GOVERNANCE AND THE EFFICIENCY OF ECONOMIC SYSTEMS
GESY

Discussion Paper No. 428

Acquisition and Disclosure of Information as a Hold-up Problem

Urs Schweizer *

* University of Bonn

October 2013

Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR 15 is gratefully acknowledged.

Sonderforschungsbereich/Transregio 15 · www.sfbtr15.de
Universität Mannheim · Freie Universität Berlin · Humboldt-Universität zu Berlin · Ludwig-Maximilians-Universität München
Rheinische Friedrich-Wilhelms-Universität Bonn · Zentrum für Europäische Wirtschaftsforschung Mannheim

Speaker: Prof. Dr. Klaus M. Schmidt · Department of Economics · University of Munich · D-80539 Munich,
Phone: +49(89)2180 2250 · Fax: +49(89)2180 3510

Acquisition and Disclosure of Information as a Hold-up Problem

Urs Schweizer,[*][†] University of Bonn

October 10, 2013

Abstract

The acquisition of information prior to sale gives rise to a hold-up situation quite naturally. Yet, while the bulk of the literature on the hold-up problem considers negotiations under symmetric information where cooperative short-cuts such as split the difference capture the outcome of bargaining, in the present setting, parties negotiate under asymmetric information where the outcome must be derived from a non-cooperative bargaining procedure. To avoid the difficult task of specifying and solving complicated games combining elements of signalling and screening, but to still compare incentives for acquiring information under voluntary versus mandatory disclosure, use of conditions such as incentive, disclosure and participation constraints only is made that are common to all non-cooperative bargaining outcomes.

JEL classification: K12, K13

Keywords: mistake, information acquisition, disclosing information

[*]address: Urs Schweizer, Department of Economics, University of Bonn, Adenauerallee 24, 53113 Bonn, Germany, schweizer@uni-bonn.de

[†]Support by the DFG through SFB/TR 15 is gratefully acknowledged.

1 Introduction

More than two thousand years ago, Cicero in "de officiis" constructed cases of contracting parties who had struck a deal under asymmetric information prior to sale. If Rhodos is suffering from a famine and a seller is shipping crop to Rhodos, does he report of other boats approaching with crop or does he remain silent in order to obtain a higher price? Or if a seller sells gold but thinks he sells brass, does the buyer tell him or does he silently buy gold at the price of brass? Ever since Cicero, legal scholars have kept debating about circumstances when such contracts should be enforced and when not.

Mistake is accepted as a valid formation defense in many legal systems. The German civil code for example, in its section on voidability for mistake, offers the following rule: "A person who, when making a declaration of intent, was mistaken about its contents or had no intention whatsoever of making a declaration with this content, may avoid the declaration if it is to be assumed that he would not have made the declaration with knowledge of the factual position and with a sensible understanding of the case" (German civil code § 119 BGB). In addition to general rules from contract law, legal systems may provide remedies that are specific for transactions on markets for equity or insurance contracts and may impose duties to disclose explicitly.

Kronman (1978) was among the first to approach the issue from a law and economics perspective. His analysis departs from an apparent inconsistency in contract law. On the one hand, there exist contract cases where a promisor, due to unilateral mistake, is excused from performance. On the other hand, there also exist cases where a party is entitled to withhold information. To resolve the issue, he proposes the following theory. The law tends to recognize a right to deal with others without disclosing what he knows provided that the information is the result of a deliberate and costly search. Such a right, however, is not recognized where the information has casually been acquired.

Shavell (1994), being stimulated by Kronman's article, introduced a formal model to explore a closely related issue in greater depth and in line with insights from information economics. He compares the incentives to acquire information prior to sale under mandatory disclosure versus voluntary disclosure. Voluntary disclosure is meant to capture those cases where the informed party has the right to deal without disclosing. Mandatory disclosure, in contrast, may reflect these other cases where the informed party will effectively be led to disclose as, otherwise, her partner may be excused from performance. Shavell's main conclusions are as follows. Voluntary disclosure generates excessive incentives for acquiring information. Mandatory disclosure is socially desirable for sellers whereas, for buyers, the right to deal without disclosing may be required to spur acquisition of socially desirable information.

The present paper considers a model quite similar to the one examined by Shavell. Nonetheless, rather different conclusions will emerge from my analysis. Voluntary disclosure need not generate excessive incentives to acquire information. Voluntary disclosure may result in even lower incentives than mandatory disclosure. Incentives to acquire information under mandatory disclosure remain insufficient quite generally. The distinction between buyers and sellers acquiring information may be of lesser significance than suggested by Shavell.

Shavell's results rest on the following assumptions. First, the informed party is assumed to unilaterally propose the contract on a take-it-or-leave-it basis which, under symmetric information at least, means that the informed party is given the entire bargaining power. Second, the parameters of his model are chosen such that the buyer is commonly known to value the good higher than the seller (trivial trade decision). Third, to establish that the buyer has vanishing incentives under required disclosure, Shavell introduces a rather peculiar assumption of how the uninformed seller would value the good outside the relationship.

The present paper differs in that it allows for more general bargaining procedures, including those where both parties have positive bargaining power. Cases are included where it depends on the acquired information whether trade should take place on efficiency grounds or not (non-trivial trade decision).

My setting is reminiscent of the hold-up literature as pioneered by Grossman and Hart (1986). In that literature, relationship-specific investments are undertaken without being contractible. At the (re-) negotiation stage, parties bargain under symmetric information and are assumed to share the negotiation surplus in fixed proportions, well in line with cooperative bargaining theory.

In the present setting, parties invest in acquiring information prior to sale. Such investments, by nature, are not contractually protected when negotiations start. It is this absent protection that causes the hold-up situation.

