

Acquisition and disclosure of information prior to sale

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This article analyzes incentives to acquire information about the value of things before sales transactions, and voluntary versus required disclosure of such information. Two distinctions are emphasized: whether information is mere foreknowledge or instead can raise value—has social value; and whether it is sellers or buyers who decide to acquire information. The main conclusions in the model are that voluntary disclosure results in socially excessive incentives to acquire information; mandatory disclosure is socially desirable for sellers; but for buyers, the freedom to keep silent may be needed to spur acquisition of socially desirable information.

1. Introduction

■ The seller or the buyer of something, a business, land, a painting, whatever, may have information about the object of the transaction that is unknown to the other party. Further, the party with private information may or may not choose to disclose—or be obligated to disclose—what he knows prior to the transaction. Moreover, the motive of a party to acquire information about something that may later be sold¹ is influenced by whether he would face a disclosure obligation, for it would lower the expected value of information for him.

In the present article, I examine a model of the acquisition of information and its disclosure, emphasizing two distinctions: whether it is sellers or buyers who decide to acquire information;² and whether information is mere foreknowledge or instead is socially beneficial because it can lead to an increase in value.³ For instance, information about the quantity of oil in an underground reservoir does not have social value if it serves only to

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I am grateful to Daniel Asquith, Richard Craswell, Louis Kaplow, Ivan Png, A. Mitchell Polinsky, Eric Rasmusen, and Kathryn Spier for comments, to Abraham Wickelgren for research assistance, and to the National Science Foundation (grant no. SES-911-1947) for research support.

¹ Parties often exert substantial effort to apprise themselves of the value of things that will be sold; a person will not generally sell or buy something of importance, like a home or a car, without first investigating its value.

² Sellers often have opportunities to obtain information about property, being in possession of it. But buyers frequently have opportunities also: for example, a potential purchaser of a business or real estate can investigate its probable future value; a potential purchaser of a painting can have it appraised. In the model, I make the simplifying assumption that only one party has the opportunity to obtain information, but I discuss informally in the last section the situation where both parties have opportunities to obtain information.

³ Information that gives foreknowledge of an outcome but does not allow for an enhancement in value was studied originally by Hirshleifer (1971).

predict the amount of oil that will be obtained; but information about characteristics of the reservoir (such as its depth and internal pressure) that will enable more oil to be extracted (or allow cheaper recovery) has social value.⁴

The main ideas considered in the model are as follows. First, if information is socially valuable because it can be used to raise value, then its disclosure by a seller to a buyer is clearly desirable; but if information is not socially valuable, then disclosure per se does not matter.

Second, if information is not socially valuable, then effort to acquire it (such as spending on a geologist's report to determine the quantity of oil in a reservoir) is a social waste. Accordingly, a disclosure obligation is socially desirable because it will reduce (to zero in the model) the incentive to acquire information. In contrast, in the absence of an obligation to disclose, information will have positive private expected value; a seller, for instance, could reveal favorable information to secure a higher price but keep silent about unfavorable information.⁵ Thus, in the absence of a disclosure obligation, parties will be led to invest in acquisition of information even though that is socially undesirable.

Third, if information is socially valuable, then effort to acquire it is socially desirable if its cost is lower than its expected value. If sellers are deciding whether to acquire information, they will have an excessive incentive to obtain it in the absence of a disclosure requirement (for essentially the reason given in the previous paragraph). But sellers will make the socially desirable decision about acquisition of information if there is a disclosure requirement. Sellers will have the correct, positive incentive to acquire information even when required to disclose it because they will be able to capture an increase in value due to information (such as that associated with an increase in the amount of oil that can be extracted). If, however, it is buyers who are deciding whether to acquire information, and they are subject to a disclosure requirement, the conclusion is different. Buyers will then have no incentive to acquire information, for they will not be able to capture any increase in value due to information because sellers, being the holders of property rights, naturally enjoy the option of not selling and instead using valuable information themselves. Thus, for buyers to have an incentive to acquire information, they must have the right not to disclose it. Yet if they have this right, their incentive to acquire information will be excessive. Thus, it may or may not be socially desirable for buyers to be free from a disclosure obligation, depending on the particulars of the situation.

The foregoing difference between buyers and sellers concerning the desirability of freedom not to disclose information is, I suggest in the last section of the article, fundamental, not specific to the model studied. In the last section I also address other issues, including the credibility of the information that is revealed by a party, the relative capacities of sellers and buyers to obtain information, information obtained prior to sale versus information obtained after sale, and the ability of the law to enforce an obligation to disclose information.

Before proceeding, it should be noted that this article was stimulated by Kronman (1978), who suggested in an informal study that freedom not to disclose information is often needed as an inducement for acquisition of information.⁶ The present article is also

⁴ In the model, socially valuable information is that which allows an action to be taken that raises the value of the good to the party who possesses it. Another way in which information may raise social value is that it could allow a better match between seller and buyer. It will be apparent that the basic points made here would not be affected were this source of the social value of information taken into account.

⁵ Of course, a seller's silence will lead to an inference by the buyer that if the seller obtained information, it must not have been favorable; this is taken into account in the model.

⁶ Kronman drew on examples, such as a well-known case in which the firm Texas Gulf Sulfur secretly undertook an aerial survey of land to determine its mineral-bearing potential and then bought it without revealing that it contained valuable deposits. Kronman surmised that Texas Gulf Sulfur would not have made the several-million-dollar investment it did in aerial surveys if it would have had to disclose its findings, for then the seller

informed by a series of articles, beginning with Grossman (1981) and Milgrom (1981), that focus on the question of how much information will be disclosed voluntarily by sellers.⁷ The model that I analyze builds on Farrell and Sobel (1983), who first investigated costly acquisition of information prior to disclosure;⁸ I add to their model by allowing for information to have social value and for buyers to be the parties who acquire information.⁹

2. The Model

■ There are two types of parties, risk-neutral sellers of a good and risk-neutral buyers of the good.¹⁰ Each seller has one unit of the good to sell, and each buyer wants to buy at most one unit. Units of the good differ in value, and initially no one knows the value of particular units (for example, of particular parcels of land). However, information about the value of a (unit of the) good can be determined by an expenditure. In the first version of the model, sellers decide whether to make expenditures to acquire information before they meet with buyers; buyers can obtain information only from sellers. In the second version of the model, it is buyers alone who have the opportunity to acquire information.

