Dynamic Adverse Selection and Debt

By

Gilles Chemla and
Antoine Faure-Grimaud

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Gilles Chemla

University of British Columbia and CEPR

and

Antoine Faure-Grimaud

London School of Economics and CEPR

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Abstract

In many long-term relationships, parties may be reluctant to reveal their private information in order to bene¯t from their informational advantage in the future. We point out that the strategic use of debt by an uninformed party induces another party to reveal pr

Non Technical Abstract

There is by now a large litterature on the advantages of debt ¯nance based on two sorts of informational asymmetries between external investors and internal managers/entrepreneurs. Essentially debt is viewed either as a useful tool to help solve moral hazard problems, or as a signalling device. Both types of analysis su®er from some shortcommings, the main one being that there is probably some other ways to solve these problems at a much cheaper cost: why not o®ering proper monetary incentive contracts to managers or signalling with other instruments than the ¯nancial structure?

Our idea is that debt makes a big di®erence in situations exhibiting dynamic adverse selection problems. When the interactions with a privately informed party are repeated over time, this party realises that disclosing some information at the current stage not only a®ects current payo®s but also the future informational rents. Compared to a static case, the possibility to repeat a relationship makes information revelation even more problematic. The longer the horizon, the more di±cult the problem. Compared to other types of arrangement, debt has two interesting characteristics: ¯rst it creates a scope for bankruptcy, second renegotiating it in a way which increases the payo®s of everybody is unlikely to be feasible.

We use these features in a particular illustration to make our point. We study the ¯nancing decision of a monopolist selling a good to a buyer who has private information about his true valution for the good. In a long term relationship, i.e. when parties can make more than one o®er to each other, di®erent analyses have shown after Coase that the monopolist is in fact competing with herself over time: her capacity to decrease the price subsequent to a low level of sales creates an incentive for any type of buyer (including buyers willing to pay a high price) to turn down any current o®er. Buyers prefer to wait for a future discount. Hence, even high valuation buyers may refuse to reveal that they are willing to pay a relatively high price for the good at the

beginning of the relationship. Firm's profits are decreased.

We show that in this situation, the strategic use of debt induces the buyer to reveal his information early. The monopolist's contract offers are subject to the constraint that the buyer's expected rents from not revealing information are lower than the utility from revealing it at an early stage. We point out that the strategic use of debt may relax this constraint: not revealing information may lead to cash constrained, and thus inefficient, debt renegotiation ending up in (partial) liquidation which reduces a buyer's expected rent of mimicking a lower valuation buyer. From this point of view, debt is a credible commitment with a third party. Using debt as a mechanism to elicit information enables the monopolist to charge a higher price and to increase her profit.

We then extend the argument to other standard dynamic adverse selection problems, like the Ratchet effect, to show that the conclusion of the analysis are valid in these situations. We also perform some comparative statics exercises regarding the durability of the good sold and we also apply our result to a repeated procurement relationship between a firm and a government agency.

1 Introduction

In May 1989 Sealed Air Corporation (SAC) announced a one-time leveraged special dividend of $40 per share, almost equal to the equity price. Before this announcement SAC had never paid a dividend exceeding 18 cents per share. To ¯nance this special dividend, SAC borrowed $307 million (using private and public debt) representing 136% of total assets. The poor rating of this debt re°ected the risk associated with this operation. Interestingly, this leveraged special dividend was followed by a 29% increase in sales, a 20% decrease in inventories and a 64.5% increase in the operating pro¯t by 1992. The total value of the ¯rm increased by 80% over the same years. There is no evidence whatsoever that these performances were due to exogenous factors[1].

SAC manufactures protective packaging materials. Many of its products were protected from product market competition by patents and the ¯rm entertained long-term relationships with most of its clients. It had been run by the same CEO since 1971 and enjoyed a pro¯table growth during these years. Before the special dividend, SAC was already a successful company.

Some of the spectacular increase in pro¯ts which followed the special leverage of 1989 could be attributed to a \free cash °ow" reduction e®ect (Jensen (1986)). Wruck (1994) points out some evidence in that direction: managers felt that cash °ows were abundant and that the ¯rm did not know what to do with these cash °ows. Nevertheless, although the abundance of cash °ow is a necessary condition for this theory, it is not su±cient: debt increases performance only when managers divert these cash °ows to their own bene¯t instead of paying them out to shareholders: \the problem (with free cash °ow) is how to motivate managers to disgorge the cash rather than invest it at below the

[1] Our source for this information on SAC is Wruck's (1994) excellent paper. In particular, Wruck did not ¯nd any evidence of a takeover threat. She shows that tax shields can only explain a very small percentage of the pro¯t increase. In addition, a signalling argument (Ross (1977)) is not consistent with the poor rating of debt and the absence of abnormal stock price reaction after the announcement of the leveraged special dividend.

cost of capital or waste it through organizational efficiencies. [...] Such cash flow should be paid out to shareholders [...] However, payment of cash reduces the resources controlled by managers" (Jensen 1988). Debt is beneficial because it disciplines managers. Wruck (1994) clearly shows that the whole story of SAC is an example, maybe unusual, of almost no conflict between shareholders and managers: "the evidence for SAC is completely inconsistent with poor performance due to management entrenchment". And the very fact that managers decided to pay out to shareholders this excess of cash (the efficient decision), plus a huge income financed by debt, contradicts the existence of serious agency problems associated with management. Finally, the efficiency effects of a free cash flow reduction are deemed to be more important in a declining industry, which is not the case of SAC.

More generally, there may have been moral hazard issues at different levels of the organization. In the absence of proper monetary incentive schemes, debt may reduce these agency costs. However, there is no evidence of moral hazard problems at low organizational levels or commitment difficulties at higher levels of the hierarchy which seem to be sufficiently important to explain the spectacular increases in efficiency and sales or the substantial decrease in inventories. An alternative argument, not based on any moral hazard issues, may better explain the beneficial role of debt. In the case of SAC, Wruck (1994) suggests that efficiency enhancement was due to a change of "culture". Debt was "a tool to disrupt the status quo". The aim of our paper is to provide an economic explanation of this modification.

One indication of the reasons of this drastic change can be found in an interview given by CFO Hickey (Mintz (1995)): "There was no breakthrough", Hickey says. "Nothing we did could not have been done 10 years ago. The difference was debt. The new urgency to solve problems precipitated solutions"[2].

Our explanation is based on the existence of dynamic adverse selection

[2] Authors' emphasis.

problems in organizations. A well-known example is the ratchet e®ect: agents engaged in a long-term relationship are reluctant to reveal their private information at early stages. For example, a worker refuses to reveal a high productivity because he anticipates more challenging performance requirements and hence the loss of corresponding informational rents in the future. A buyer whose buying decision repeats over time is unwilling to pay a high price today because he expects that the seller will consequently charge high prices for all subsequent periods. In both cases, ¯rm's pro¯ts are decreased by the fact that partners adopt long-term objectives. Debt is bene¯cial because it creates scope for liquidation which may end long-term relationships. Debt forces strategic agents to adopt shorter objectives. The strategic use of debt favours information revelation, i.e. it helps to solve dynamic adverse selection problems.