At the negotiation stage, the informational setting depends on the legal disclosure regime. To begin with, suppose an effective regime of mandatory disclosure prior to sale is in place such that negotiations take place among symmetrically informed parties. Therefore, in line with the hold-up literature, parties may be assumed to share the negotiation surplus (if any) in fixed proportions. Split the difference, e.g., as predicted by Nash's cooperative bargaining solution would correspond to equal bargaining power for both parties.

Unless the party who acquires information is assigned the entire bargaining power, she must share the fruits of her investments with the other party which then leads to the underinvestment result well known from the hold-up literature. In other words, under mandatory disclosure and at less than full bargaining power, incentives to acquire information would typically seem positive but insufficient, no matter whether it is the seller or the buyer who acquires information.

For conceptual reasons, examining incentives to acquire information under voluntary disclosure proves more demanding. A regime of voluntary disclosure necessarily entails bargaining under asymmetric information such that the convenient shortcut of a cooperative solution concept (split the difference, e.g.) is no longer available. As a way out, the negotiated outcome must rather be derived from a Bayesian Nash equilibrium of a non-cooperative bargaining game. Shavell, in fact, has considered a simple bargaining procedure of take-it-or-leave-it nature.

The present paper allows for more general bargaining games whose solutions, however, may remain difficult to determine explicitly. Fortunately, as it turns out, the exact form of the bargaining procedure does not matter and its explicit solution can be dispensed with. To make my point, exclusive use is made of constraints that are common to all equilibrium outcomes of non-cooperative bargaining games.

Of particular importance will be the disclosure and participation constraints. Participation constraints are derived from the fact that each party may unilaterally enforce the outside option simply by not signing the contract. Disclosure constraints result from the assumption that the informed party, by disclosing voluntarily, can trigger the cooperative bargaining solution, in line with the hold-up literature. The disclosure constraints reflect the informed party's incentives to disclose whenever disclosing promises a higher payoff as compared with the Bayesian Nash equilibrium outcome of the non-cooperative bargaining game.

As mentioned before, the non-cooperative game will not be specified explicitly but the reader may think of some particular bargaining procedure that would lead, if played among symmetrically informed parties, to sharing the surplus in the proportions of the underlying cooperative solution.

The paper is organized as follows. In section 2, the general model is introduced and, for later reference, the first best solution is examined. Section 3 deals with the legal regime where mandatory disclosure is effectively imposed. Negotiations take place under symmetric information and parties share the negotiation surplus in fixed proportions. This version of the model shares its structure exactly with those from the hold-up literature and, as a consequence, it also features the same tendency for underinvestment (relative to first best).

Section 4 deals with incentives under voluntary disclosure. The outcome of negotiations is based on a Bayesian Nash equilibrium of a non-cooperative bargaining game. Disclosure, participation and incentive constraints are derived for the general version of the decision problem. Under voluntary disclosure, it is shown that, quite generally, incentives to acquire information are (at least weakly) excessive but only under the provision that the party acquiring information has the entire bargaining power (Shavell's assumption).

In section 5, the model is restricted to binary trade decisions. Moreover, I distinguish selfish from cooperative acquisition of information. I borrow these terms from Che and Chung (1999) who have compared incentives for investments that either directly affect the valuation of the investing or that of the non-investing party. In my case, investments do not affect the valuations themselves but rather may reveal information concerning their true values.

For a setting of selfish acquisition, incentives to acquire information are shown to be lower than first best but higher as compared with mandatory disclosure. In this setting, voluntary disclosure outperforms mandatory disclosure on efficiency grounds.

For a setting of cooperative acquisition, however, the welfare ranking is shown to be reverse. While mandatory disclosure, due to the hold-up situation, still provides insufficient incentives to acquire information, voluntary disclosure would generate even lower incentives. Section 6 concludes.

2 The model

The general setting is as follows. Parties A and B face some decision q from a given set Q_p of alternatives. While Q_p contains all pure decisions, let Q denote the set of all mixed decisions. The set Q consists of all probability distributions over the set of pure decisions.

The decision q will eventually emerge from bargaining. I have two interpretations in mind. Either the decision concerns the quantity of a commodity to be traded in which case Q_p could be interpreted as the real line (or a subset of it). Or the trade decision is of binary nature $Q_p = \{0, 1\}$ such that $Q = [0, 1]$ coincides with the unit interval with the interpretation that $q \in Q$ corresponds to the probability with which trade takes place.

In any case, the set Q_p of pure decisions is assumed to contain the particular decision $q = 0$ not to trade at all (outside option).

The parties' payoffs may be uncertain. Uncertainty is captured by a random move ω of nature from the outcome space Ω. This outcome space is endowed with a probability measure π in the sense that, for any event $\Omega' \subset \Omega$, the value $\pi(\Omega')$ denotes the probability of this event.

By assumption, party A is the only one to acquire information. She has the option to learn the true move of nature with probability $x \in X \subset [0, 1]$ by investing effort $k(x)$ expressed in monetary equivalent. For convenience and in line with the hold-up literature, the decision x will be referred to as investments.[1] Investments are assumed specific to A's potential relationship with some given party B.

In the following, I refer to A and B as buyer and seller, respectively. At

[1] Notice, in Shavell (1994), parties differ in their exogenously given costs of being informed. The present model, in contrast, introduces the probability of being informed as a decision variable such that the incentives to be informed can be explored. Yet, the difference in modelling is rather a matter of taste than of substance. Under both approaches, it is the value of being informed only that matters.

pure decision $q \in Q_p$ and move of nature $\omega \in \Omega$, party A's utility amounts to $v(\omega, q)$ whereas party B's costs amount to $c(\omega, q)$. But notice, no assumptions on the signs of these functions are imposed such that parties A and B could equally well be in the reverse roles of seller and buyer, respectively (just reinterpret v as minus the cost function and c as minus the utility function). At not trade, utility and costs are assumed to vanish, i.e. $v(\omega, 0) = c(\omega, 0) = 0$ holds for any move ω of nature.