In each version of the model, two cases are considered: where information about the good has no social value, because it does not increase the value of the good; and where information has social value, because it allows actions to be taken that increase the value of the good.

The analysis identifies, in each case, socially optimal behavior, behavior if disclosure of information is voluntary, and behavior if disclosure is required. The measure of social welfare is the net value obtained from use of goods minus the costs of acquisition of information.

□ **Sellers may acquire information.** The sequence of actions and certain basic assumptions are as follows. First, each seller decides whether to spend an amount to acquire information about his good. Buyers cannot observe whether sellers have acquired information. Second, each seller meets with a buyer and may reveal his information—he chooses to do so if disclosure is voluntary; he must reveal it if disclosure is required. Information revealed by sellers is assumed to be credible, believed by buyers. Third, each seller makes a single demand of a buyer, who either accepts or rejects the demand.¹¹ Fourth, in the

of land would have charged a much higher price. Kronman's article, while insightful in a variety of respects, did not consider the issue of socially valuable information versus mere foreknowledge, nor did it discuss the difference between buyers and sellers (although, as is consistent with the result of this article, most of the examples in Kronman's article in which freedom not to disclose seems socially desirable involve acquisition of information by buyers, not sellers). Another informal study, extending Kronman's, is Schäfer (1991).

⁷ They find that complete voluntary disclosure of information results because a buyer's negative inference from a seller's silence would lead to an unravelling of any situation in which a seller is silent. This complete unravelling does not occur—and some sellers keep silent in equilibrium—under a variety of alternative assumptions: in Jovanovic (1982), information is costly for sellers to disclose; in Farrell and Sobel (1983) and Farrell (1986), information is costly for sellers to acquire; in Shavell (1989a), some sellers are unable to credibly convey information. Okuno-Fujiwara, Postlewaite, and Suzumara (1990) provide a fairly general analysis of conditions under which voluntary disclosure leads to complete disclosure of information.

⁸ Also, Matthews and Postlewaite (1985) study a model with free acquisition of information and disclosure and find that sellers will acquire information and voluntarily disclose it (if they cannot prove that they are ignorant).

⁹ Disclosure of information has been studied in contexts other than the sale of something. For example, a number of articles examine whether oligopolists will benefit from exchanging private information with each other; see, for instance, Novshek and Sonnenschein (1982) and Shapiro (1986). Also, several recent articles ask about the sharing of information between litigants before they decide whether to settle or go to trial; see Shavell (1989b) and Sobel (1989). In addition, one recent article, Craswell (1988), studies acquisition of information before the making of contracts, but does not deal with disclosure.

¹⁰ The case where parties are risk averse is briefly discussed in the concluding section.

¹¹ The conclusions reached would be essentially the same if it were assumed instead that buyers make single offers to sellers; see the last section.

case where information has social value, buyers are able to use the good in a way that depends on the information they receive.

Information has no social value. Define the following notation (which will be employed throughout the article).

- v = value of the good to a buyer; $v \in [0, \bar{v}]$; $\bar{v} > 0$.
- $f(v)$ = probability density of v over the population of buyers; $f(v) > 0$ for all $v \in [0, \bar{v}]$;
 $F(y)$ is the cumulative distribution function (cdf) of f .
- c = cost of acquiring information—of learning v ;¹² $c \geq 0$.
- $g(c)$ = probability density of c over the population of sellers; $g(c) > 0$ for all $c \geq 0$; $G(y)$ is the cdf of g .¹³

It is assumed that each buyer values a particular good in the same way (so that if the seller learns v , he knows exactly what it will be worth to any buyer); that each seller knows his cost c of acquiring information but buyers cannot observe c ; and that v and c are independent random variables.

Social optimality. Because acquisition of information about the good does not raise its value but is costly, the following is clear.

Proposition 1. Suppose that information about the good has no social value. Then it is socially optimal for sellers not to acquire information about their goods.

Voluntary disclosure of information. If disclosure is voluntary, behavior is assumed to be determined by a sequential equilibrium, a situation in which two things are true: first, at each stage, parties act optimally given their information and the strategies of other parties; second, buyers' probabilistic beliefs about silent sellers' types are correct.¹⁴

It is convenient to describe sequential equilibrium by describing the last stage, then the middle and the first stages. At the final stage, a seller who has acquired information and reveals v will make an offer to sell of v , for v is the maximum that the buyer will be willing to pay; this offer will just be accepted. A seller who is silent (either because he chooses not to reveal v or because he does not know it) will make an offer to sell of v^* , where v^* is the maximum that buyers will pay to silent individuals. Thus we must have

$$v^* = \text{mean of } v \text{ conditional on sellers being silent.} \quad (1)$$

We will return to (1) after we identify the sellers who are silent.

At the preceding stage, a seller who knows v decides whether to reveal it. It is evident from what has been said that for a seller who knows v ,

$$\begin{aligned} v \leq v^* &\text{ implies the seller will be silent and receive } v^*,^{15} \\ v > v^* &\text{ implies the seller will reveal } v \text{ and receive } v. \end{aligned} \quad (2)$$

With regard to the initial stage, when the seller decides whether to obtain information, let I equal the expected value of information to a seller. From (2), it is apparent that

$$I = \int_{v^*}^{\bar{v}} (v - v^*) f(v) dv. \quad (3)$$

Notice that the right-hand side of (3) shows that I inheres in the chance that information will be "favorable" —above v^* —in which case the seller will reveal it and obtain a higher

¹² The assumption that information about the value of a good is perfect is inessential.

¹³ The importance of the assumption that c differs among sellers is discussed after Proposition 2.

¹⁴ For the general definition of sequential equilibrium (in finite games), see Kreps and Wilson (1982).