This paper analyses this basic idea and illustrates it in a particular setting. We study the ¯nancing decision of a monopolist selling a good to a buyer with private information about his valuation[3]. We show that when the relationship is a long-term one, that is when the monopolist charges the buyer on at least two di®erent occasions, the strategic use of debt induces the buyer to reveal his information early. Crucial features of dynamic adverse selection problems are that the buyer's early decision reveals information about his type and that the monopolist (or principal) can use information strategically when deciding on her subsequent contract o®ers. Hence, it is costly for the buyer to reveal information and the monopolist's contract o®ers are subject to the constraint that the buyer's expected rents from not revealing information are lower than the utility from revealing it at an early stage. We point out that the strategic use of debt may relax this constraint: not revealing information may lead to cash constrained, and thus ine±cient, debt renegotiation ending up in (par-

[3] Importantly, our argument that debt favours information revelation is much more general than this illustration. For instance, it holds in a competitive setting with imperfect substitutes but also for internal relationships within ¯rms (e.g. in employer-employee relationships).

tial) liquidation which reduces a buyer's expected rent of mimicking a lower valuation buyer. >From this point of view, debt is a credible commitment with a third party. Using debt as a mechanism to elicit information enables the monopolist to charge a higher price and to increase her pro¯t.

The analysis suggests a number of extensions. First, a crucial feature of our argument is that liquidation a®ects the quantity to be sold in the future. A priori, the monopolist can choose either to produce to order (or adopt just in time manufacturing) or to produce to market. If there is production to market, the quantity o®ered will be available after it is produced regardless of the liquidation decision. Thus, partial liquidation will only restrict the quantity o®ered at the next stage under production to order. Hence, the monopolist's payo® and debt are higher under production to order than under production to market[4].

Second, a dynamic adverse selection problem decreases the monopolist's pro¯t all the more as the good is more durable. Hence, the bene¯t of the strategic use of debt to the monopolist increases with the durability of the good. The more durable the good, the higher the possible increase in price in the ¯rst stage and the lower the pro¯t to be made in the second stage. This suggests that ceteris paribus debt should increase with the durability of the good[5]. This idea that debt may increase the expected pro¯t of a monopolist selling a durable good is to be contrasted with Titman (1984). Titman argues that, other things being equal, when the buyers' valuation depends on after-sale services, debt decreases the value of durable goods: the higher the debt level, the higher the probability of bankruptcy and the lower the ability to grant after-sale services. Hence, the price the monopolist can charge in the ¯rst place is lower with debt. As Titman, we show that the pricing decision

[4] This point that the strategic use of debt works better with a production to order matches SAC's decrease in inventories after 1989.

[5] It also implies that we may expect our e®ect to be particularly relevant in situations characterised by repeated transactions amongst agents: the more important the long-term relationships, the more drastic the \cultural" change associated with leverage should be.

of a monopolist is not independant of her capital structure. But \things are not equal" when buyers anticipate a possible liquidation, and this possibility implies that the monopolist competes less with herself over time. Ignoring the after-sale problem, debt is shown to induce the buyer to purchase earlier at a higher price and allows the monopolist to appropriate a higher share of the surplus. Compared to Titman, our e®ect is likely to be dominant for goods with few maintenance problems, bought once for all by customers. Beyond the durable good monopolist example, we believe that there is a rationale for using debt to break long term relationships which helps ¯x a short-term market failure. The paper can also deal with the ratchet e®ect in employment relationships and show how debt can again help the ¯rm (employer) to overcome this problem. This is why our paper is more generally related to the literature on capital structure and incentives within organizations.

Our arguments should be seen as complementary to those viewing debt as a hard claim to provide incentives in (mostly static) moral hazard models (Jensen and Meckling (1976), Grossman and Hart (1982), Jensen (1986), Hart (1993), Perotti and Spier (1993) or, Zwiebel (1996) amongst others). In situations where agents seem to be relatively willing to exert e®ort (workoholic managers), debt would be of no use. Moreover, most of these theories leave unanswered the question of whether these incentives to e®ort could be provided more cheaply with proper monetary contracts. Under mild commitment assumptions, the moral hazard problems generally considered seem to be relatively easy to solve in that way. This is unfortunately less true for dynamic adverse selection problems: even when long term contracts are available, the possibility of Pareto e±cient renegotiation makes it extremely di±cult to elicit information (La®ont and Tirole (1988)). In our setting, we recognize that the uninformed party cannot commit not to use the information revealed by the informed party, as the optimal long term contract would call for (Baron and Besanko (1984)). Monetary schemes are feasible but likely to be renegotiated. Unlike monetary schemes, debt is a credible mechanism since renegotiation (with a third party) is ¯nancially constrained and thus ine±cient. This is why debt may improve things even in the absence of moral hazard problems or when allowing for monetary schemes.

In a setting where both adverse selection and moral hazard problems are at work, Harris and Raviv (1990) exhibit an informational role of debt where it elicits information which is then used to discipline management. In our paper, debt is only accompanied by a possibility of terminating the relationship, which is su±cient to induce the privately informed party to truthfully reveal its information.

Section 2 describes the strategic use of an optimal debt contract in Coasian dynamics. It provides a number of extensions and applications such as the e®ects of money diversion and cost padding, the timing of production and good durability. In section 3, we address the ratchet e®ect, allowing for variable quantities and non linear pricing rules. We also brie°y discuss how the buyer's capital structure a®ects the monopolist's pricing strategy. Section 4 concludes.

2 Coasian Dynamics and the Optimal Debt Contract

The two basic dynamic adverse selection problems are the Coasian dynamics faced by a durable good monopolist and the ratchet e®ect in long-term relationships. In this section, we ¯rst address the ¯nancing decision of a durable good monopolist to illustrate our argument.

Coase (1972) ¯rst observed that the pricing problem of such a monopolist is constrained by the buyer's expectation that the price will decrease over time. The Coasian intuition is that the durable good monopolist competes with herself over time. When the monopolist charges di®erent consecutive prices, following the rejection of a price, she updates her beliefs about the buyer's valuation and decreases her price over time. Anticipating this, the buyer with a high valuation may be better o® waiting for a decrease in the price before buying.

We point out that a buyer with a high valuation may choose to buy early when the monopolist may be (partly) liquidated before the price decreases. Hence, the monopolist may wish to choose a high level of debt to commit to this ex post ine±cient behaviour. We then give a number of comparative statics results.

We focus on debt renegotiation and describe an \ideal" property of an optimal debt contract. Debt forces a high valuation buyer to pay the static monopoly price at the beginning of the game. In addition, there is no scope for ine±cient liquidation after the sale takes place. The debt

2.1.2 The financial contract

The monopolist has an initial wealth of w and needs capital $K > w$ to buy an asset necessary to enter the product market. K only needs to be paid once at the beginning of the relationship. The firm can be liquidated (and the asset sold), generating a return L_t at the end of stage t whether the good was produced and sold or not. The asset depreciates ($L_1 < K$) and we assume $L_2 = 0$[6]. The liquidation decision can be made either by the monopolist or by the creditor. Entering the product market is profitable. We assume $L_1 < \delta V_l$, where δ is the discount factor common to all agents. That is, liquidating the asset at the end of stage 1 is inefficient if the good is not sold.

