists if and only if Condition (17) is satisfied (with the condition holding as an equality when $d^* \in (0,1)$) and

$$C'(\rho^*) = \hat{q}\Big[w_1\hat{\delta} - q'(\rho^*, d^*)\sigma_2 - \widehat{q}'(\rho^*, d^*)\frac{\rho^*(1-d^*)}{1-\rho^* d^*}p\Big]. \tag{18}$$

As in scenario (b) above, when $d^* \in (0,1)$, because player 1 must be indifferent between disclosing and not disclosing at stage (3), the return to investing in information acquisition in case player 1 discloses (the right-hand-side of (18)) must coincide with the return

$$\hat{q}\Big[w_1(1-\beta)\hat{\delta} - p\Big]$$

to information gathering in case player 1 conceals at stage (3). We then have the following result:

Proposition 4. ***[penalties when information dissimulation is partly detectable]*** *Suppose that, in case player 1 conceals information at stage (3), the court finds evidence of such a behavior with strictly positive probability and then charges the player a fine.*

1. Penalties for concealing information involve the same trade-offs as mandatory-disclosure laws: They increase the incentives for early disclosure but reduce the benefits to investing in information acquisition.

2. A policy of mandatory-disclosure is strictly dominated by a large penalty that is paid by player 1 only when the court finds evidence of information concealment.

3. When, in the absence of any regulation, the equilibrium features disclosure with certainty at stage (3), any penalty $p \geq 0$ is optimal.

Proof of Proposition 4. The result in part 1 follows from the arguments preceding the proposition. The result in part 2 follows from the fact that investment in information acquisition and stage-(3) disclosure are the same under the two policies, but information received exogenously at stage (5) is disclosed with probability 1 under a penalty for concealment and with probability zero under a mandatory-disclosure law. Finally, Part 3 is an immediate implication of the fact that, by disclosing with probability one at stage (3), player 1 does not pay any penalty. Q.E.D.

The take-away message from the last two propositions is that appropriately-designed penalties (either for late disclosure or for concealment of information prior to contracting, when the latter can be detected with positive probability) do better than mandatory disclosure laws as they do not disincentivize the relevant parties from disclosing information received exogenously after the signing of the contract.

6 Concluding remarks

Information acquisition, broadly defined, is at the core of informational asymmetries, and therefore frictions in contracting. This paper introduces the concept of *relative exposure to the unconventional* and shows that the latter plays a fundamental role for the players' incentives to acquire information, the benefits to align their investments to other players' expectations, the incentives to disclose hard information, and the welfare implications of pre-contractual disclosure obligations.

Disclosure is a central topic in law and economics. We have formalized some of the relevant trade-offs and used the model to assess the welfare merits of various policy proposals and identify novel policy recommendations. Clearly, applications abound beyond the framework developed here. A case in point is patenting, as the search for prior art embodies both efficiency and rent-seeking aspects. As in this paper, the inventor may casually or deliberately acquire information about relevant prior art and choose whether or not to disclose this information to the patent office when applying for a patent. By concealing prior art, the intellectual property (IP) owner can exploit the monopoly power conferred by the patent beyond what motivated by the necessity to incentivize R&D toward novel content. In this context, the patent office does not negotiate a monetary transfer, but chooses the patent's coverage and scope, both of which impact the inventor's incentives and total welfare. Disclosure rules play an important role also for the diligence of search, the opposition process, and the choice of what to include in a patent. Assessing the welfare merits of various policy interventions requires developing a proper framework.

Another case in point is disclosure in standard-setting processes. Many standard setting organizations (SSOs) require that any IP owner participating in working group discussions disclose any potentially relevant patent rights they own that they know of, or reasonably should know of. Such requirements allow the SSO members to assess the nature of IP ownership covering the proposed standard. On the other hand, search and disclosure are costly for IP owners; their patent portfolios may have thousands of items, and they may need to search for "the needle in the haystack". Furthermore, early disclosure of plans may limit the IP owner's ability to get future patent awards and may convey information to rivals about what the IP owner intends to do with its existing patents. Again, the terms of the disclosure requirement are complex (type of disclosures, timing of information release) and the duty of disclosure is worth theoretical and empirical investigations.