¹⁵ If $v = v^*$, the seller will be indifferent whether to reveal v , but I adopt the convention that he does not; and I make similar assumptions below without further comment.

price than v^* ; and the expression also reflects the seller's ability to keep quiet when v is below v^* (otherwise, the integration would be over the interval $[0, v^*)$ as well, where the integrand $v - v^*$ would be negative). The initial decision of a seller whether to obtain information is therefore

$$\begin{aligned} c \leq I &\text{ implies the seller will spend } c \text{ and obtain information;} \\ c > I &\text{ implies the seller will not obtain information.} \end{aligned} \quad (4)$$

Observe that the total expenditures on acquisition of information are

$$\int_0^I cg(c)dc; \quad (5)$$

these expenditures represent a social waste.

The behavior of sellers and buyers in equilibrium has now been described, presuming that (1), which was not fully specified, has a solution. To be specific, because silent sellers are composed of sellers with $c > I$ —those who do not obtain information—together with sellers with $c \leq I$ and $v \leq v^*$ —those who obtain information but who do not reveal it—we can rewrite (1) as follows:

$$v^* = (1 - p(I))E(v) + p(I)E(v \mid v \leq v^*), \quad (6)$$

where

$$p(I) = F(v^*)G(I)/[1 - G(I) + F(v^*)G(I)], \quad (7)$$

$E(v)$ is the mean of v , and $E(v \mid v \leq v^*)$ is the mean of v conditional on v being less than or equal to v^* . Notice that $p(I)$ is the proportion of the silent sellers who have information and that the mean of v among those sellers who do not obtain information—those for whom $c > I$ —is $E(v)$ because of the assumption that v and c are independent.

Now (6) is an equation involving v^* on both sides (on the right, v^* appears not only in $E(v \mid v \leq v^*)$ but also in I , for, from (3), I depends on v^*). Equation (6) can be shown to have a solution;¹⁶ the solution may not be unique,¹⁷ but for expositional ease I will speak as if it is.¹⁸ It is clear from (6) that $E(v \mid v \leq v^*) < v^* < E(v)$, reflecting the fact that silent sellers include both high-value sellers who do not know their v and whose value is $E(v)$ on average, and low-value sellers who know their v and whose value is $E(v \mid v \leq v^*)$ on average.

We have established the following result.¹⁹

Proposition 2. Suppose that information about the good has no social value and that disclosure of information is voluntary. Then

- (i) Sellers with costs of acquiring information below a threshold I (given by (3)) obtain information and others do not.

¹⁶ Equation (6) has a solution if and only if the function

$$h(v^*) = [(1 - p(I(v^*)))E(v) + p(I(v^*))E(v \mid v \leq v^*)] - v^*$$

equals zero for some v^* (where $I(v^*)$ is given by (3)). Now $h(0) = E(v) > 0$. And for any positive v^* , it is clear that the term in brackets is less than $E(v)$, so that $h(v^*) < E(v) - v^*$. Hence, for all $v^* \geq E(v)$, $h(v^*) < 0$. Because $h(0) > 0$, $h(v^*) < 0$ for $v^* \geq E(v)$, and $h(v^*)$ is a continuous function of v^* , $h(v^*)$ must equal zero for some v^* in the interval $(0, E(v))$.

¹⁷ The solution may not be unique because the function h of the previous footnote may not be monotonic. In particular, the term in brackets can rise or fall as v^* rises because, as the reader can verify, the derivative of p can be positive or negative.

¹⁸ I will do the same below. Nothing rests on this, however; the comparisons I make between equilibrium when disclosure of information is voluntary and when it is not are not affected by the possibility of multiple equilibria.

¹⁹ This result is essentially that of Farrell and Sobel (1983).

- (ii) The resources spent on acquiring information (given by (5)) are a social waste.
- (iii) Sellers who acquire information and learn that their goods have value less than a threshold v^* (determined by (6)) keep silent and receive v^* ; other sellers reveal their information v and receive v , which is greater than v^* .

Several remarks about equilibrium with voluntary disclosure may be of interest. First, the reason for the assumption that the cost c of acquiring information varies among sellers is that if instead c has a single value, so that sellers are identical *ex ante*, there cannot be a uniform equilibrium in which they obtain information. For then, as all sellers obtain information, $G(I) = 1$, so $p(I) = 1$, and thus the right-hand side of (6) equals $E(v \mid v \leq v^*)$; therefore (6) has no solution.²⁰

Second, we must have the assumption that sellers who do not acquire information are unable to demonstrate that this is their situation. Without this assumption, the outcome described in the proposition would not be an equilibrium; for sellers who did not acquire information would want to prove this to buyers in order to obtain a price of $E(v)$ rather than the lower amount v^* . Thus, an equilibrium in which sellers acquire information and remain silent could not exist; that in turn would make information valueless, so that no sellers would acquire it.²¹

Third, it was implicitly assumed that all sellers would be willing to sell their goods, and in particular, that those without information would be willing to sell their goods at the equilibrium price v^* even though v^* is less than $E(v)$. This assumption can be justified by a further assumption that the value of a good to a seller for his own use is $v - k$, where k is large enough that $E(v) - k < v^*$. In the absence of such an assumption, the complicating issue would arise that sellers without information might not sell, a problem similar to the "lemons" problem in Akerlof (1970).

Required disclosure of information. When disclosure of information is required, assume that behavior is determined by sequential equilibrium, as generally described above, but where a seller who acquires information must disclose it.

As before, in the last stage, a seller who reveals v will ask for and obtain v from the buyer. Also, as before, v^* is what is received by silent sellers and is given by (1). However, as silent sellers are exclusively sellers who do not have information, (1) becomes

$$v^* = E(v). \quad (8)$$

²⁰ Lack of existence of such a uniform equilibrium when c is the same for all sellers implicitly reflects the unravelling phenomenon stressed in Grossman (1981) and Milgrom (1981): Were there an equilibrium with silent sellers who obtain information, each silent seller would receive the conditional mean for silent sellers. But any silent seller whose value exceeded the conditional mean among silent sellers would then have a motive to reveal his value—causing an unravelling of equilibrium. (This unravelling argument does not apply when c varies among sellers: the mean among silent sellers is v^* ; and, as was shown, this *exceeds* the mean among silent sellers who are able to disclose their v , due to the presence of silent sellers who are not able to disclose their v —because they did not learn it on account of their c being larger than I .)