If $q \in Q$ is a mixed decision, I denote by $V(\omega, q)$ and $C(\omega, q)$ the expected utility and the expected costs under the probabilistic decision q. Social surplus then amounts to $S(\omega, q) = V(\omega, q) - C(\omega, q)$.

Also notice, while it is party A who acquires information, neither her utility function $V(\omega, q)$ nor social surplus $S(\omega, q)$ include investment costs $k(x)$. This convention proves useful as investments are decided prior to sale. At the negotiation stage, investment costs are sunk.

Both parties are assumed risk-neutral. Therefore, if the true move of nature ω is known, the first best solution requires an ex post efficient decision

$$q^*(\omega) \in \arg\max_{q \in Q} S(\omega, q)$$

being taken whereas if the move of nature is not known, an ex ante efficient decision

$$q_0 \in \arg\max_{q \in Q} E\left[S(\omega, q)\right]$$

would be the collective optimum. For later reference, let me define the resulting surplus (first best) as $\sigma^*(\omega) = S(\omega, q^*(\omega))$ and $\sigma_0(\omega) = S(\omega, q_0)$, respectively. Both are contingent on the true move ω of nature even if the decision q_o is not.

The first best solution requires investments

$$x^* \in \arg\max_{x \in X} w(x)$$

that maximize expected surplus $w(x)$. Expected surplus net of search costs amounts to

$$w(x) = E[\sigma_0(\omega)] + x \cdot \Delta^* - k(x)$$

where

$$\Delta^* = E[\sigma^*(\omega) - \sigma_0(\omega)] \geq 0$$

denotes the social gain from being informed. By definition, this gain can never be negative and it will be strictly positive whenever the information has social value.

After having described the model and its first best solution, which will serve as a reference point, the remaining sections deal with deriving and comparing the incentives to acquire information under rules of mandatory versus voluntary disclosure as well as relative to first best.

3 The hold-up problem under mandatory disclosure

In the present setting, the two parties are assumed to negotiate under a rule of mandatory disclosure. At the time of contracting, party A's effort is sunk and either A knows the true move of nature or she does not. By assumption, if A knows it to be ω then, under mandatory disclosure, she meets her duty to disclose ω truthfully. If, however, A does not know the true move she cannot disclose. In either case, bargaining takes place among symmetrically informed parties if information sharing is governed by effective mandatory disclosure.

Under symmetric information, well in line with the hold-up literature, let me assume that parties A and B share the surplus in fixed proportions, $\alpha + \beta = 1$, where $\alpha \geq 0$ and $\beta \geq 0$ reflect the bargaining power of A and B, respectively. I further assume that the parties' reservation utility outside their relationship is normalized to zero. As a consequence, party A's and party B's negotiated payoffs will amount to $\alpha \cdot \sigma^*(\omega)$ and $\beta \cdot \sigma^*(\omega)$, respectively, if A has learned and, hence, disclosed the true move ω of nature whereas they amount to $\alpha \cdot E[\sigma_0(\omega)]$ and $\beta \cdot E[\sigma_0(\omega)]$, respectively, if A has not learned it.

Anticipating these contracted payoffs, party A has the incentive of being informed with probability x^m that maximizes her objective function (m refers to mandatory disclosure)

$$\phi^m(x) = E[\alpha \cdot \sigma_o(\omega)] + x \cdot \Delta^m - k(x)$$

where A's private gain from being informed amounts to the fraction $\Delta^m = \alpha \cdot \Delta^*$ of the corresponding social gain.

For the rest of the paper it is assumed that party A's investments x remain hidden to party B.

The following proposition recalls the underinvestment result well-known from the hold-up literature.

Proposition 1 *Suppose investments x^* maximize the expected surplus whereas investments x^m maximize party A's objective function under mandatory disclosure, i.e. $x^* \in \arg\max_x w(x)$ and $x^m \in \arg\max_x \phi^m(x)$. Then investment incentives compare as follows.*

(i) If $\beta \cdot \Delta^* > 0$ then $x^m \leq x^*$.

(ii) If $\beta \cdot \Delta^* = 0$ then $\arg\max_{x \in X} w(x) = \arg\max_{x \in X} \phi^m(x)$.

Proof. (i) Since the difference $w(x) - \phi^m(x)$ of the two objective functions is strongly monotonically increasing if $\beta \cdot \Delta^* > 0$, for all x from the range $x < x^m$, it follows that

$$w(x) - \phi^m(x) < w(x^m) - \phi^m(x^m)$$

and, hence,

$$w(x) < w(x^m) - [\phi^m(x^m) - \phi^m(x)] \leq w(x^m)$$

must hold. Therefore, the welfare function $w(x)$ attains a maximum at no x from the range $x < x^m$. Claim (i) is established.

(ii) If $\beta \cdot \Delta^* = 0$ then the two objective functions $w(x)$ and $\phi^m(x)$ differ by a constant term only, from which the second claim follows easily. ■

Notice, the above proof remains valid for any shape of the cost function $k(x)$. By imposing suitable differentiability, however, the first claim could be strengthen to strictly insufficient incentives $x^m < x^*$ under mandatory disclosure.

The second claim generalizes Shavell's efficiency result to my more general model. In fact, if party A who acquires information is given the entire bargaining power, i.e. $\alpha = 1$, then $\beta = 0$ and, hence, $\beta \cdot \Delta^* = 0$ must always be fulfilled. Therefore, under mandatory disclosure, the first best solution prevails quite generally provided that party A has the entire bargaining power.