Following Hart and Moore (1989, 1996) and Bolton and Scharfstein (1996), we assume that the monopolist can divert cash flows more easily than physical assets. Formally, returns from liquidation are verifiable while profits from the sale of the good are not (they can be used for perks). In other words, the monopolist cannot be convicted of stealing the operational profit. One reason for this is that there is a probability that this profit is null.

We now turn to the set of financial contracts. Before borrowing, the monopolist can invest some of her wealth $w_0 \leq w$ in a two period project with a zero rate of non verifiable return. For instance, the money can be secretly invested in a tax heaven. To bring it back would disclose tax evasion and lead the monopolist to jail or to pay a heavy penalty. Let $w_p = w - w_0$ be the publicly known wealth of the monopolist which is invested in the project described in the previous subsection. The monopolist borrows an amount $B \geq K - w_p$ from a creditor against the pledge to repay R_1 and R_2 at the end of stages 1 and 2 whenever possible. As profits are non-verifiable, feasible contracts can only specify that the firm repays the promised amount or the creditor has the right to liquidate the asset.

[6] in a past version, we investigated the effect of asset durability and qualitative results were unchanged.

Nevertheless, before liquidation takes place, the stream of promised repayments can be renegotiated. This is a central feature of our model: introducing a commitment possibility with a third party would allow the monopolist to commit to a price and, of course, would solve the coasian dynamics. However, such an agreement is not renegotiation-proof because the monopolist could always bribe the third party ex post to lower the price.

At the final stage, the creditor can obtain nothing from the operational profit as the monopolist will always divert it. However, at the first stage, the monopolist may be prepared to give up some of the operational profit to the creditor to avoid liquidation. For simplicity, we also assume that the monopolist has all bargaining power in case of renegotiation in stage 1 and that the creditor cannot seize the monopolist's savings (that is, in stage 1, $B - (K - w_p)$).

Without loss of generality, we assume that the market for creditors is perfectly competitive. All parties are risk-neutral.

2.1.3 Definition of the equilibrium

The sequence of events is as follows:

- In stage 1, the monopolist chooses w_p and w_0 and borrows an amount B from the creditor against the pledge to repay $\{R_t\}$. M charges a price p_1. The buyer decides whether to buy or not. Accordingly, M produces and sells the quantity ordered. Renegotiation may take place and M satisfies her financial obligations.

- In stage 2, if the monopolist carries on, she chooses a price p_2. The buyer chooses whether to buy or not. M sells the asset and repays the creditor.

In case of default, renegotiation implies that a fraction $1 - f$ of the asset is liquidated. The production capacity at stage 2 is then f. Alternatively, $1 - f$ may be thought of as the probability of liquidation following a default. For a given financial contract, a Perfect Bayesian Equilibrium in the product market is defined by:

i) a sequence of prices $\{p_1; p_2\}$ characterizing the monopolist's strategy, conditional upon her beliefs regarding the buyer's type (an offer at date 2 occurs only if the prior offer was rejected). According to the renegotiation outcome, M can supply either a quantity f or 0 at price p_2.

ii) a sequence of buyer's decisions whether to buy or not the good supplied. Let $x_t^i(p_t)$ be the probability to buy at price p_t $(t = 1; 2)$.

iii) a probability distribution defining the monopolist's beliefs derived from equilibrium strategies using Bayes' rule whenever possible.

Our equilibrium definition does not involve the creditor's strategy. This is because, from the creditor's perspective, the market equilibrium is irrelevant since returns are non-verifiable: his strategy depends only on the liquidation values.

2.2 Coasian Dynamics and Financial Constraints

We proceed by backward induction. The strategy of a buyer of type i in stage 2 is:

$$x_2^i(p_2) = \begin{cases} 1 & \text{if } p_2 \leq v_i \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

Let $\lambda_2(p_1)$ be the probability that $i = h$ knowing that p_1 was rejected. The monopolist plays:

$$p_2 = \begin{cases} V_h & \text{if } \lambda_2 V_h > V_l \\ V_l & \text{otherwise} \end{cases} \tag{2}$$

Since the monopolist has all bargaining power with the creditor in the renegotiation game at the end of stage 1, the creditor cannot be repaid more than L_1. The creditor refuses to lend more than L_1. Thus, w_p must satisfy $w_p \geq K - L_1$. Indeed, the creditor will get $D_1 = \min\{R_1; L_1\}$ and $D_2 = 0$.

Given that the market for creditors is perfectly competitive, $D_1 = B$.

Two cases arise:

- if the buyer bought in stage 1, M closes the ¯rm and sells the assets. The creditor is repaid D_1[7].
- if the buyer did not buy in stage 1, then the continuation value is at least $\pm V_l > L_1$. When the creditor liquidates a fraction $1 - f$ of the assets in stage 1, the monopolist loses at least $(1 - f)(\pm V_l - L_1)$. Thus, the monopolist will prefer to pay back in cash ¯rst and liquidate as little as possible. Once the monopolist received B and invested K, the amount of cash left $B - (K - w_p)$ is not high enough to repay D_1 (as $D_1 = B$). Since liquidation is ine±cient, the monopolist will repay as much as possible in cash. Nonetheless, she will have to accept the liquidation of a fraction $1 - f$ of the assets such that $B - (K - w_p) + (1 - f)L_1 = D_1$:

$$f = 1 - \frac{K - w_p}{L_1} \tag{3}$$

When no sale occurs, the monopolist would like to convince the creditor to reschedule the loan, allowing her to produce at full capacity to increase the operating income and hence making possible a higher repayment. But this renegotiation takes one period and in $t = 2$, the liquidation value of the ¯rm is no longer L_1 but $L_2 = 0$. The creditor would refuse such a deal. Note also that forgiving some of the debt today or contracting a new loan to partly repay the debt against a reimbursement at $t = 2$ is impossible: as $L_2 = 0$, D_2 is null[8].

[7] The proceeds of a liquidation triggered by the monopolist are veri¯able.

[8] As long as $L_1 > L_2$, the arguments go through. One may think that following a liquidation M could decide to buy a new asset to replace the initial investment of K. The cost of such a policy is K. It seems natural to assume that the depreciation process is identical to the one which occurred during the ¯rst period. Hence, the liquidation value of an asset bought at the beginning of the second period is also L_1 at the end of $t = 2$. But the di®erence is that now M has no more cash w_p to invest in the project. As $K > L_1$ such a solution is not feasible.