There may, however, be nonuniform equilibria when c is the same for all sellers; in such equilibria, sellers are indifferent between obtaining information and not doing so, and a fraction obtain information and the remaining fraction do not. The proof is as follows. Find the v^* such that the single c equals $I(v^*)$. From (3), such a v^* exists if $c < E(v)$. If this v^* is less than $E(v)$, there exists a unique fraction p of sellers who are silent and have information, such that (6) is satisfied for v^* , since $E(v) > v^*$ and $E(v \mid v < v^*) < v^*$. Using this p and $F(v^*)$, one can find the G that satisfies (7): by manipulation of (7), $G = p/[p + F(v^*) - pF(v^*)]$. Thus, if this fraction G of sellers acquires information, there is an equilibrium.

²¹ The same result would occur if sellers were able to make contracts for sale at a contingent price, equal to the value v that the good turns out to have. For then a seller who did not acquire information would want to make such a contract—he would obtain $E(v)$ on average, which exceeds v^* —and a buyer would be willing to make such a contract. Contracts contingent on v may be difficult to make if courts are not able easily to verify v .

And because in the middle stage any seller who has information must reveal it, the value of information to sellers is

$$I = \int_0^{\bar{v}} (v - v^*)f(v)dv = E(v) - v^* = E(v) - E(v) = 0. \quad (9)$$

Hence, no sellers obtain information. (Equation (9) reflects the fact that the expected price received when information is obtained equals the mean, which is the certain price if no information is obtained.) We have established

Proposition 3. Suppose that information about the good has no social value and that disclosure of information is required. Then

(i) No sellers spend to acquire information, so the outcome is socially optimal.

(ii) Sellers offer and receive $E(v)$ from buyers.

Information has social value. Now assume that information v about the good has social value because it allows an action to be taken that increases the value of the good. Specifically, let the action be an investment (or effort),

x = buyer's investment in the good.

$vr(x)$ = value of the good given v and x ; $r(x) > 0$; $r'(x) > 0$; $r''(x) < 0$.

Thus, v is now a parameter determining the value of the good rather than being the value itself; the value of the good net of investment is²²

$$w(v, x) = vr(x) - x. \quad (10)$$

The socially optimal x maximizes (10) and is determined by

$$vr'(x) = 1 \quad (11)$$

where it is positive. Denote by $x(v)$ the optimal x , and note that when $x(v)$ is positive, it is increasing in v .

Social optimality. If a seller acquires information and reveals v to the buyer, the buyer can maximize (10) and choose $x(v)$; if the buyer is not told v , he cannot choose $x(v)$. Thus, if a seller has information, it is optimal for him to reveal it.

If a seller does not have information, the buyer selects x to maximize the expected net return,

$$\int_0^{\bar{v}} (vr(x) - x)f(v)dv = E(v)r(x) - x, \quad (12)$$

so that the x chosen is $x(E(v))$. Hence, the social value of information is

$$\begin{aligned} I^* &= \int_0^{\bar{v}} [w(v, x(v)) - w(v, x(E(v)))]f(v)dv \\ &= \int_0^{\bar{v}} w(v, x(v))f(v)dv - w(E(v), x(E(v))) \\ &= \int_0^{\bar{v}} [w(v, x(v)) - w(E(v), x(E(v)))]f(v)dv. \end{aligned} \quad (13)$$

The first integrand is positive for all v other than $E(v)$ itself, where it is zero. Hence,

²² This particular formulation of $w(v, x)$ is convenient but not of significance; the analysis would be essentially the same for any function $w(v, x)$ such that $w(v, x(v))$ is increasing in v and $x(v)$ depends in a nontrivial way on v , where $x(v)$ is the x that maximizes w given v .

$I^* > 0$, and sellers for whom $c < I^*$ ought to obtain information, and then disclose it whatever it is. To summarize, we have

Proposition 4. Suppose that information v about the good has social value because it affects the optimal level of investment x in the good. Then socially optimal behavior is as follows.

- (i) Sellers whose cost of information is less than its social value (given by (13)) obtain information.
- (ii) Sellers who obtain information disclose it to buyers.
- (iii) A buyer who has information v invests $x(v)$, and a buyer who does not have information invests $x(E(v))$.

Voluntary disclosure of information. The sequential equilibrium is found much as before. In the final stage, if a seller reveals v , he will ask for and obtain

$$w(v, x(v)) = vr(x(v)) - x(v).$$

If a seller is silent, the buyer's willingness to pay w^* is determined by the expected value of the good, conditional on sellers' silence, where the buyer chooses the best x given his information. Thus

$$\begin{aligned} w^* &= \max_x E(w(v, x) \mid \text{silence}) = \max_x E(v \mid \text{silence})r(x) - x \\ &= w(E(v \mid \text{silence}), x(E(v \mid \text{silence}))). \end{aligned} \quad (14)$$

(Equation (14) is the analogue of (1).) Denote $E(v \mid \text{silence})$ by v^* and $x(E(v \mid \text{silence}))$ by x^* , so that

$$w^* = w(v^*, x(v^*)) = w(v^*, x^*). \quad (15)$$

A seller who acquires information will reveal v if and only if $w(v, x(v))$ exceeds w^* , which is to say, if and only if v exceeds v^* . Hence, the value of information to a seller is

$$I = \int_{v^*}^{\bar{v}} (w(v, x(v)) - w^*)f(v)dv. \quad (16)$$

Sellers will acquire information if and only if $c \leq I$. Since silent sellers are those for whom $c > I$ together with those for whom $c \leq I$ and $v \leq v^*$, we have that (6) still applies, but where I in (6) is now determined by (16) rather than by (3). Equation (6) can again be demonstrated to have a solution.²³

Observe that the private value of information (16) is different from the social value (13): the integration in (16) is only over v exceeding v^* , since the seller will reveal only these v , whereas in (13) the integration is over all v ; also, the integrands in (16) and (13) are different. It can be demonstrated that the private value exceeds the social value.²⁴ This

²³ We can proceed essentially as in footnote 16 above. In (16), write w^* as $w(v^*, x(v^*))$, and let $I(v^*) = \int_{v^*}^{\bar{v}} (w(v, x(v)) - w(v^*, x(v^*)))f(v)dv$. Thus, if there exists a v^* such that the function

$$h(v^*) = [(1 - p(I(v^*)))E(v) + p(I(v^*))E(v \mid v \leq v^*)] - v^*$$

equals zero, (6) has a solution, and that there exists a v^* such that $h(v^*) = 0$ follows from the argument given in footnote 16.