Finally, again under suitable differentiability of the cost function $k(x)$, incentives are easily shown to remain strictly positive under mandatory disclosure, i.e. $x^m > 0$, if party A's share from benefits of being informed is positive, i.e. if $\alpha \cdot \Delta^* > 0$ holds. At first glance, positive incentives seem at odds with Shavell's findings of vanishing incentives for buyers to acquire information under mandatory disclosure. The discrepancy, however, is due to Shavell's implicit assumption of a non-vanishing outside option which he imposes but only if it is the buyer who acquires information.

4 Voluntary disclosure

In this section, the legal regime is explored where the disclosure of information is at the discretion of party A. Yet, even if disclosure is not mandatory, party A may still voluntarily disclose. More precisely, the following informational setting is imposed.

If A does not learn the true move of nature, she cannot produce any evidence at all and, hence, she must remain silent. In particular, she cannot credibly communicate the fact that she is uninformed.

If, however, A learns the true move ω of nature, she may either voluntarily disclose ω truthfully or may hide it, but she cannot reveal any untrue move of nature.

Notice, if A discloses the (true) move ω of nature, negotiations take place under symmetric information such that the (ex post) efficient surplus $\sigma^*(\omega)$ is shared in fixed proportions $a \cdot \sigma^*(\omega)$ and $\beta \cdot \sigma^*(\omega)$ among the two parties, as under the rule of mandatory disclosure explored in the previous section.

If, however, party A remains silent then party B does not know whether such silence is due to A having not learned the true move of nature or whether A knows the true move of nature but prefers hiding it. As a consequence, parties are asymmetrically informed whenever party A remains silent and, hence, sharing the efficient surplus in fixed proportions is no longer available as a convenient shortcut to capture the negotiated outcome.

In such a situation of asymmetric information, the bargaining procedure should be specified as a non-cooperative game. Shavell, e.g., imposes that (the potentially informed) party A makes a take-it-or-leave-it offer to party B. Other games may be considered as well. In any case, the Bayesian Nash equilibrium of a given bargaining procedure will serve as the predicted outcome of negotiations among the two asymmetrically informed parties.

The equilibrium analysis could be quite tedious and equilibrium may fail to be unique. To avoid specifying and solving a bargaining game explicitly, the present paper relies instead on a method close in spirit to the revelation principle. In particular, I will derive incentive, participation and disclosure constraints that are common to any equilibrium of any bargaining game. As it turns out, under some circumstances, incentives to acquire information can be compared on the basis of these common constraints alone.

To derive these common constraints, think of any given bargaining game. If it comes in extensive form, consider the associated normal form with strategy sets A_p and B_p (pure strategies) and A and B (mixed strategies) from which parties A and B, respectively, choose their bargaining strategies simultaneously. At strategy profile $(a, b) \in A \times B$, the (possibly mixed) decision $q(a, b) \in Q$ is assumed to result whereas $T(a, b)$ denotes the resulting (expected) payment from A to B. Notice, the set A and B of available bargaining strategies and the outcome in terms of decisions $q(a, b)$ and payments $T(a, b)$ do not depend on the actual move ω of nature but the parties' payoffs do.

In fact, the payoffs of parties A and B amount to

$$V(\omega, q(a, b)) - T(a, b) \text{ and } T(a, b) - C(\omega, q(a, b)),$$

respectively. The game in normal form with A and B as strategy sets and the above payoff functions is played whenever party A remains silent, be it that A does not know the move of nature or that A knows ω but hides it.

A Bayesian Nash equilibrium consists of mutually best responses combined with consistent beliefs. Given that party B does not learn the move of nature on his own, his best response always consists of a non-contingent bargaining strategy $b^N \in B$.

Party A may or may not know the true move of nature. If she does not know it, her best response consists of a non-contingent bargaining strategy $a^N \in A$ as well. If, however, she knows the true move ω of nature yet hides it, her bargaining decision $a^N(\omega) \in A$ may still be state-contingent.

To qualify as a Bayesian Nash equilibrium, the following conditions of mutually best responses must be met. If A does not know the move of nature, she chooses a non-contingent best response

$$a_0^N \in \arg\max_{a \in A} E\left[V(\omega, q(a, b^N))\right] - T(a, b^N)$$

to B's equilibrium strategy b^N. If, however, she knows ω to be the true move of nature, her best response

$$a^N(\omega) \in \arg\max_{a \in A} V(\omega, q(a, b^N)) - T(a, b^N)$$

to b^N may well be state-contingent. For convenience, I am specifying such a best response even for moves ω of nature where A, by disclosing voluntarily, would trigger the cooperative bargaining outcome instead.

Let

$$q_0^N = q\left(a_0^N, b^N\right) \text{ and } T_0^N = T\left(a_0^N, b^N\right)$$

denote the equilibrium outcome if A does not know the move of nature and let

$$q^N(\omega) = q\left(a^N(\omega), b^N\right) \text{ and } T^N(\omega) = T\left(a^N(\omega), b^N\right)$$

denote the possibly state-contingent equilibrium outcome if A knows the true move of nature to be ω. The corresponding payoffs of party A are denoted as

$$\Phi_0^N(\omega) = V(\omega, q_0^N) - T_0^N$$

and $\Phi^N(\omega, \omega)$, respectively, where

$$\Phi^N(\omega, \omega') = V(\omega, q^N(\omega')) - T^N(\omega')$$

would correspond to A's payoff if she knows the true move of nature to be ω but would negotiate as if it were ω'.

Since these outcomes are based on best responses, the following incentive constraints have to be met:

$$\Phi^N(\omega, \omega') \leq \Phi^N(\omega, \omega) \text{ for all } \omega, \omega' \in \Omega \tag{1}$$

$$\Phi_0^N(\omega) \leq \Phi^N(\omega, \omega) \text{ for all } \omega \in \Omega \tag{2}$$

and

$$E\left[\Phi^N(\omega, \omega')\right] \leq E\left[\Phi_0^N(\omega)\right] \text{ for all } \omega' \in \Omega \tag{3}$$

The first set of inequalities corresponds to the traditional incentive constraints whereas the second one means that the informed party A cannot gain from negotiating as if she were uninformed. The third set, finally, corresponds to the case where the uninformed party A cannot gain from bargaining as if she had observed ω' as the true state of nature.