Finally, many contracts (such as laws, international agreements) involve more than two protagonists and their negotiation obeys certain protocols which are likely to influence information acquisition. We leave these topics and many other issues broadly related to information acquisition in contracting not covered in the present paper for future research.

7 Appendix A: Participation Constraints

In this Appendix, we show that the assumption that U_i is large (for given $U_i - \hat{U}_i$), $i = 1, 2$, guarantees that, under the assumed Rubinstein-Stahl bargaining protocol, the players never benefit from walking away from the negotiations to enjoy the payoffs associated with their outside options. The analysis below considers the case in which $\beta = 1$ (the model of Sections 2 and 3). Because each player's payoff is weakly higher when disclosure can be delayed to stage (5) than when it must be done at stage (3) or never thereafter, the conditions below also guarantee that no player prefers to walk away in the version of the model of Sections 4 and 5 in which $\beta < 1$. Furthermore, because $\hat{U} \geq 0$ and because, under the assumed protocol, each player gets a payoff equal to $w_i\hat{U}$, $i = 1, 2$, in case of disclosure, to establish the result, it suffices to consider the payoff that each player expects in the absence of disclosure.

Player 2. In the absence of any disclosure by player 1, when the transfer is the one in (2), player

2's expected payoff is equal to $w_2[q'U + \hat{q}'(\hat{U} - \hat{\delta})]$, where q' and $\hat{q}'$ are shortcuts for $q'(\rho^*, d^*)$ and $\hat{q}'(\rho^*, d^*) = 1 - q'(\rho^*, d^*)$, respectively, with $q'(\rho^*, d^*)$ as defined in (3). Because U and $\hat{U}$ are non-negative and because $\hat{q}' \leq \hat{q}$, a sufficient condition for player 2's to never gain by taking the outside option is that the expected aggregate surplus under the common prior $(q, \hat{q})$ is non-negative:

$$qU + \hat{q}(\hat{U} - \hat{\delta}) \geq 0. \tag{19}$$

Clearly, because in any equilibrium in which player 1 does not acquire information, $q' = q$, Condition (19) is also necessary to guarantee that the player does not prefer taking the outside option in any equilibrium involving no information acquisition.

Player 1. The analysis is more complex for the player acquiring information. After choosing $\rho_1 = \rho^*$, where ρ^* is the equilibrium investment level, player 1 clearly never gains from taking the outside option. To see this, consider first the case in which player 1 discovers that the state is $\hat{\omega}$. By disclosing, player 1 obtains $w_1\hat{U}$ which is strictly higher than her outside option given that $U, \hat{U} \geq 0$. When not disclosing gives player 1 a payoff even higher than the one under disclosure, such a payoff is necessarily higher than the one under the outside option. Hence, no matter whether on path player 1 discloses or not, upon learning that the state is $\hat{\omega}$, player 1 is better off not taking her outside option.[25]

Next, consider the case in which player 1 does not find evidence that the state is $\hat{\omega}$. Her expected payoff is then equal to $w_1[q'U + \hat{q}'(\hat{U} - \hat{\delta})]$, where again q' and $\hat{q}'$ are shortcuts for $q'(\rho^*, d^*)$ and $\hat{q}'(\rho^*, d^*) = 1 - q'(\rho^*, d^*)$, respectively. The latter's payoff is thus weakly greater than the player's outside option under the same assumptions that guarantee that player 2's equilibrium payoff is non-negative (e.g., when (19) is satisfied).

Now suppose that player 1 deviates and chooses $\rho \neq \rho^*$. Suppose first that $w_1\hat{\delta} \leq q\sigma_2$. The analysis in Section 3 implies that, if taking the outside option was not a possibility, in the (unique) equilibrium, player 1 does not acquire information, so that $\rho^* = 0$. Thus consider the situation that player 1 faces when she deviates to $\rho_1 > 0 = \rho^*$. If, after deviating, player 1 learns that the state is $\hat{\omega}$, condition $w_1\hat{\delta} \leq q\sigma_2$ implies that, by concealing, player 1 obtains more surplus than by disclosing. Because the latter's strategy gives player 1 a payoff equal to $w_1\widehat{U} \geq 0$, concealing information and then signing the contract is preferable to the outside option.