In stage 1, buyers' strategies can be characterized as follows. The buyer of type l cannot expect any surplus if he waits. His strategy in stage 1 is:

$$x_1^l(p_1; R_1) = \begin{cases} 1 & \text{if } p_1 \leq V_l(1 + ±) \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

Indeed, if $p_1 = V_l(1+±)$, then the buyer accepts with probability 1 whatever his type. Consider now $p_1 > V_l(1 + ±)$. A type h buyer is willing to buy at $t = 1$ if and only if he gets at least what he would obtain by deferring his purchase. If he expects a fraction $1 - f$ of the asset to be liquidated in case he does not buy, then he buys with probability 1 for $\{p_1; p_2\}$ satisfying $V_h(1 + ±) - p_1 \geq ±f(V_h - p_2)$. For such prices, a buyer of type h buys with probability 1 and a buyer of type l does not buy. The ex post beliefs of the monopolist are $¸_2 = 0$, i.e. the equilibrium is fully separating. Hence, $p_2 = V_l$ and the maximum fully separating stage 1 price is:

$$\hat{p}_1 = V_h(1 + ±) - ±f(V_h - V_l) \tag{5}$$

Let us now consider the case where the monopolist charges $p_1 > \hat{p}_1$. In this range, only semi-separating equilibria (where type h randomizes) may exist. This type of equilibrium requires the monopolist be indi®erent between $p_2 = V_l$ and $p_2 = V_h$[9]. Therefore, the probability x that a high valuation buyer buys at $t = 1$ must be such that $¸_2 V_h = V_l$, i.e.:

$$¸_2 = \frac{¸_1(1 - x)}{¸_1(1 - x) + (1 - ¸_1)} = \frac{V_l}{V_h} = \frac{¹}{¸} \tag{6}$$

In equilibrium, the buyer of type h must be indi®erent between accepting and rejecting a ¯rst stage o®er. Let $¾_2 = \mathrm{Prob}\{p_2 = V_l\}$. This requires $V_h(1 + ±) - p_1 = ±¾_2 f(V_h - V_l)$. If the buyer did not buy, the monopolist's expected payo® at stage 2 is $±[¾_2 V_l + (1 - ¾_2)\frac{¹}{¸}V_h] = ±V_l$. As the second stage payo® does not depend on the price strategy, the monopolist charges the highest possible price at $t = 1$, i.e. $p_1 = V_h(1 + ±)$.

[9] If $p_2 = V_h$ with probability 1, a buyer strictly prefers buying at $t = 1$. If $p_2 = V_l$ with probability 1, either the equilibrium is fully separating ($p_1 \leq \hat{p}_1$) or the buyer is strictly better o® waiting for the decrease in price.

Therefore, the separating and semi-separating expected utilities of the monopolist are:

$$U_s \equiv \delta f_s V_l + \lambda_1[V_h(1 + \delta(1 - f_s)) + L_1 - (K - w_{p;s})] + w_{0;s} \tag{7}$$

$$U_{ss} \equiv \frac{\lambda_1 - \frac{\mu}{\lambda}}{1 - \frac{\mu}{\lambda}}[V_h(1 + \delta) - (K - w_{p;ss}) + L_1] + \frac{1 - \lambda_1}{1 - \frac{\mu}{\lambda}}\delta f_{ss} V_l + w_{0;ss} \tag{8}$$

where subscripts s and ss hold for separating and semi-separating, respectively[10]. For a given financial contract, the monopolist's equilibrium strategy is to choose p_1 leading to either the separating or the semi-separating outcome according to the values of λ_1. In turn, the financial contract chosen by the monopolist depends on the anticipated equilibrium in the product market.

U_s increases with the liquidated fraction which itself decreases with the wealth invested in the project. A higher liquidated fraction increases the buyer's willingness to buy at stage 1. The monopolist can then charge a higher price to a high valuation buyer. This expected benefit is higher than the expected cost of liquidation -equal to the profit lost at $t = 2$ if the buyer is a low valuation one- for $\lambda_1 \geq \frac{\mu}{\lambda}$. Therefore, the monopolist wants to deposit as much money as possible in the alternative project. Nevertheless, she has to invest a minimum amount $w_{p;s} = K - L_1$ to obtain the funding necessary to enter the product market. In a separating equilibrium, the monopolist makes sure that no sale triggers complete liquidation (the equilibrium value f_s equals zero). The expectation of liquidation induces the buyer to buy, which makes complete liquidation optimal ex post[11].

The monopolist's preferences are different in the semi-separating equilibrium. Whatever the financial contract, the stage 1 price is equal to $V_h(1 + \delta)$.

[10] Following the literature, the parameter values make sure that the (uninteresting) pooling equilibrium is dominated.

[11] This point is similar to Fudenberg et al (1987) where a fixed cost of continuation corresponds here to a decrease in the liquidation value.

Any increase in the liquidated fraction has no positive e®ect on stage 1 profits. In constrast, the possibility of liquidation decreases the stage 2 payo®. Thus, the semi-separating utility is increasing in f and the monopolist wants to avoid the scope for liquidation. To this purpose, she invests all her wealth in the durable good project. We thus obtain:

Proposition 1 : For all $¸_1$, the monopolist invests $w_p = K - L_1$ in the durable good project and borrows $B = L_1 = K - w_p$. Hence, default triggers her complete liquidation. The only equilibrium in the product market is a fully separating one with a stage 1 price $p_1 = V_h(1 + ±)$.

Proof: See Appendix.

The monopolist chooses the fraction to be liquidated in case of default so as to obtain a fully separating equilibrium in the product market. Investing the minimum amount of wealth in the project ensures that a potential semi-separating equilibrium in traditional Coasian dynamics is replaced by a unique fully separating equilibrium. With $w_0 = w - (K - L_1)$, the monopolist is committed to be completely liquidated if the high valuation buyer does not buy. This forces the high valuation buyer to purchase with probability 1 for prices up to his valuation in stage 1. This credible commitment arises from the ¯nancial constraint. Even renegotiable, debt restores full static monopoly power[12].

Note that if the equilibrium were semi-separating without money diversion, then some ine±cient liquidation would occur with probability $(1 - ¸_1)=(1 - \frac{1}{¸})$. Being ¯nancially constrained allows the monopolist to switch to a separating

[12] A Bolton-Scharfstein debt contract would also capture our point. In Bolton and Scharfstein (1996), there is no temporal correlation between the payo®s to the monopolist. In their setup, this implies that the optimal ¯nancial contract is less \tough" than a standard debt contract. In a product market characterized by dynamic adverse selection, the monopolist competes with herself over time. This implies that the optimal Bolton-Scharfstein ¯nancial contract is a standard debt contract where there is liquidation with probability 1 (resp. 0) if low (resp. high) pro¯ts are reported by the monopolist.

equilibrium which implies that inefficient liquidation only occurs with probability $1 - \lambda_1$. Thus, a harder financial constraint and a higher level of debt may decrease the probability of inefficient liquidation.

In addition, in the traditional Coasian dynamics without debt, the low valuation buyer purchases the good when the price goes down. In contrast, the strategic use of debt makes sure that the good is produced and sold to the high valuation buyer only, i.e. with probability λ_1 only. The price is always too high for the low valuation buyer to buy the good. Hence, the strategic use of debt decreases social surplus. This is natural since debt enables the monopolist to restore her static monopoly power.