Since, by disclosing voluntarily, party A can trigger the cooperative bargaining outcome, further constraints, referred to as disclosure constraints, have to be met. If she discloses the (true) move of nature ω her negotiated payoff amounts to $\alpha \cdot \sigma^*(\omega)$. Let Ω_0^N be the event in which the informed party A prefers to be silent. The complementary set $\Omega_1^N = \Omega \backslash \Omega_0^N$ corresponds to the event in which the informed party A discloses voluntarily. For A's disclosure strategy to be optimal, the following disclosure constraints have to be met in equilibrium. If

$$\Phi^N(\omega, \omega) < \alpha \cdot \sigma^*(\omega) \text{ then } \omega \in \Omega_1^N \tag{4}$$

whereas if

$$\alpha \cdot \sigma^*(\omega) < \Phi^N(\omega, \omega) \text{ then } \omega \in \Omega_0^N \tag{5}$$

must hold.

At the investment stage, party A is assumed to anticipate the outcome of bargaining. If she decides to become informed with probability x, her expected payoff amounts to

$$\phi^v(x) = E\left[\Phi_0^N(\omega)\right] + x \cdot \Delta^v - k(x)$$

where

$$\begin{aligned} \Delta^v &= \pi(\Omega_0^N) \cdot E\left[\Phi^N(\omega, \omega) - \Phi_0^N(\omega) \mid \Omega_0^N\right] + \\ &\quad + \pi(\Omega_1^N) \cdot E\left[\alpha \cdot \sigma^*(\omega) - \Phi_0^N(\omega) \mid \Omega_1^N\right] \end{aligned} \tag{6}$$

denotes A's private value of being informed under voluntary disclosure. In equilibrium, she chooses investments

$$x^v \in \arg\max_x \phi^v(x)$$

that maximize her objective function.

To qualify as an equilibrium, party B must also choose a best response to party A's bargaining strategy as described above. To this end, party B forms beliefs p^N concerning the probability of party A being informed conditional on A remaining silent. Given such beliefs, party B's best response b^N maximizes his expected payoff $\psi^N(b)$ which is defined as

$$\begin{aligned} \psi^N(b) &= (1 - p^N) \cdot E\left[T(a_0^N, b) - C(\omega, q(a_0^N, b))\right] + \\ &\quad + p^N \cdot E\left[T(a^N(\omega), b)) - C(\omega, q(a^N(\omega), b)) \mid \Omega_0^N\right]. \end{aligned}$$

Moreover, in equilibrium, these beliefs must be consistent which means that

$$p^N = \frac{x^v \cdot \pi(\Omega_0^N)}{1 - x^v + x^v \cdot \pi(\Omega_0^N)}$$

has to hold.

By not signing a contract, each party can unilaterally trigger the no trade decision $q = 0$ and zero payments. As a consequence, equilibrium payoffs have to be non-negative. The corresponding constraints are referred to as participation constraints. But notice, participation does not mean that trade will necessarily take place.

In particular, if A discloses ω (i.e. $\omega \in \Omega_0^N$), then $\Phi^N(\omega, \omega) \geq 0$ must hold for such moves of nature. If A does not learn the move of nature, $E[\Phi_0^N(\omega)] \geq 0$ must hold for similar reasons.

Party B's expected payoff $\psi^N(b^N)$ if A remains silent must be non-negative in equilibrium as well to satisfy B's participation constraint.

Based on the above notions, the following proposition can be established.

Proposition 2 *(i) Under voluntary disclosure, the private gain from being informed must be non-negative, i.e.* $\Delta^v \geq 0$.

(ii) If it would be too costly to know the true move of nature for sure (i.e. if $x^v < 1$*) then* $E\left[\sigma_0(\omega) - \Phi_0^N(\omega)\right] \geq 0$ *must hold.*

(iii) If it would be too costly to know the true move of nature for sure and if, under symmetric information, party A has all the bargaining power (i.e. if $x^v < 1$ *and* $\alpha = 1$*) then* $\Delta^v \geq \Delta^*$ *and, hence, party A has excessive incentives to invest as compared with first best investments.*

Proof. (i) For any $\omega \in \Omega$, it follows from (2) that $\Phi^N(\omega, \omega) - \Phi_0^N(\omega) \geq 0$. Moreover, due to the disclosure constraint (4), $\alpha \cdot \sigma^*(\omega) \geq \Phi^N(\omega, \omega)$ and, hence, $\alpha \cdot \sigma^*(\omega) - \Phi_0^N(\omega) \geq 0$ hold for all $\omega \in \Omega_1^N$. It then follows from (6) that $\Delta^v \geq 0$ must hold indeed. Claim (i) is established.

(ii) It follows from B's participation constraint that

$$\begin{aligned} & (1 - p^N) \cdot E\left[\Phi_0^N(\omega)\right] + p^N \cdot E\left[\Phi^N(\omega, \omega) \mid \Omega_0^N\right] \\ \leq \; & (1 - p^N) \cdot E\left[S(\omega, q_0^N)\right] + p^N \cdot E\left[S(\omega, q^N(\omega)) \mid \Omega_0^N\right] \\ \leq \; & (1 - p^N) \cdot E\left[\sigma_0(\omega)\right] + p^N \cdot E\left[\sigma^*(\omega) \mid \Omega_0^N\right] \end{aligned}$$

and, hence,

$$\begin{aligned}(1-p^N)\cdot E\left[\sigma_0(\omega)-\Phi_0^N(\omega)\right] &\geq p^N\cdot E\left[\Phi^N(\omega,\omega)-\sigma^*(\omega)\mid\Omega_0^N\right]= \\ &= p^N\cdot E\left[\Phi^N(\omega,\omega)-\alpha\cdot\sigma^*(\omega)\mid\Omega_0^N\right]\geq 0\end{aligned}$$

must hold. Therefore, since $x^v<1$ and, hence, $p^N<1$,

$$E\left[\sigma_0(\omega)-\Phi_0^N(\omega)\right]\geq 0$$

must hold. Claim (ii) is established.