²⁴ Because $E(v \mid \text{silence}) < E(v)$, $w^* < w(E(v), x(E(v)))$. Hence,

$$\int_0^{\bar{v}} [w(v, x(v)) - w^*]f(v)dv > \int_0^{\bar{v}} [w(v, x(v)) - w(E(v), x(E(v)))]f(v)dv = I^*.$$

But $\int_{v^*}^{\bar{v}} [w(v, x(v)) - w^*]f(v)dv > \int_0^{\bar{v}} [w(v, x(v)) - w^*]f(v)dv$, since $w(v, x(v)) < w^*$ for all $v < v^*$. Thus, $\int_{v^*}^{\bar{v}} [w(v, x(v)) - w^*]f(v)dv > I^*$.

result is not surprising, for when the seller reveals v he obtains $w(v, x(v))$, and he obtains more than this when he keeps silent (but this reasoning is only suggestive, for it does not refer to the difference between the private and social payoffs when information is not obtained).

We may summarize as follows.

Proposition 5. Suppose that information about the good has social value and that disclosure is voluntary. Then

- (i) The value of information to sellers I (given by (16)) exceeds the social value of information I^* .
- (ii) Sellers with costs of acquiring information below I obtain information and others do not.
- (iii) The amount spent by sellers acquiring information is socially excessive.
- (iv) Sellers who acquire information and learn that their information v is less than a threshold level v^* keep silent and receive w^* ; other sellers reveal their information v and receive $w(v, x(v))$, which is greater than w^* .
- (v) Failure to disclose information by sellers who have information is socially undesirable because buyers do not choose optimal levels of investment even though information is available.

Required disclosure of information. In the last stage, if a seller obtains information and therefore reveals v , he will ask for and receive $w(v, x(v))$. If he does not obtain information and is silent, he will obtain w^* given again by (14), but the mean of v among silent sellers will now be $E(v)$, so that

$$w^* = w(E(v), x(E(v))). \quad (17)$$

Consequently, the value of information to a seller is

$$\int_0^v [w(v, x(v)) - w(E(v), x(E(v)))] f(v) dv = I^*. \quad (18)$$

Accordingly, we have

Proposition 6. Suppose that information about the good has social value and that disclosure is required. Then

- (i) The private value of information equals the social value and behavior is socially optimal.
- (ii) Sellers acquire information if and only if their costs are below the social value of information I^* .
- (iii) Sellers who acquire information then disclose it.
- (iv) Buyers choose optimal amounts of investment given the information sellers supply them.

Conclusion. It has been seen that the obligation to disclose information is socially beneficial in both the case where information does and does not have social value. Allowing sellers to choose whether to disclose information is socially undesirable for two reasons. First, it gives them a socially excessive motive to obtain information because they can conceal unfavorable information. Second, their failure to disclose socially valuable information is itself undesirable.

□ **Buyers may acquire information.** Let us reconsider the model, using the same notation but assuming that it is buyers who alone can acquire information and that their sequence of actions is like that of sellers above. In particular, buyers initially choose whether to acquire information and whether or not to disclose it, if disclosure is voluntary. Then buyers make offers to sellers and, in the case where information has social value, the good is used in a way reflecting available information.

Because the buyer makes an offer to the seller, we now have to specify the value of a good to the seller (before we did not, as we assumed that the seller made a demand to the buyer, except as discussed in the remarks following Proposition 2). We will assume that the value of a good to the seller is less than the value to a buyer by a constant amount. This captures the idea that sellers are in the market as sellers—for they value the goods systematically less than do buyers.²⁵

Information has no social value. Let

$$k = \text{difference between a seller's and a buyer's value of the good; } k > 0$$

so that

$$v - k = \text{seller's value of the good.} \quad (19)$$

Social optimality. As in the last case, the following is clear.

Proposition 7. Suppose that information about the good has no social value. Then it is socially optimal for buyers not to acquire information about the good.

Voluntary disclosure of information. At the final stage, a buyer who has acquired information and reveals v will make an offer to purchase of $v - k$, the value to the seller, which the seller will just accept. A buyer who is silent will make an offer to purchase of $v^* - k$, where $v^* - k$ is the least that sellers will accept from silent buyers. Hence,

$$v^* = \text{mean of } v \text{ conditional on buyers being silent.} \quad (20)$$

At the preceding stage, the following describes whether a buyer who knows v will reveal it.

$$v \leq v^* \text{ implies the buyer will reveal } v \text{ and pay } v - k$$

$$v > v^* \text{ implies the buyer will keep silent and pay } v^* - k. \quad (21)$$

That is, buyers reveal bad news, not good news. The value of information to a buyer is

$$I = \int_0^{v^*} (v^* - v) f(v) dv, \quad (22)$$

and (4) and (5) describe when buyers will acquire information and the total amount spent on information. Also, (20) can be rewritten in a way analogous to (6),

$$v^* = (1 - p(I))E(v) + p(I)E(v \mid v > v^*) \quad (23)$$

where

$$p(I) = (1 - F(v^*))G(I) / [1 - G(I) + (1 - F(v^*))G(I)]. \quad (24)$$

Because $E(v \mid v > v^*) > v^*$, it is apparent that any solution to (23) obeys $v^* > E(v)$,

²⁵ Of course, there are other ways of capturing the idea that sellers value goods less than buyers; the difference between a buyer's and a seller's values needs only to be positive, not a constant. It will be clear to the reader that the conclusions where information has no social value are not sensitive to the assumption that the difference between buyer's and seller's values is a constant. But this assumption may matter where information has social value; see footnote 30 below.

reflecting the presence among silent buyers of those who are voluntarily silent because their true v exceeds v^* .²⁶ In summary, we have

Proposition 8. Suppose that information about the good has no social value and that disclosure of information is voluntary. Then

- (i) Buyers with costs of acquiring information below a threshold I (given by (22)) obtain information and others do not.
- (ii) The resources spent on acquiring information are a social waste.
- (iii) Buyers who acquire information and learn that their information exceeds a threshold level v^* (determined by (23)) keep silent and pay $v^* - k$; other buyers reveal their information v and pay $v - k$, which is less than $v^* - k$.