A related idea on the pricing policy of an indebted dynamic monopolist is that an increase in debt gives the monopolist an incentive to lower prices to increase present profits and meet her financial obligations. However, this point would only hold if the monopolist charged prices above the static monopoly price[13]. Debt would then induce the monopolist to decrease its present price to increase static profits, which would prevent her from discriminating. However, the usual Coasian dynamics involve a commitment problem which makes her charge a price lower than the static monopoly price. Therefore, it is natural that the price increases with the debt level. The threat of liquidation associated with debt makes pricing policy closer to that of a static monopolist.

Is a direct interpretation of Proposition 1 sufficient to fully explain the increase in SAC's profit, the example mentioned in the introduction? According to Wruck, the increase in profit was also due to improvements of the internal efficiency. Even though this proposition emphasizes the the impact of debt on external efficiency, the general principal that debt favours information revelation also holds for internal efficiency. The monopoly case is only one possible illustration[14] More importantly, protective packaging systems are not durable

[13] This can only be an equilibrium strategy in particular cases where

goods. The next section shows that our e®ect pertains even if goods are non durable as long as the valuation of the buyer is private information. It also provides a motivation for the usefulness of debt to solve for internal dynamic adverse selection problems. Nonetheless, it must already be noted that a substantial part of the increase in sales which followed the special dividend can be attributed to the type of e®ect characterized in Proposition 1. The existence of patents protected SAC from competition in many markets. The possibility of bankruptcy may have in°uenced the behavior of large industrial clients in these markets in a way similar to the one described above.

2.3 Extensions and Applications

2.3.1 Cost Padding and Money Diversion

We have seen that the binding ¯nancial constraint, $L_1 = K - w_p$, can be obtained by investing in another two period project. Alternatively, the monopolist could make sure that the liquidation value L_1 is low enough, i.e. that the asset depreciates fast enough. For this, she could initially spend her resources in perks rather than in acquiring skills or material to maintain the asset to a good second-hand value. Cost padding with no \shadow cost", where the manager can appropriate every unit of an increase in K, is also similar to investing in the alternative project. The monopolist could increase K and spend the additional cost in perks.

Corollary 1 : Cost padding up to $K = w + L_1$ is optimal and leads to a unique separating equilibrium with $p_1 = V_h(1 + \pm)$.

The results above are very clear-cut because they assume that the monopolist can fully use the resources she diverts. It may be the case, though, that she can only partly bene¯t from the resources she diverts. Our results are reason-

c_L or c_H.

ably robust to this assumption. As a benchmark case, we turn to a monopolist who cannot enjoy anything from the diverted resources.

Proposition 2 : Assume that the monopolist cannot use the resources she diverts. Then, there exist $¸_a$ and $¸_b$, with $¸_b > ¸_a$ for some parameter values, such that when $¸_1 \in [¸_a; ¸_b]$, the monopolist initially burns $w - (K - L_1)$, borrows up to $B = L_1$ and charges a fully separating price $p_1 = V_h(1 + ±)$.

Proof: See Appendix.

The strategic use of debt in promoting information revelation arises from the feature that no sale triggers complete liquidation. This occurs if no money is left to renegotiate at the end of stage 1. When the only possibility is to burn the money taken away from the project, restoring the static monopoly power entails an additional cost. The range of $¸_1$ such that the equilibrium is separating is reduced by the monopolist's inability to bene¯t from money diversion.

When $¸_1$ is large (when the incentive to discriminate is high), the utility in the separating equilibrium decreases with w_p. She is willing to burn money as it allows her to restore her monopoly power. Nonetheless, she only does so if her utility after burning money is higher than what she would obtain in another equilibrium. This condition is met when $¸_1$ is not too large. By burning money, the monopolist can endogeneize f because it reduces her initial wealth[15].

If money burning is impossible and $¸_1 \in [¸_a; ¸_b]$, then a high cost to undertake the project and/or a low initial wealth (respectively up and down to $K = w + L_1$) are utility increasing. The higher K and the lower w, the greater the scope for liquidation if the buyer of type h does not buy in stage 1 and the

[15] If the monopolist can divert resources to her own bene¯t ex ante, $L_2 > 0$ does not a®ect Proposition 1. If she cannot, the results of Proposition 2 still hold with $¸'_a \leq ¸_a$ and $¸'_b < ¸_b$ decreasing with L_2 (indeed, the fraction liquidated would be $f' = \frac{L_1 - (K - w_p)}{L_1 - \delta L_2}$ for L_2 not too high).

higher his willingness to buy in stage 1. A high cost reduces the pro¯tability of the project, but increases the monopolist's expected payo®.

2.3.2 Financial Constraints and Production to Order versus Production to Market

Our previous results are driven by the assumption that liquidation restricts production. It would not be the case if the monopolist produced to market (before the buyer decision is made). If so, debt would not constrain her capacity to supply the good: even if the ¯rm was totally liquidated, the good would still be available to the buyer and the threat of liquidation would not a®ect the buyer's decision (unless the monopolist owns the delivery technology). Thus, we have:

Corollary 2 : Retaining the assumptions of Proposition 1 or 2 under which the equilibrium in the product market is separating, under production to order, the monopolist's utility and debt are higher than under production to market.

However, in the semi-separating equilibrium, liquidation does not a®ect the buyer's probability of ordering the good in stage 1. Producing to market in stage 1 allows the monopolist to produce one unit before being at least partly liquidated. This increases her stage 2 expected pro¯t. Thus, in the semi-separating equilibrium, production to market dominates production to order.

2.3.3 Debt and the Durability of the Good

Assume that, with probability ®, a buyer ordering the good at stage 1 can still consume it at stage 2. With probability 1 − ®, he cannot consume it any more. In this case, he can buy another good at stage 2, given his ¯rst period decision gave information to the monopolist about his type. We refer to ® as the durability of the good. Whether the good is durable or not is revealed at the beginning of stage 2.

Clearly, the final stage strategies in the product market are as in the durable good case. f is also determined as before. Proceeding as in section 2.2, we obtain:

$$\hat{p}_1 = V_h(1+\alpha\delta) - \delta f(V_h - V_l) \tag{9}$$

$$\begin{aligned} U_s - U_{ss} &= \frac{1-\lambda_1}{1-\frac{1}{\lambda}}\left[V_l(1-\delta+\alpha\delta) + \frac{1}{\lambda}\max\{L_1;(1-\alpha)\delta V_h\}\right] \\ &+ (1-\lambda_1)L_1 + \frac{1-\lambda_1}{1-\frac{1}{\lambda}}(K-w)(\delta V_l/L_1 - 1) \end{aligned} \tag{10}$$

$U_s - U_{ss}$ is still positive and increases with α. We thus obtain:

Proposition 3 : There is a unique fully separating equilibrium with $w_{p;s} = K - L_1$ and maximum indebtness. The increase in the monopolist's utility due to this strategic use of debt increases with the durability of the good.

In other words, the benefit from being financially constrained increases with the durability of the good. This is natural since the less durable the good, the less competition the monopolist faces with herself over time. The special case $\alpha = 0$ refers either to the sale of a non durable good or to the rental of a durable good. In this case, the supplier faces the well-known ratchet effect which is developed in a richer setting in Section 3[16].