(iii) It follows from (6) that

$$\begin{aligned}\Delta^v-\Delta^* &= \pi(\Omega_0^N)\cdot E\left[\Phi^N(\omega,\omega)-\Phi_0^N(\omega)-\sigma^*(\omega)+\sigma_0(\omega)\mid\Omega_0^N\right]+ \\ &\quad +\pi(\Omega_1^N)\cdot E\left[\alpha\cdot\sigma^*(\omega)-\Phi_0^N(\omega)-\sigma^*(\omega)+\sigma_0(\omega)\mid\Omega_1^N\right]= \\ &= \pi(\Omega_0^N)\cdot E\left[\Phi^N(\omega,\omega)-\sigma^*(\omega)\mid\Omega_0^N\right]- \\ &\quad -\pi(\Omega_1^N)\cdot E\left[\beta\cdot\sigma^*(\omega)\mid\Omega_1^N\right]+E\left[\sigma_0(\omega)-\Phi_0^N(\omega)\right]\end{aligned}$$

and, since $\beta=0$, from claim (ii) that $\Delta^v-\Delta^*\geq 0$ must hold. Claim (iii) is established as well. ■

If the information has no social value, i.e. $\Delta^*=0$, then, under voluntary disclosure, investment incentives are always excessive as follows from claim (i). Moreover, if party A has all the bargaining power whenever she triggers the cooperative solution, i.e. if $a=1$, then investment incentives remain excessive even if information has social value.

5 Binary trade decision

To gain insights beyond proposition 2, the setting is now simplified to binary trade decisions. In this case, the set of pure decisions contains just two elements $Q_p=\{0,1\}$ and the set of mixed decisions Q coincides with the unit interval $[0,1]$. Under the mixed decision $q\in Q$, trade occurs with probability q whereas no trade is the outcome with probability $1-q$.

At move $\omega\in\Omega$ of nature and decision $q\in Q$, party A's expected utility amounts to $V(\omega,q)=v(\omega)\cdot q$, party B's expected cost to $C(\omega,q)=c(\omega)\cdot q$. If $E[v(\omega)]<E[c(\omega)]$ then, in the absence of information, no trade should take place (i.e. $q_0=0$) and, hence, the surplus $\sigma_0(\omega)=S(\omega,0)=0$ would vanish for all moves of nature.

Particular attention will be paid to two subcases at the extreme edges of the binary trade setting to which I refer to as selfish and cooperative acquisition of information, respectively. Under selfish acquisition of information, the move of nature directly affects only the party who searches for information. More precisely, this means that party A's willingness-to-pay $v(\omega)$ is a function of the move ω of nature but party B's cost of production is not, i.e. $c(\omega) \equiv c_0$ remains constant under all moves of nature.

For cooperative acquisition, it is the other way round. While costs of production $c(\omega)$ now are a function of the move ω of nature, the willingness-to-pay is equal to some constant value $v(\omega) \equiv v_0$.

The following two propositions deal with one of these two subcases each.

Proposition 3 *In the case of selfish acquisition of information (i.e. $c(\omega) \equiv c_0$) the following claims are valid:*

(i) If, in the absence of information, trade would be inefficient then trade will neither take place in equilibrium and $\Delta^* \geq \Delta^v \geq \Delta^m$ must hold, that is even under voluntary disclosure incentives to invest would be insufficient as compared with first best investments. Under mandatory disclosure, investment incentives would even be lower.

(ii) If, under symmetric information, party A has positive bargaining power (i.e. $\alpha > 0$) and if party A observes the true move ω of nature but hides it (i.e. $\omega \in \Omega_0^N$) then the negotiated equilibrium outcome will be ex post efficient, i.e.

$$q^N(\omega) \in \arg\max_{q \in Q} [v(\omega) - c_0] \cdot q$$

must hold.

Proof. (i) Given that trade would be inefficient in the absence of information, expected willingness-to-pay must be lower than the known costs, i.e. $E[v(\omega)] < c_0$. Since $q_0 = 0$, $\sigma_0(\omega) = 0$ must hold for all moves ω of nature.

Moreover, to satisfy party B's participation constraint, $c_0 \cdot q_0^N \leq T_0^N$ must hold (B knows c_0). To ensure the uninformed party A's participation, $T_0^N \leq E[v(\omega)] \cdot q_0^N$ must also hold. Combining the two participation constraints yields $c_0 \cdot q_0^N \leq E[v(\omega)] \cdot q_0^N$ from which $q_0^N = 0$ follows immediately, i.e. trade does not take place in equilibrium. This settles the first part of claim (i).

As a consequence,

$$\Phi_0^N(\omega) = v(\omega) \cdot q_0^N - T_0^N = 0$$

must hold for all moves ω of nature if $E[v(\omega)] < c_0$.

To compare investment incentives, it follows from (6) that

$$\begin{aligned}
& \Delta^* - \Delta^v \\
= \; & \pi(\Omega_0^N) \cdot E\left[\sigma^* - \sigma_0 - \Phi^N + \phi_0^N \mid \Omega_0^N\right] + \\
& +\pi(\Omega_1^N) \cdot E\left[\beta \cdot \sigma^* - \sigma_0 - +\phi_0^N \mid \Omega_0^N\right] \\
= \; & \pi(\Omega_0^N) \cdot E\left[\sigma^* - \Phi^N \mid \Omega_0^N\right] + \pi(\Omega_1^N) \cdot E\left[\beta \cdot \sigma^* \mid \Omega_0^N\right] \\
& -E\left[\sigma_0 - \phi_0^N\right]
\end{aligned}$$

must hold.