Required disclosure of information. In this case, proceeding in a way analogous to that in the beginning of Section 2, we obtain

Proposition 9. Suppose that information about the good has no social value and that disclosure of information is required. Then

- (i) No buyers spend to acquire information, so the outcome is socially optimal.
- (ii) All buyers offer and pay $E(v) - k$ to sellers.

Information has social value. Assume that the situation is the same as in the last subsection except that, if the buyer does not purchase the good, the seller's value is $vr(x) - x - k$ because the seller can invest x and obtain a gross return of $vr(x) - k$; that is, continue to assume the seller's value is lower than the buyer's by the constant k .

Social optimality. In this case, (12) again gives the expected value of the good to a buyer if he does not have information and chooses x , and (13) still gives the social value of information I^* . Hence, a buyer should obtain information if its cost is less than I^* , in which case he should choose $x(v)$. However, it is not socially necessary for the buyer to disclose his information to the seller, for it is only the buyer who needs this information (the buyer ought to receive the good, since he values it more). Thus, we have

Proposition 10. Suppose that information v about the good has social value because it affects the optimal level of investment x in the good. Then socially optimal behavior is as follows.

- (i) Buyers whose cost of information is less than its social value obtain information.
- (ii) It is irrelevant whether buyers who have information disclose it to sellers.
- (iii) A buyer who has information v invests $x(v)$, and a buyer who does not have information invests $x(E(v))$.

Voluntary disclosure of information. In the last stage, if a buyer reveals v , he will offer and pay $w(v, x(v)) - k$, which the seller will just accept. If a buyer is silent, he will pay $w^* - k$, where w^* is of the form (14). A buyer will reveal information if and only if $w(v, x(v))$ is less than w^* , that is, if and only if v is less than $v^* = E(v \mid \text{silence})$. The value of information to a buyer involves two elements: saving $w^* - w(v, x(E(v)))$ when

²⁶ To show that (23) has a solution, we need to demonstrate that

$$b(v^*) = (1 - p(I(v^*)))E(v) + p(I(v^*))E(v \mid v > v^*)$$

equals v^* for some v^* , where $I(v^*)$ is given by (22). But $b(E(v)) > E(v)$ and $b(\bar{v}) < \bar{v}$, so that there must exist v^* in $[E(v), \bar{v}]$ such that $b(v^*) = v^*$.

v is less than v^* and he reveals v ;²⁷ and gaining $w(v, x(v)) - w(v, x(E(v)))$ when v is at least v^* and he remains silent.²⁸ The value of information to a buyer is thus

$$I = \int_0^{v^*} [w^* - w(v, x(E(v)))] f(v) dv + \int_{v^*}^{\bar{v}} [w(v, x(v)) - w(v, x(E(v)))] f(v) dv. \quad (25)$$

This can be demonstrated to exceed the social value I^* .²⁹ Buyers will acquire information if and only if $c \leq I$, and (23) will determine v^* , but where I in (23) is determined by (25). In summary, we have

Proposition 11. Suppose that information about the good has social value and that disclosure is voluntary. Then

- (i) The value of information to buyers I (given by (25)) exceeds the social value of information I^* .
- (ii) Buyers with costs of acquiring information below I obtain information and others do not.
- (iii) The amount spent by buyers on information is socially excessive.
- (iv) Buyers who acquire information and learn that their information is less than a threshold level v^* reveal v and pay $w(v, x(v)) - k$; other sellers keep silent and pay $w^* - k$, which is less than $w(v, x(v)) - k$.
- (v) Failure to disclose information by buyers who have information is not itself socially undesirable, since they purchase the good and use their information.

Required disclosure of information. In the last stage, if a buyer acquires information and thus must reveal v , he will pay $w(v, x(v)) - k$ and will obtain $w(v, x(v))$, so he will gain k . If he does not obtain information, he will pay $w(E(v), x(E(v))) - k$ and obtain $w(v, x(E(v)))$, and so gain $w(v, x(E(v))) - w(E(v), x(E(v))) + k$. Accordingly, the value of information to a buyer is³⁰

$$I = \int_0^{\bar{v}} [w(E(v), x(E(v))) - w(v, x(E(v)))] f(v) dv = 0. \quad (26)$$

Hence, no buyers will acquire information, and we have

²⁷ To demonstrate this, observe that with information, his net return is $w(v, x(v)) - (w(v, x(v)) - k) = k$; without information his net return is $w(v, x(E(v))) - (w^* - k)$; subtracting, we obtain $w^* - w(v, x(E(v)))$.

²⁸ If he has information, his net value is $w(v, x(v)) - (w^* - k)$; if he does not have information, his net value is $w(v, x(E(v))) - (w^* - k)$; the difference is $w(v, x(v)) - w(v, x(E(v)))$.

²⁹ Since $w^* > w(v, x(v))$ for $v < v^*$, we have

$$\int_0^{v^*} [w^* - w(v, x(E(v)))] f(v) dv > \int_0^{v^*} [w(v, x(v)) - w(v, x(E(v)))] f(v) dv.$$

Hence, from (25),

$$\begin{aligned} I &> \int_0^{v^*} [w(v, x(v)) - w(v, x(E(v)))] f(v) dv + \int_0^{v^*} [w(v, x(v)) - w(v, x(E(v)))] f(v) dv \\ &= \int_0^{v^*} [w(v, x(v)) - w(v, x(E(v)))] f(v) dv = I^*. \end{aligned}$$

³⁰ If the difference between a buyer's and seller's values is not a constant, the value of information to a buyer will not in general be zero. Suppose, for example, that a seller's value is $z(v, x) = \alpha vr(x) - x$, where $0 < \alpha < 1$. Then an increase in v would raise the value by less for the seller than for the buyer (for whom the value is $vr(x) - x$). Therefore, the buyer would not have to raise the price he offers the seller by as much as the value rises for him. Thus, information may have positive value to the buyer. (Yet information would still have less value to the buyer than the social value, so that the conclusion to be reached that voluntary disclosure may be superior to mandatory disclosure will still hold.)