3 Ratchet Effect with Menu Offers and Debt

The durable good case makes the monopolist's competition with herself over time extreme. When the good is not durable, the monopolist's profit is still constrained by the ratchet effect. The intuition behind this effect is that a high valuation buyer may refuse to buy the good at a high price as

[16] In a richer setup, the higher benefit from using debt associated with a more durable good may have to be balanced with a lower maximum borrowing amount. If the creditor had some bargaining power, the maximum amount that he would lend (and, for a given w_p, $1-f$) would decrease with the durability of the good. Indeed, when the good is more durable, the expected profit at stage 2 is higher and the monopolist is ready to pay more to keep a high fraction of the asset. Hence, a more durable good implies a higher incentive to be financially constrained but a lower borrowing capacity.

this would reveal information which would induce the monopolist to charge a high price in next stages. The ability to discriminate between types is limited because the high valuation buyer compares his future rent when he mimicks the low valuation one today and when he does not. The positive rent di®erential makes information revelation more di±cult than in the static case (although the problem is not as severe as in Coasian dynamics).

In this section, it is shown that the positive e®ect of debt on information revelation pertains even though (1) the demand curve is more general and the monopolist may use non linear pricing rules (second degree price discrimination) and (2) the buyer is not pivotal. So far, the incentives for a high valuation buyer to buy early were maximized: no sale at $t = 1$ triggered complete liquidation of the monopolist. Here, instead of focusing on renegotiation issues between the monopolist and the creditor, we assume that the former can be liquidated independently of the buyer's decision. Since debt comes together with a possibility of liquidation, it still decreases the expected rent of mimicking a lower type buyer. However, the bene¯t from debt is smaller than in the durable good case[17].

3.1 The Product Market

We extend the previous model to the case where the quantity is variable and where the monopolist can make menu o®ers stipulating a quantity and a tari®. We adapt La®ont and Tirole's (1988, 1993) approach to this dynamic version of Maskin

The good is perishable, i.e. it can be consumed for one stage only. Alternatively, one may consider that the buyer can only rent the durable good. It is assumed that the buyer is not anonymous: in stage 2, the monopolist remembers the ¯rst stage o®er and the buyer's previous decision. Following La®ont and Tirole (1988), we assume that a buyer who bought at $t = 1$ can refuse to consume at $t = 2$ (these authors refer to this strategy as a \take the money and run" strategy). At each stage, the buyer's utility is:

$$U_t^i = \mu_i V(q_t) - T_t; \qquad t = 1; 2: \tag{11}$$

with $\mu_i \in \{\mu_l; \mu_h\}$ and $V' > 0$, $V'' < 0$. Denote the probability $Prob(\mu = \mu_h) =$ ¸$_1$. At each date, the monopolist o®ers a contract $\{q_t; T_t\}$. Therefore, the product market of the previous section is a special case with $q_t \in \{0; 1\}$ and $V_i = \mu_i V(1)$.

For the sake of exposition, we recall the usual results in the static case. If μ_i is perfectly observable by the monopolist, the optimal contract maximizes $T_i - cq_i$, where c is the marginal cost, subject to $\mu_i V(q_i) - T_i \geq 0$. For each type, the monopolist o®ers the ¯rst best quantity (such that $\mu_i V'(q_i^{fb}) = c$) and the buyer receives zero rent. Now, if μ_i is private information to the buyer, the monopolist discriminates the two types by o®ering quantities (see Maskin and Riley, 1984):

$$\mu_h V'(q_h^{fb}) = c \tag{12}$$

$$\mu_l V'(q_l^{sb}) = c + \frac{¸_1}{1 - ¸_1} ¢\mu . V'(q_l^{sb}) \tag{13}$$

where $¢\mu = \mu_h - \mu_l$. A low valuation buyer has no rent, $T_l = \mu_l V(q_l^{sb})$. As $T_h = \mu_h V(q_h^{fb}) - ¢\mu V(q_l^{sb})$, the rent of a high valuation buyer is equal to $¢\mu V(q_l^{sb})$. Let $¼^{AI}$ be the monopolist's pro¯t under asymmetric information, we have[19]:

$$¼^{AI} = ¸_1(\mu_h V(q_h^{fb}) - cq_h^{fb}) - ¸_1 ¢\mu V(q_l^{sb}) + (1 - ¸_1)(\mu_l V(q_l^{sb}) - cq_l^{sb}) \tag{14}$$

[19] In this static case, we assume that no shutdown occurs: it is optimal to sell to the type l buyer because neither ¸$_1$ nor $¢\mu$ is very high.

3.2 The Two-Stage Case with Debt

We assume that when the firm is indebted, there is an exogenous probability of liquidation, $1 - f$. Once more, the analysis in the preceding section may justify why this probability is non null even though liquidation is inefficient.

When the monopolist cannot commit to a particular future contract, the stage 2 contract is the optimal one (ex post) given her beliefs. Let λ_2^k be her belief that the buyer is of type h after the contract k was chosen at stage 1. If $\lambda_2^k < 1$, then the stage 2 offer is the second best static one with beliefs λ_2^k and the profit is $\pi^{AI}(\lambda_2^k)$ this holds when $\lambda_2^k = 0$ as well). If $\lambda_2^k = 1$, M knows that the buyer has a high valuation and offers the first best quantity at a price $\theta_h V(q_h^{fb})$. Consequently, the high valuation buyer's rent is null ($U_2^h = 0$).

We now turn to stage 1. Assume, for the sake of the argument, that the usual second-best contract is offered in stage 1. A type h buyer's incentive constraint is binding, meaning that in stage 1 he is indifferent between choosing $\{q_h^{fb}; T_h^{fb}\}$ and $\{q_l^{sb}; T_l^{sb}\}$. If he picks $\{q_h^{fb}; T_h^{fb}\}$, he is identified as a type h buyer, which implies that $U_2^h = 0$ and that his intertemporal utility equals his first stage utility $\Delta\theta V(q_l^{sb})$. If he chooses $\{q_l^{sb}; T_l^{sb}\}$, he still gets a stage 1 utility $\Delta\theta V(q_l^{sb})$, but since he is not identified as a type h buyer, he has a positive rent in stage 2 ($\delta U_2^h > 0$). Hence, his intertemporal utility is higher, i.e. the usual second-best contract is no longer incentive compatible. Figure 1 illustrates the intuition.

The two points on the bold θ_h-indifference curve represent the static solution. For the high valuation buyer to consume the first best quantity at $t = 1$, the monopolist must lower the first stage payment by $\delta\Delta U_2^h$. ΔU_2^h represents the differential at $t = 2$ for a high valuation buyer between utility deriving from his choices at $t = 1$ ($\{T_l; q_l\}$ or $\{T_h; q_h\}$). The high valuation buyer's rent in stage 2 is greater when the monopolist believes that the type is low. The third point is incentive compatible. Yet, for a high second stage "extra" rent, a high valuation buyer reveals his type only for a large decrease in T_1^h. For this reason, a low valuation buyer may prefer to choose the allocation proposed for the high valuation buyer. This is possible if the low type erroneously identi¯ed as a high type can quit the market at $t = 2$: at this date, the monopolist, believing that the buyer's type is $µ_h$, makes an o®er that is binding out the high valuation buyer's individual rationality constraint. If the low type is forced to accept this contract, his utility is negative and incentive compatibility at $t = 1$ is restored. Under the alternative assumption, screening the di®erent types may not be possible. In particular, if $µ_h - µ_l$ is small (in the continuous case), the translated $µ_h$-indi®erence curve crosses $q = q^{fb}$ below the $µ_l$-indi®erence curve. Even in a 2 type case, di®erent classes of equilibria may arise (according to which incentive constraint binds) and a pooling contract may be optimal.