When, instead, player 1 does not receive evidence that the state is $\hat{\omega}$, because

$$t_1 = w_1[qU + \hat{q}(\hat{U} - \hat{\delta})] - qU_1 - \hat{q}(\hat{U}_1 - \hat{\delta}_1),$$

her payoff from signing the contract is equal to

$$q'U_1 + \hat{q}'(\hat{U}_1 - \hat{\delta}_1) + t_1 = w_1[qU + \hat{q}(\hat{U} - \hat{\delta})] + (q' - q)[U_1 - (\hat{U}_1 - \hat{\delta}_1)], \tag{20}$$

[25]When, on path, player 1 discloses, it is possible that, by not disclosing, player 1 expects a payoff $\hat{U}_1 - \hat{\delta}_1 + t_1$below the outside option, after learning that the state is $\hat{\omega}$. This, however, has no implications for the conclusions drawn here.

where here we abuse notation and let $q' \equiv q'(\rho)$ denote player 1's posterior that the state is ω when investing ρ in information acquisition and not finding evidence that the state is $\hat{\omega}$; similarly, we let $\hat{q}' \equiv 1 - q'(\rho)$ denote player 1's posterior that the state is $\hat{\omega}$ when player 1's investment in information acquisition is ρ and she finds no evidence that the state is $\hat{\omega}$.

Under Condition (19), the above payoff is positive for any q' (equivalently, for all ρ) if and only if

$$w_1[qU + \hat{q}(\hat{U} - \hat{\delta})] + (1-q)[U_1 - (\hat{U}_1 - \hat{\delta}_1)] \geq 0. \tag{21}$$

Hence, jointly, Conditions (19) and (21) imply that player 1 prefers not to acquire any information and trade at the negotiated price t_1 to taking her outside option.

Next, suppose that $w_1\hat{\delta} > q\sigma_2$. Recall that, in this case, if taking the outside option was not a possibility, player 1's investment in information acquisition would be strictly positive in any equilibrium. Now take any equilibrium in the game without outside option in which player 1 invests $\rho^* > 0$ and discloses with certainty, and let $q'(\rho^*, 1)$ and $\hat{q}'(\rho^*, 1) = 1 - q'(\rho^*, 1)$ denote the posterior probability that player 2 assigns to the state being ω and $\hat{\omega}$, respectively, in the absence of any disclosure, when player 1 is expected to invest ρ^* and disclose with certainty (clearly, the same probabilities also coincide with player 1's beliefs when player 1 invests ρ^* and does not receive any evidence that the state is $\hat{\omega}$). In any such equilibrium, player 1's ex-ante expected payoff, net of the cost of acquiring information, is equal to

$$(1 - \hat{q}\rho^*)w_1[q'(\rho^*, 1)U + (1 - q'(\rho^*, 1))(\hat{U} - \hat{\delta})] + \hat{q}\rho^* w_1 \hat{U} - C(\rho^*).$$

In the game with outside option, the following is thus a necessary condition for player 1 to find it optimal not to take the outside option:

$$(1 - \hat{q}\rho^*)w_1[q'(\rho^*, 1)U + (1 - q'(\rho^*, 1))(\hat{U} - \hat{\delta})] + \hat{q}\rho^* w_1 \hat{U} - C(\rho^*) \geq 0. \tag{22}$$

Note that, by the law of iterated expectation, the expression in the left-hand-side of (22) is bounded from below by

$$w_1[qU + (1-q)(\hat{U} - \hat{\delta})] - C(\rho^*).$$

Next, recall that, in the game without outside option, in any equilibrium in which player 1 invests ρ^* in information acquisition, necessarily $w_1\hat{\delta} > q'(\rho^*, 1)\sigma_2$. Now suppose that, in the game with outside option, player 1 deviates and invests $\rho \neq \rho^*$. When player 1 learns that the state is $\hat{\omega}$, disclosing yields her a gross payoff $w_1\hat{U} \geq 0$ which is higher than the payoff that player 1 can obtain by either concealing and negotiating a price t_1 or dropping out and enjoying the outside option. When, instead, player 1 does not receive evidence that the state is $\hat{\omega}$, signing a contract specifying the default action a and the transfer t_1 as in Condition (2) yields the player a gross payoff equal to