Proposition 12. Suppose that information has social value and that disclosure is required. Then

- (i) No buyers will acquire information (so that none will disclose it).
- (ii) Buyers purchase goods at the price $w(E(v), x(E(v)) - k$.

We can compare the desirability of required disclosure and voluntary disclosure. The outcome, and thus social welfare, is the same under required disclosure and under voluntary disclosure with regard to all buyers for whom $c > I$, for under voluntary disclosure they will not obtain information. Under voluntary but not required disclosure, buyers for whom $c \leq I$ will acquire information and use it (whether or not they reveal it). Hence, the effect of voluntary disclosure is that for each buyer for whom $c \leq I$, there is an expected social gain equal to I^* achieved at a cost c . It follows that voluntary disclosure of information is superior to required disclosure if and only if

$$\int_0^I (I^* - c)g(c)dc > 0 \quad \text{or} \quad F(I)I^* > \int_0^I cg(c)dc. \quad (27)$$

The second condition is that the increase in value of goods due to information exceeds the costs of its acquisition among buyers for whom $c \leq I$. Condition (27) is also equivalent to

$$\int_0^{I^*} (I^* - c)g(c)dc > \int_{I^*}^I (c - I^*)g(c)dc. \quad (28)$$

The term on the left in (28) is the net social gain due to socially desirable acquisition of information, and the term on the right is the net social loss due to socially undesirable acquisition of information (the loss is positive because $I^* < I$). We therefore have

Proposition 13. Suppose that information has social value. Then voluntary disclosure of information is socially preferable to required disclosure if and only if, under voluntary disclosure, the social gain from those who desirably acquire information exceeds the social loss from those who acquire information even though its cost exceeds its value (see (28)).

Conclusion. We have seen that when buyers are the ones who may acquire information, the situation when information has no social value is analogous to the case when sellers acquire information: allowing voluntary disclosure of information is socially undesirable because it encourages expenditure on information acquisition.

However, when information is socially valuable, the results here are different from before. When disclosure is required, the incentive of buyers to acquire information is eliminated, rather than being reduced to the socially optimal level. Hence, for buyers to be induced to acquire information, they must be allowed to decide whether to disclose it.

It follows that when information has social value, either required or voluntary disclosure of information could be socially better (depending on (27) or (28)).

3. Discussion

■ I now consider several issues going outside the model and how the conclusions would be affected by various changes in assumption.

□ **The identity of the parties making offers and obtaining surplus from transactions.** In the model, the parties who may acquire information make offers and thereby have an advantage in obtaining surplus from transactions, but this assumption is not crucial. Consider the situation where sellers may acquire information that does not have social value and suppose, unlike in the model, that buyers make offers. If a seller reveals his

value v , he then will be offered $v - k$ by the buyer and sell for that amount; otherwise, if a seller is silent, he will receive $v^* - k$, for some appropriate v^* . Hence, sellers will voluntarily reveal v if and only if $v > v^*$. Thus, just as was true in the model, the value of information for sellers will be positive and the outcome will not be socially optimal.³¹ Moreover, if disclosure of information is required, sellers will not acquire information,³² and the outcome will be optimal. Thus, the conclusions will be the same as in the model. Consider next the situation where information has social value and assume that disclosure by sellers is required.³³ Then, again as was true in the model, sellers will have the socially correct incentive to acquire information, for a seller who obtains information and reveals v will obtain $w(v, x(v)) - k$.³⁴

Now consider the situation where buyers may acquire information that has no social value and suppose that sellers make offers. Then if a buyer reveals v , the seller will demand v . Thus, a buyer will voluntarily reveal v if and only if v is less than the equilibrium v^* , and it is again apparent that the situation will be essentially the same as in the model. Also, in the case where information has social value, information will have no value to buyers if its disclosure is required: for then the seller will charge the buyer who acquires and reveals v the amount $w(v, x(v))$.³⁵ In sum, the qualitative nature of the conclusions is not sensitive to the assumption in the model about which party makes offers.

□ Fundamental nature of the asymmetry of position between buyers and sellers.

One of the main conclusions from the model was that required disclosure of information discourages buyers but not sellers from acquiring socially valuable information. The reason for this conclusion, recall, was that because a buyer is someone who by definition does not possess property rights in the good he is seeking, his revealing information that can raise the value of the good will not improve his bargaining position. By telling the seller what he knows, the buyer confers an advantage on the seller, allows the seller to charge more for the good because the good is now worth more to the seller. In contrast, when the seller discloses information that can raise the value of his good, the seller is able to collect more for the good because he does enjoy property rights in the good when he is bargaining. This appears to be a fundamental difference between the positions of buyers and sellers. Thus, I would expect that in many models different from the one I studied—such as a model in which a seller cannot use the good himself but can sell to another buyer (see below)—the conclusion would still hold that requiring disclosure would more strongly reduce buyers' incentives to acquire socially valuable information than it would reduce sellers' incentives.³⁶

³¹ Equation (3) will still determine the value of information and (4) and (5) will continue to apply. The determination of v^* , however, will be different. On one hand, v^* must be such that sellers who do not acquire information are willing to sell; hence we must have $v^* - k \geq E(v) - k$, or $v^* \geq E(v)$. On the other hand, buyers must be willing to pay $v^* - k$; thus, $v^* - k \leq E(v \mid \text{silence}) = (1 - p(I))E(v) + p(I)E(v \mid v \leq v^*)$, where $p(I)$ is defined by (7). That is, v^* must satisfy $E(v) \leq v^* \leq E(v \mid \text{silence}) + k$. This condition can be satisfied for a range of v^* , so the equilibrium, defined in this way, is not unique.