In this setting, debt alleviates the dynamic adverse selection problem. A type h buyer will enjoy an \extra" rent at $t = 2$ with probability f only: the bene¯t of misreporting his type is lower since the buyer's utility at $t = 2$ will be null with probability $1 - f$[20]. Graphically, the $µ_h$-indi®erence curve is translated by $f \pm ¢U_2^h$).

Proposition 4 There exists $\pm_0(f)$ such that the equilibrium is separating for any $\pm \leq \pm_0(f)$ and pooling otherwise. $\pm_0(\cdot)$ increases with the probability of liquidation.

Proof: Appendix.

An increase in the probability of liquidation favours separating equilibria. The fact that the monopolist may not supply the market in the future decreases the bene¯t of mimicking a low valuation buyer. The strategic use of debt reduces the informational rent given up to the buyer. The cost of debt is that the monopolist may lose the second stage pro¯t. When the discount factor is low, she puts more weight on the present gain than on future losses. The threshold

[20] The existence of a new entrant in stage 2 would not a®ect our result as long as the monopolist's information is not transferable.

increases with the probability of liquidation as more liquidation increases both the ¯rst stage gain and the second stage loss.

Interestingly, this e®ect of debt on the revelation of information would persist if the buyer instead of the monopolist may be liquidated. In this case, debt only advantages the monopolist, provided a bankrupt buyer is replaced by a new one at $t = 2$ (otherwise, debt entails a cost identical to the previous one). An indebted buyer, who decides at $t = 1$ to misreport his type, expects an extra gain at $t = 2$ with probability f. This observation is particularly relevant in the original La®ont-Tirole setting where the \buyer" is a regulated ¯rm. If this ¯rm is indebted, the regulator may obtain information about its cost more easily. Debt forces the ¯rm to adopt short term objectives. As a result, problems of dynamic adverse selection are less severe.

The previous result may also illustrate the relationship between a worker who is privately informed about his productivity and an employer. In a two period model, the ¯rm would o®er a contract stipulating an output and a wage at each date and the worker would have to decide whether or not he accepts to reveal his productivity. The objective, and the constraints as well, of the employer are identical to those of the monopolist; the worker's decision is of the same nature as the buyer's one. Note that, in this type of problem, the assumption that the worker is non pivotal is generally fairly justi¯ed. Now, if the employer cannot commit to a wage and a performance requirement for the two periods, any information revealed in the ¯rst stage will be used strategically. A highly productive worker, anticipating employer's opportunism is reluctant to reveal his type. Such a behavior, at every level of an organization, leads to suboptimal performances. With the same reasoning, it appears that debt may help to solve this dynamic problem. Hence, debt may also promote internal e±ciency. This interpretation is consistent with the SAC example. Wruck emphasizes that the existence of debt has changed internal behaviors. She also shows that prior attempts, without the existence of debt, had failed to achieve this goal. We attribute this cultural change to the existence of a credible possibility, associated with debt, that long-term relationships may be broken. Individuals are then more willing to reveal their information.

4 Concluding Remarks

Focusing on the example of a monopolist engaged in a repeated relationship with a privately informed buyer, this paper has shown that debt can be thought of as a mechanism to elicit information. A strategic use of debt can solve dynamic adverse selection problems and can bene¯t the uninformed party. Our results prove to be quite robust to di®erent extensions of the dynamic problem considered as well as to alternative ¯nancial contracts or product market situations. For instance, our point may also be modelled in a more traditional durable good monopoly setup so that ine±cient liquidation never occurs in equilibrium.

Our argument can be viewed as complementary to moral hazard ones like the free cash °ow theory to help understand the way \hard claims" like debt can promote e±ciency in organizations. It is to be contrasted with signalling theories of ¯nancing decisions as well (see, for instance, Ross (1977), Myers and Majluf (1984)). These theories typically analyze the ¯nancing decisions of a privately informed manager facing uninformed investors. In this paper, there is no such asymmetric information. The ¯nancing decision is made by an uninformed party engaged in a long-term relationship with another privately informed party. We are not aware of any other theory of debt considering this type of situations.

Our point also holds for other ¯nancing arrangements which increase the threat of terminating a long-term relationship. For instance, it applies to leveraged buyouts. It is consistent with empirical results which indicate that the increase in debt inhere

nt to LBOs leads to an increase prices and pro¯ts (Chevalier (1995)). It is not by chance that eight years after its spectacular leveraged special dividend, Sealed Air Corporation has decided both to both buy a company nearly twice its size and to engage

in another recapitalization (Mintz (1995, 1997)).

APPENDIX:

Proof of Proposition 1:

The monopolist allocates w between w_p and w_0. The way she allocates money among the two projects enables her to manipulate the fraction of the asset she can keep if the buyer does not buy the good in stage 1.

$$U_s = \delta f_s V_l + \lambda_1[V_h(1+\delta(1-f_s)) + L_1 - (K - w_{p;s})] + w - w_{p;s} \quad (15)$$

$$U_{ss} = \frac{\lambda_1 - \frac{1}{\lambda}}{1-\frac{1}{\lambda}}[V_h(1+\delta) - (K - w_{p;ss}) + L_1] + \frac{1-\lambda_1}{1-\frac{1}{\lambda}}\delta f_{ss} V_l + w - w_{p;ss} \quad (16)$$

U_s decreases with f_s and U_{ss} increases with f_{ss}. The monopolist chooses between a separating equilibrium with $f_s = 0$ (investing $L_1 - (K - w_{p;s})$ in the alternative project) and a semi-separating equilibrium with a f_{ss} as high as possible (where $w_{p;s} = w$, i.e. all the money is invested in entering the durable good market). The separating payoff dominates the semi-separating one if and only if:

$$\lambda_1 V_h(1+\delta) + w - (K - L_1) > \frac{\lambda_1 - \frac{1}{\lambda}}{1-\frac{1}{\lambda}}[V_h(1+\delta) + L_1 - (K - w)] + \frac{1-\lambda_1}{1-\frac{1}{\lambda}}[L_1 - (K - w)]\delta V_l / L_1 \quad (17)$$

which is always satisfied. In addition, it is easy to check that the pooling equilibrium is always dominated by the separating one with $f_s = 0$. □

Proof of Proposition 2:

Assume now that the monopolist cannot appropriate any resources she diverts from the project. She cannot manipulate f (which is fully determined by L_1

and $K - w_p$) without completely wasting the resources she diverts. In this case, there is a tradeo® between having more money initially and making more pro¯t by being ¯nancially constrained. The separating outcome with money burning requires that:

- The separating utility decreases with w_p. This holds if and only if $¸_1 >$ $±V_l=[(±V_h - L_1)$. In this case, U_s is maximised when $w - (K - L_1)$ is burnt, which implies $f = 0$ and leads to $U_s = ¸_1 V_h(1 + ±)$.
- This outcome is preferred to both the semi-separating one and the pooling one (when no money is burnt since the monopolist's utility increases with w in both cases). This holds if and only if:

$$¸_1 \leq ¸_b \equiv \frac{V_l(1 + ±) - (±V_l=L_1 - V_l=V_h)(L_1 - (K - w))}{V_l(1 + ±) - (±V_l=L_1 - 1)(L_1 - (K - w))} \tag{18}$$

$$¸_1 \geq V_l=V_h + (L_1 - (K - w))=V_h(1 + ±) \tag{19}$$

$¸_b$ increases with K, decreases with w and equals 1 when $L_1 = K - w$.