$$q'(\rho, 1)U_1 + \hat{q}'(\rho, 1)(\hat{U}_1 - \hat{\delta}_1) + t_1 = w_1[q'(\rho^*, 1)U + \hat{q}'(\rho^*, 1)(\hat{U} - \hat{\delta})] + (\hat{q}'(\rho, 1) - \hat{q}'(\rho^*, 1))[U_1 - (\hat{U}_1 - \hat{\delta}_1)],$$

where $\hat{q}'(\rho, 1) - \hat{q}'(\rho^*, 1) \in [-(1-q), 1-q]$. Player 1 thus prefers signing the contract to her outside option if and only if

$$w_1[q'(\rho^*, 1)U + \hat{q}'(\rho^*, 1)(\hat{U} - \hat{\delta})] + (\hat{q}'(\rho, 1) - \hat{q}'(\rho^*, 1))[U_1 - (\hat{U}_1 - \hat{\delta}_1)] \geq 0. \tag{23}$$

Note that a sufficient condition for (23) to hold is that

$$w_1[q'U + \hat{q}'(\hat{U} - \hat{\delta})] \geq (1-q)\left|U_1 - (\hat{U}_1 - \hat{\delta}_1)\right|. \tag{24}$$

We conclude that Conditions (19), (21), (22), and (23), with the latter holding for all ρ, are sufficient to guarantee that all the equilibria of the game without outside option are also equilibria in the game in which the players can walk away from the negotiations to enjoy their outside options. These conditions are always satisfied when, given $U_i - \hat{U}_i$, U_i is large, $i = 1, 2$. Also note that, Conditions (21) and (23) are implied by Condition (19) in the following special cases:

- $U_i = \hat{U}_i = \hat{U}_i - \hat{\delta}_i$, $i = 1, 2$.
- $U_i = \hat{U}_i - \hat{\delta}_i$, $i = 1, 2$. The idea is that the default action a has also known consequences so that $U_i = \hat{U}_i - \hat{\delta}_i$. But a better design in state $\hat{\omega}$ might improve player i's utility.

8 Appendix B: Two-sided Information Gathering

Suppose both parties have the possibility to acquire information prior to contracting, with each investment denoted by ρ_i and each cost function C_i satisfying the same assumption as in the baseline model. We first establish that over-investment in information acquisition (relative to what is efficient) can occur only when a single player acquires information in equilibrium. We then establish a few properties of equilibria in which both parties acquire information.

8.1 Over-investment in information acquisition under one-sided information gathering implies no incentives for other player to acquire information.

Observe that, when player i is the only player acquiring information, she over-invests if and only if

$$q'(\rho_i^D, 1)\sigma_i > w_j\hat{\delta}, \tag{25}$$

where ρ_i^D is the unique solution to $C_i'(\rho_i^D) = \widehat{q}[w_i\hat{\delta} - q'(\rho_i^D, 1)\sigma_j]$. To see this, use Lemma (3) to observe that, when player i discloses with certainty at stage (4), then her investment in information acquisition is given by ρ_i^D. When, instead, she discloses with probability $d^* \in (0, 1)$, then her investment is given by ρ_i^{ND}, with ρ_i^{ND} satisfying $C_i'(\rho_i^{ND}) = \widehat{q}w_i(1-\beta)\hat{\delta}$. The socially-optimal investment ρ_i^E under unilateral information gathering is given by the unique solution to $C_i'(\rho_i^E) = \widehat{q}\hat{\delta}$. Condition (25) implies that

$$\widehat{q}[w_i\hat{\delta} - q'(\rho_i^D, 1)\sigma_j] > \widehat{q}\hat{\delta}$$