The second term is obviously non-negative because $\beta \cdot \sigma^*(\omega) \geq 0$ always holds whereas the third term vanishes as shown in the first part of this proof. The first term, finally, has to be non-negative for the following reason.

If the move of nature $\omega \in \Omega_0^N$ remains hidden then $T^N(\omega) \geq c_0 \cdot q^N(\omega)$ must hold as follows from B's participation constraint. Since the social surplus in equilibrium amounts to $S(\omega, q^N(\omega))$, it follows that

$$\Phi^N(\omega, \omega) = S(\omega, q^N(\omega)) - \left[T^N(\omega) - c_0 \cdot q^N(\omega)\right] \leq S(\omega, q^N(\omega)).$$

As the actual surplus $S(\omega, q^N(\omega))$ cannot exceed the maximum surplus $\sigma^*(\omega)$, it follows that $\sigma^*(\omega) - \Phi^N(\omega, \omega) \geq 0$ must hold for all $\omega \in \Omega_0^N$ and, hence, the first term has to be non-negative as well. The claim $\Delta^* \geq \Delta^v$ is fully established.

To establish the remaining part of claim (i), it follows from (6) that

$$\begin{aligned}
& \Delta^v - \Delta^m \\
= \; & \pi(\Omega_0^N) \cdot E\left[\Phi^N - \phi_0^N - \alpha \cdot \sigma^* + \alpha \cdot \sigma_0 \mid \Omega_0^N\right] + \\
& +\pi(\Omega_1^N) \cdot E\left[\alpha \cdot \sigma_0 - \phi_0^N \mid \Omega_0^N\right] \\
= \; & \pi(\Omega_0^N) \cdot E\left[\Phi^N - \alpha \cdot \sigma^* \mid \Omega_0^N\right] + E\left[\alpha \cdot \sigma_0 - \phi_0^N\right]
\end{aligned}$$

must hold. The first term is non-negative as follows from the disclosure constraint (5) whereas the second term vanishes as was shown in the first part of this proof. Claim (i) is fully established.

(ii) Suppose $\omega \in \Omega_0^N$. If no trade takes place in equilibrium, i.e. if $q^N(\omega) = 0$ then $\Phi^N(\omega, \omega) = 0 \geq \alpha \cdot \sigma^*(\omega)$ must hold as follows from the disclosure constraint (5). Since $\alpha \cdot \sigma^*(\omega) \geq 0$ holds by definition and $a < 1$ by assumption it follows that $\sigma^*(\omega) = 0$ and, hence, that trade would be inefficient indeed.

If, however, trade takes place in equilibrium, i.e. $q^N(\omega) = 1$ then $c_0 = c \cdot q^N(\omega) \leq T^N(\omega) \leq v(\omega) \cdot q^N(\omega) = v(\omega)$ must hold as follows from the two parties' participation constraints. Therefore, if trade occurs in equilibrium then $c_0 \leq v(\omega)$ such that trade would be efficient in this case as well. Claim (ii) is established. ■

Suppose trade would be inefficient in the absence of information. Then, as the above proposition shows, the negotiated outcome under voluntary disclosure will always be ex post efficient.

If, however, trade would be efficient even in the absence of information trade need not necessarily take place under voluntary disclosure. Moreover, comparing the incentives to acquire information may become ambiguous because some terms in the differences $\Delta^* - \Delta^v$ and $\Delta^v - \Delta^m$ are negative such that the comparison of incentives depends on the exact shape of distribution functions. The above proposition, in contrast, holds universally, independent of any particular shape of probability distributions.

The next proposition deals with acquisition of information of the cooperative type. While costs $c(\omega)$ are a function of the move of nature, the utility v_0 from trade remains constant. In this case, party A's payoff has to be constant as well.

Proposition 4 *In the case of cooperative acquisition of information (i.e. $v(\omega) \equiv v_0$), the following claims are true:*

(i) There exists a constant value $n_0 \geq 0$ such that

$$\Phi^N(\omega, \omega) = \Phi_0^N(\omega) = n_0$$

holds for all moves of nature.

(ii) Suppose trade would be inefficient in the absence of information. Then investment incentives under voluntary disclosure are lower as compared with mandatory disclosure, i.e. $\Delta^m \geq \Delta^v$.

Proof. To establish claim (i), use of the incentive constraints is made. In the binary trade setting, the incentive constraints (1) can conveniently be summarized in the following way. For any two moves ω and ω' of nature, the pair

$$\Phi^N(\omega, \omega') \leq \Phi^N(\omega, \omega) \text{ and } \Phi^N(\omega', \omega) \leq \Phi^N(\omega', \omega')$$

of incentive constraints is equivalent to the two constraints

$$[v(\omega') - v(\omega)] \cdot q^N(\omega) \leq \Phi^N(\omega', \omega') - \Phi^N(\omega, \omega) \leq [v(\omega') - v(\omega)] \cdot q^N(\omega').$$

Since, in the case of cooperative acquisition, $v(\omega) = v(\omega') = v_0$, it follows

$$\Phi^N(\omega', \omega') = \Phi^N(\omega, \omega) = n_0$$

must hold for some constant value n_0.

For the uninformed party A, the incentive constraint (3) requires that

$$\begin{aligned} E\left[\Phi_0^N(\omega)\right] &= v_0 \cdot q_0^N - T_0^N = \Phi_0^N(\omega) \geq \\ v_0 \cdot q^N(\omega') - T^N(\omega') &= \Phi^N(\omega', \omega') = n_0 \end{aligned}$$

holds for all moves ω' of nature whereas the incentive constraints (2) require

$$\Phi_0^N(\omega) = v_0 \cdot q_0^N - T_0^N \leq \Phi^N(\omega, \omega) = n_0$$

to hold for all moves ω of nature. Combining the above inequalities leads to the conclusion that

$$\Phi_0^N(\omega) = n_0$$

must also be satisfied for all $\omega \in \Omega$. Claim (i) is established.