The result is obtained with $¸_a \equiv \max\{±V_l=[(±V_h - L_1)]; V_l=V_h + (L_1 - (K - w))=V_h(1 + ±)\}$. □

Proof of Proposition 4:

Following La®ont and Tirole, we assume that the monopolist o®ers two contracts in stage 1: $\{q^0; T^0\}$ for the low valuation buyer and $\{q^1; T^1\}$ for the high valuation one. Let x be the probability that a high valuation buyer chooses $\{q^0; T^0\}$ and y be the probability that a low valuation buyer chooses $\{q^0; T^0\}$. The updated probability that $µ = µ_h$ given that $\{q^k; T^k\}$ was chosen in stage 1, $¸_2^k$, satis¯es:

$$\lambda_2^1 = \frac{\lambda_1(1-x)}{\lambda_1(1-x) + (1-\lambda_1)(1-y)} \tag{20}$$

$$\lambda_2^0 = \frac{\lambda_1 x}{x\lambda_1 + y(1-\lambda_1)} \tag{21}$$

We solve the game by backward induction. In stage 2, the monopolist's program, offers and profit are those of the static case given λ_2^k. In stage 1, the monopolist's program can be written:

$$\begin{aligned}
\max_{\{q^0;T^0;q^1;T^1\}} \quad & \lambda_1[x(T^0 - cq^0) + (1-x)(T^1 - cq^1)] \\
& +(1-\lambda_1)[y(T^0 - cq^0) + (1-y)(T^1 - cq^1)] \\
& +\delta f[(\lambda_1 x + (1-\lambda_1)y)\pi^{AI}(\lambda_2^0) \\
& +(\lambda_1(1-x) + (1-\lambda_1)(1-y))\pi^{AI}(\lambda_2^1)] \qquad (22)
\end{aligned}$$

$$\begin{aligned}
s{:}t{:} \quad (IC_h) \quad & \theta_h V(q^1) - T^1 + \delta f U_2^h(\lambda_2^1) \geq \theta_h V(q^0) - T^0 + \delta f U_2^h(\lambda_2^0) \\
(IC_l) \quad & \theta_l V(q^0) - T^0 \geq \theta_l V(q^1) - T^1 \\
(IR_h) \quad & \theta_h V(q^1) - T^1 + \delta f U_2^h(\lambda_2^1) \geq 0 \\
(IR_l) \quad & \theta_l V(q^0) - T^0 \geq 0
\end{aligned}$$

It is clear that (IR_l) is binding. In the Laffont-Tirole setting, 3 cases may arise: either only (IC_h) is binding, or only (IC_l) is binding or both bind. It turns out that in our case either only (IC_h) is binding or the solution is pooling. This difference arises because, in the Laffont-Tirole monopolist case, the isoprofit curves are strictly convex. So we have two types

$$
\begin{aligned}
\Pi = {} & \lambda_1[x(\theta_l V(q_l^{sb}) - c q_l^{sb}(\lambda_1)) + (1-x)(\theta_h V(q_h^{fb}) - c q_h^{fb})] \\
& - \lambda_1[\Delta\theta V(q_l^{sb}(\lambda_1)) + \delta f\, \Delta\theta V(q_l^{sb}(\lambda_2^0))]
\end{aligned}
\tag{23}
$$

$$
\begin{aligned}
& + (1-\lambda_1)[\theta_l V(q_l^{sb}(\lambda_1)) - c q_l^{sb}] \\
& + \delta f[(\lambda_1 x + (1-\lambda_1))\pi^{AI}(\lambda_2^0) + \lambda_1(1-x)\pi_1^{FI}]
\end{aligned}
\tag{24}
$$

Type II equilibrium is pooling. The best pooling equilibrium is such that $\theta_l V'(q^p) = c$, i.e. $q^p = q_l^{fb}$ and gives the monopolist a payoff:

$$
\Pi^p = \pi_1^p + \delta f \pi^{AI}(\lambda_1) \tag{25}
$$

The best type I equilibrium is separating with $x = 0$, yielding an expected payoff:

$$
\begin{aligned}
\Pi^s = {} & \lambda_1(\theta_h V(q_h^{fb}) - c q_h^{fb}) - \lambda_1[\Delta\theta V(q_l^{sb}(\lambda_1)) + \delta f\, \Delta\theta V(q_l^{sb}(\lambda_2^0))] \\
+ {} & (1-\lambda_1)[\theta_l V(q_l^{sb}(\lambda_1)) - c q_l^{sb}] \\
+ {} & \delta f[(1-\lambda_1)\pi^{AI}(\lambda_2^0) + \lambda_1 \pi_1^{FI}]
\end{aligned}
\tag{26}
$$

In this case, since $\lambda_2^0 = 0$, we obtain, by denoting $\pi_0^{FI} \equiv \pi^{AI}(0)$:

$$
\begin{aligned}
\Pi^s = {} & \pi^{AI}(\lambda_1) - \delta f \lambda_1 \Delta\theta V(q_l^{fb}) \\
+ {} & \delta f[(1-\lambda_1)\pi_0^{FI} + \lambda_1 \pi_1^{FI}]
\end{aligned}
\tag{27}
$$

By definition of $\pi^{AI}(\lambda_1)$, we have:

$$
\lambda_1 \pi_1^{FI} + (1-\lambda_1)\pi_0^{FI} - \Delta\theta \lambda_1 V(q_l^{fb}) < \pi^{AI}(\lambda_1) \tag{28}
$$

Otherwise, the optimal second best contract would not maximise the monopolist's payoff in the static case. Using the same argument, it is clear that $\pi^{AI}(\lambda_1) > \pi_1^p$. Hence, $\Pi^p < \Pi^s$ if and only if:

$$¼_1^p - ¼^{AI}(¸_1) < ±f[(1 - ¸_1)¼_0^{FI} + ¸_1¼_1^{FI} - ¢µV(q_l^{fb}) - ¼^{AI}(¸_1)] \tag{29}$$

that is if and only if:

$$± < \frac{¼^{AI}(¸_1) - ¼_1^p}{f[¢µV(q_l^{fb}) + ¼^{AI}(¸_1) - (1 - ¸_1)¼_0^{FI} - ¸_1¼_1^{FI}]} \tag{30}$$

Denoting the right hand side by $±_0(f)$ gives the result. □

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