and hence that $\rho_i^D > \rho_i^E$. As shown above, $\rho_i^{ND} \geq \rho_i^D$. Hence, under Condition (25), irrespective of whether player i discloses with certainty at stage (4) or only with probability d^*, she over-invests. When, instead, Condition (25) is inverted (that is, $q'(\rho_i^D, 1)\sigma_i < w_j\hat{\delta}$), because $\widehat{q}w_i(1-\beta)\hat{\delta} < \widehat{q}\hat{\delta}$, then $\rho_i^{ND} < \rho_i^E$. Again, because $\rho_i^{ND} \geq \rho_i^D$, player i necessarily underinvests.
Condition (25) in turn implies that, when player i invests ρ_i^D and discloses with certainty, player j, if she were to learn that the state is $\widehat{\omega}$, she would not want to disclose the information. This follows from steps similar to those leading to Lemma (1). In particular, note that, when player i invests ρ_i^D and discloses with certainty, then, when she does not find any evidence that the state is $\widehat{\omega}$, player i assigns probability $q'(\rho_i^D, 1)$ to the state being ω. Condition (25) then implies that player j, when learning that the state is $\widehat{\omega}$, prefers not to disclose the information to take advantage of player i's optimistic beliefs that the state is ω.

Next, suppose that, under one-sided information gathering, player i invests ρ_i^{ND} and then discloses with probability $d^* \in (0,1)$. Then, in the absence of any disclosure by player i, player j cannot conclude that player i did not learn that the state is $\widehat{\omega}$. However, she knows that, in the negotiations, player i is going to behave as if the probability that the state is ω is equal to $q'(\rho_i^*, d^*) = w_i\beta\hat{\delta}/\sigma_j$ (again, see the analysis leading to Lemma (3)). Condition (25) then continues to imply that player j, if she learned that the state is $\widehat{\omega}$, would not gain by disclosing the information.

We conclude that, irrespective of whether, under one-sided information gathering, in the equilibrium player i discloses with certainty at stage (4), when Condition (25) holds, player j does not want to acquire information, however small the cost of doing so. The intuition for this result is that excess investment by player i occurs when the private benefit of information exceeds the social benefit. Put it differently, information, at the margin, reduces j's welfare; and so player j has no incentive to acquire information, however cheap.

8.2 Actual information gathering by both players

Next, we look for an equilibrium in which both parties invest in information acquisition (and disclose information), which, as we saw, requires that $w_i\hat{\delta} + q'\sigma_i > 0$ for all i, where q' is the posterior belief that the state is ω conditional on none of the parties having disclosed that the state is $\widehat{\omega}$. Assume that the search outcomes are independent. Such an equilibrium must satisfy the following properties. For all i, under mandatory disclosure, or if $\sigma_i \geq 0$, either $\rho_i = 0$ if $w_i\hat{\delta} \leq q'\sigma_j$, or ρ_i is given by the solution to

$$C_i'(\rho_i) = \hat{q}(1-\rho_j)(w_i\hat{\delta} - q'\sigma_j), \tag{26}$$

where the probability that the state is ω in case neither player discloses is given by

$$q' = \frac{q}{q + \hat{q}(1-\rho_i)(1-\rho_j)}. \tag{27}$$

In the absence of mandatory disclosure and if $\sigma_i < 0$, ρ_i is given by the solution to[26]

$$C_i'(\rho_i) = \hat{q}(1-\rho_j)w_i\hat{\delta}. \tag{28}$$

Note that the first-order condition (26) can be rewritten as

$$C_i'(\rho_i) = \hat{q}\left[(1-\rho_j)w_i\hat{\delta} + (-\sigma_j)\frac{q}{\dfrac{q}{1-\rho_j} + \hat{q}(1-\rho_i)}\right]. \tag{29}$$

If $\sigma_j \leq 0$, that is, if player i is relatively more exposed to the unexpected, player i's reaction curve (ρ_i as a function of ρ_j) is downward-sloping. Strategic substitutability in information gathering holds also if $\sigma_j > 0$. In fact, the derivative of the right-hand-side of Condition (29) with respect to ρ_j is $\hat{q}\left[-w_i\hat{\delta} + \sigma_j\left(q'\right)^2\right]$, which is negative when both players engage in information acquisition.
Assuming that the cost functions C_i are sufficiently convex so that the reaction curves cross only once, thus defining a stable equilibrium, we then have, when both players invest in information acquisition, their investments are locally strategic substitutes, reflecting the public good nature of information. Furthermore, when player i is relatively more exposed to the unconventional ($\sigma_i > 0$), then lifting the mandatory disclosure requirement increases j's investment and reduces i's.

[26] Note that in this case player j always discloses.

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