To establish claim (ii), it follows from (6) that

$$\begin{aligned} & \Delta^m - \Delta^v \\ = \; & \pi(\Omega_0^N) \cdot E\left[\alpha \cdot \sigma^* - \alpha \cdot \sigma_0 - \Phi^N + \phi_0^N \mid \Omega_0^N\right] + \\ & +\pi(\Omega_1^N) \cdot E\left[\phi_0^N - \alpha \cdot \sigma_0 \mid \Omega_0^N\right] \\ = \; & \pi(\Omega_0^N) \cdot E\left[\alpha \cdot (\sigma^* - \sigma_0) \mid \Omega_0^N\right] + \pi(\Omega_1^N) \cdot E\left[n_0 - \alpha \cdot \sigma_0 \mid \Omega_0^N\right] \end{aligned}$$

must hold. The first term is non-negative because σ^* denotes the maximum surplus whereas the second one must be non-negative because, in the absence of information, trade would be inefficient and, hence, $\sigma_0(\omega) = 0$ must hold for all moves of nature. The proposition is fully established. ■

Suppose, in the absence of information, trade would be inefficient. Then, in the case of cooperative acquisition of information, investment incentives are lower under voluntary than under required disclosure which, in turn, remain insufficient relative to first best. Worse, under voluntary disclosure, the negotiated outcome may even fail to be ex post efficient. In this case, mandatory disclosure clearly outperforms voluntary disclosure on efficiency grounds.

If, however, trade would be efficient in the absence of information then comparing investment incentives may become ambiguous again unless party A has the entire bargaining power (i.e. $\alpha = 1$). Endowed with the entire bargaining power, her investment incentives under voluntary disclosure exceed those under mandatory disclosure as follows from Proposition 2 quite generally whereas mandatory disclosure would lead to the first best solution.

To conclude this section, let me point out that the intensity relations as established by the above propositions need not necessarily hold in the strict sense. In fact, if party A has encompassing bargaining power (i.e. $\alpha = 1$) investment incentives under voluntary disclosure have been shown to be excessive quite generally such that $\Delta^v \geq \Delta^*$ will hold. If combined with the results for the binary trade setting, it follows that party A has efficient incentives to invest under voluntary as well as mandatory disclosure. Yet, at less than full bargaining power (i.e. $\alpha < 1$), the intensity relations established for the binary trade setting may well hold in the strict sense.

6 Conclusion

The acquisition of information prior to sale gives rise to a hold-up situation quite naturally. Since the acquisition takes place before parties have agreed on a contract and since the information may be of specific value for the seller-buyer relationship the setting is reminiscent indeed of the models pioneered by Grossman and Hart (1986). But while in the vast majority of contributions to the hold-up literature parties are assumed to agree ex ante on some contract, incomplete as it may be, in the present setting, they meet for the first time after information has already been acquired and corresponding investments are sunk.

As a substitute for ex ante contracting, disclosure duties are provided and governed by law and by courts. Such duties, if anticipated, affect incentives to search for information. Not unexpectedly, a mere policy choice between required and voluntary disclosure fails to generate efficient incentives for information acquisition and, as usual in a world below first best, comparing incentives on efficiency grounds becomes cumbersome.

Most previous contributions to the hold-up literature assume ex post negotiations to take place among symmetrically informed parties where the outcome can easily be described by cooperative solution concepts such as split the difference. Yet, if acquisition of information prior to sale combined with voluntary disclosure is at stake, such a convenient short-cut is no longer available.

There are two ways out. Either a non-cooperative bargaining game is specified explicitly. Except for very simple specifications, the solution may become difficult to calculate. Alternatively, investment incentives may be derived from constraints that are shared by all bargaining outcomes. The present paper has opted for the second approach.

Under a regime where information can be voluntarily disclosed but cannot be misrepresented, disclosure constraints come on top of the more usual incentive and participation constraints. Use exclusively of such constraints is made to compare incentives for acquiring information prior to sale under mandatory versus voluntary disclosure.

Courts are still struggling with the disclosure topic. Deutsche Telekom which, in 2000, went public with a set of their shares may serve as an illustration. The prospectus contained an estimate of the value of Telekom's real estate. After the stock value of Telekom has fallen substantially, buyers claimed that the estimate of real estate as listed in the prospectus was suffering from a strong upwards bias and has misled the plaintiffs to buy the stocks by mistake. In 2012, the case has been ruled against the plaintiffs and in favour of Deutsche Telekom by a court (OLG) in Frankfurt.

Plaintiffs had accused Deutsche Telekom of outright misrepresentation of information acquired by the seller prior to sale. The present paper concentrates on truthful revelation versus hiding of acquired information only. Including the possibility of outright misrepresentation may be a subject worthwhile for future research where the methods of the present paper may prove useful again.

7 References

Akerlof, G.A. (1970), "The market for 'lemons', Quarterly Journal of Economics 84, 488 – 500.

Che, Y.-K. and Chung, T.-Y. (1999), "Contract Damages and Cooperative Investments", Rand Journal of Economics 30, 84 – 105.

Grossman, S.J. and Hart, O.D. (1986), "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration", Journal of Political Economy 94, 691-719.

Kronman, A.T. (1978), "Mistake, disclosure, information, and the law of contracts", The Journal of Legal Studies 7, 1 – 34.

Shavell, S. (1994): "Acquisition and disclosure of information prior to sale", Rand Journal of Economics 25, 20 – 36.