³² A seller who acquires information and discloses it will receive $v - k$, so that his expected revenue is $E(v) - k$, which is what he will receive if he does not acquire information. The value of information to him is therefore zero.

³³ For brevity, I omit the case where disclosure is voluntary.

³⁴ If the seller does not obtain information, he will be paid $w(E(v), x(E(v))) - k$, so that the expected value of information is $\int_0^v [w(v, x(v)) - w(E(v), x(E(v)))] f(v) dv$, which equals I^* .

³⁵ Hence, the buyer's expected return is zero if he discloses information. If he does not acquire information, he will be charged $w(E(v), x(E(v)))$, so his expected return will also be zero. Thus, information will have no value to him.

³⁶ Yet it is not clear that the conclusion would always hold. Suppose that information can only be used by the buyer to increase value (say the buyer is the only party capable of developing mineral deposits). Then requiring the buyer to disclose information might still allow him to obtain significant profit and thus leave him with a reasonable incentive to obtain information.

□ **Credibility of revealed information.** It was assumed in the model that if a party revealed information, he would be believed. This assumption is appropriate if false statements are punished or if the validity of the information can be directly verified, guaranteed by a third party (such as a firm specializing in geological surveys), or warranted in some way.

If information cannot be conveyed credibly, however, a party cannot gain any advantage from revealing it in bargaining. Hence, disclosure rules are irrelevant, and the value of information to a party is solely that he may use the information himself. It follows that when information does not have social value, that is, when it cannot raise the value of a good, information will not be acquired. When information does have social value and it is sellers who may acquire information, it is possible that they will decide to acquire information, but only if they might decide to keep the good for their own use. When it is buyers who may acquire information, they will have the socially optimal motive to invest in it.

□ **Value of a good to a seller: for his own use versus for sale to alternative buyers.** In the model, it was assumed that if a seller did not sell to the buyer with whom he was bargaining, the seller could derive value from the good by using it himself; this value governed the amount the buyer had to offer the seller to induce him to sell. Another possible determinant of the seller's alternative value for the good is the possibility that he could sell it to other buyers. For the most part, taking this determinant into account would not seem to alter the conclusions, but in one respect it would. Suppose that a buyer reveals unfavorable information to a seller (a survey shows that a seller's land is not as valuable as would have been expected) in order to persuade the seller to accept a low price. If the seller is able to keep this unfavorable information secret from an alternative buyer, then the present buyer may not be able to drive down the price by very much. In other words, issues surrounding the transferability of information, not just its credibility between the seller and the buyer, become relevant.

□ **What are the relative abilities of buyers and sellers to acquire information?** In many situations, the seller may enjoy a natural advantage in the ability to acquire information about his good because he possesses the good. Thus, determining the quantity of oil in an underground reservoir may require entry onto the land under which the reservoir is located, or estimating the value of antique jewelry may require that it be handed over to an expert appraiser. In such cases a buyer would be unable unilaterally to acquire information, and the assumption that the seller alone decides whether to acquire information is apposite.

However, possession of property rights in a good is not always necessary for evaluation of worth. In a case involving Texas Gulf Sulfur (see footnote 6), information about land was gathered by a company that did not own it, using an aerial survey. If a buyer is considering purchasing a business, he may obtain significant information about its earnings prospects (by studying the industry, competitors, and so forth) even though he does not have access to its books. Further, a buyer may sometimes have prior knowledge unknown to a seller that leads the buyer to undertake an investigation (as was true with Texas Gulf Sulfur). Hence, it seems that there is a substantial number of instances in which the assumption that buyers but not sellers choose whether to acquire information approximates reality.

An assumption not considered in the model is that sellers and buyers each have an opportunity to acquire information prior to sale, as when either could hire an expert to appraise a piece of undeveloped land. Analysis of this assumption would have to take into account the chance of duplication of effort to acquire information and how such effort

would be influenced by the possibility, or the knowledge if observable, that the other party has acquired information.

□ **Adventitious acquisition of information.** In the model, acquisition of information was assumed to be the product of intentional and costly effort by the buyer or the seller. In fact, however, information may come to a party by accident (as I pass by a secondhand bookstore, for example, and notice a rare book worth thousands of dollars marked for \$5) or as a concomitant of ownership (by virtue of living in my house, I learn whether the basement leaks after a heavy rain). To the degree that this is the case, the issue of incentives to acquire information is moot; thus the freedom to keep information secret is not needed to spur its acquisition, and mandatory disclosure becomes attractive.³⁷

□ **Acquisition of information prior to sale versus after sale.** Acquisition of information was assumed to take place prior to sale in the model, but information can usually be obtained after sale as well. What issues does the latter possibility raise? When information has no social value, acquisition of information after sale has no relevance: no buyer would rationally engage in costly acquisition of information after making a purchase if it could not be used to raise the value of his good. When, however, information does have social value, the situation changes, and it seems that the value of information obtained before sale, both private and social, would be attenuated by the opportunity of buyers to obtain information after making purchases.

□ **Risk aversion.** The effect of risk aversion was not discussed in the model, but it has relevance to disclosure because disclosure affects price. To the degree that information is disclosed, the price will reflect value, so that buyers will bear less risk and sellers more risk. Other things being equal, this will be socially desirable if buyers are risk averse and sellers risk neutral (or buyers are more risk averse than sellers), so that disclosure will become more appealing, whereas if buyers are risk neutral and sellers risk averse, disclosure will become less appealing.

□ **Enforcement of requirements to disclose information.** Whereas it was assumed in the model that disclosure of information could be compelled, actual enforcement of disclosure rules is a nontrivial problem for the law. Enforcement requires discovery of concealment of information, and one suspects that our ability to uncover instances of this behavior is not great. A low probability of detecting concealment, though, can sometimes be offset by a high penalty, so that enforcement might be effective. When it is not, then we are, *de facto* if not *de jure*, in a regime in which disclosure is voluntary.

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³⁷ This point is stressed by Kronman (1978).

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