ASYMMETRIC INFORMATION IN A BILATERAL MONOPOLY

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ABSTRACT. This paper explores the role of the asymmetry in information in business to business (B2B) transactions. In a vertical setting with successive monopolies we present the equivalence that holds under complete information, that is, the profitability of the powerful party does not depend on its position in the industry and we investigate how potential information advantages affect this relationship. We demonstrate that under asymmetric information this equivalence breaks down and a firm that is positioned in the downstream sector reduces more effectively the information rents that it has to sacrifice for a truthful reporting, but the consumers remain indifferent. Under wholesale price contracts consumers prefer the less informed party to be at the downstream level since the excessive pricing distortion is less intense. Moreover, if second degree of price discrimination is not allowed then the principal prefers to be at the upstream level of production and consumers are better off in this case which comes in contrast to our previous results.

1. Introduction. Asymmetric information is a common occurrence in real economic activity and a prevalent phenomenon in business to business (B2B) transactions. Economists have paid enough attention in situations where informational asymmetries exist between the parties in a particular relationship. There is a whole literature based on the well-known principal-agent model which focuses on the consequences of the asymmetry in information on the principal(s), on the agent(s) and on welfare. In fact this partial equilibrium model is a Stackelberg model where the party that acts first can be either informed or uninformed. We focus on a situation where the uninformed party acts first, known as the screening case, and by offering a contract it tries to separate-screen the different types of the contracted party. The interesting side of this phenomenon comes from the fact that the privately informed parties use that piece of information strategically. They want to use it so as to increase their payoff and secure some (information) rents if that is possible. It is clear that we are interested in situations where information matters that is when it affects the payoffs of both sides.

Given that less information brings one party at a worse position, we must note that any information disadvantages cause distortions that arise in comparison to the full information case. These distortions may concern less profit of one party,
worse performance of the whole market and/or welfare reduction. In this paper we use a bilateral monopoly and deal with a pure adverse selection problem where the party who acts first suffers from hidden information.

Our main interest is to investigate a contracting problem in a vertical chain that is represented by a bilateral monopoly in the presence of asymmetric information. Following the standard approach of the principal-agent model in a vertical setting we check what would be the market performance in such an environment. We combine two main things from the literature, vertical contracts and asymmetry in information. Vertical contracts refer to contracts that are employed in a vertical production chain, that is between upstream and downstream firms. The interesting thing in the relationship between the parties in the two sectors stressed upon the fact that any action performed by any of them directly affects the profits of the others, that is vertical externalities exist. A common approach it is followed in the literature is that the upstream firms have the bargaining power and they make take-it-or-leave-it offers to the downstream ones. The usual contracts or vertical restrains include besides simple wholesale prices, non-linear prices, exclusive clauses, quantity fixing, resale price maintenance etc. Asymmetry in information and adverse selection (hidden knowledge) models is a quite extensive literature and describes situations where some of the participants have more information for a specific characteristic. In particular in our vertical framework, one party may be less informed about the demand parameter or about the unit production cost. The principal is uninformed and acts first by proposing the contract terms. It uses any of the available instruments in order to screen the different types it faces where the standard trade-off between rent extraction and efficiency takes place. In the screening case the principal attempts to eliminate as much as possible the rents that the informed party will get by being constrained of what efficiency commands.

Bearing in mind all these ideas from the two literatures, vertical contracting and adverse selection, we compare two different cases: (i) U does not know the cost of D and it must propose a two-part tariff contract (it has all the bargaining power), (ii) D does not know the cost of U and now this party has all the bargaining power proposing the exact contract terms. In these two cases we assume extreme form of bargaining power either for the upstream firm or for the downstream one. Our aim is to investigate how the position of the uninformed party in the industry affects the total surplus (total profits), the welfare (consumer surplus plus profits) and each firm’s profits. The motivation for this work comes from the fact that in the complete information case the total surplus that is created in such a relationship is the same in both cases and this holds also for the welfare. The party who has all the bargaining power appropriates the rents. The main question is what happens in the presence of asymmetric information, does this “equivalence” hold?

1 A vertical chain is usually described in the literature as a combination of two sectors, the upstream and the downstream sector. In the upstream sector we usually include wholesalers or input manufacturers known as upstream firms (U’s) while in the downstream retailers or final good producers known as downstream firms (D’s).

2 Some well-known vertical externalities that arise in such a setting include the “double marginalization” problem first identified by Spengler (1950) or the underprovision of services due to the free-riding problem proposed by Telser (1960). For more details see Tirole (1988), Motta (2004).

3 The cases we cover are reminiscent of Coase Bargaining where the information asymmetry can be interpreted as a transaction cost. Our aim is to enrich the analysis by considering the vertical aspect and the consequences of this relationship to the final consumers.
It is common wisdom that asymmetric information plays a central role in the contracting between U and D by introducing two sources of inefficiency. The uninformed party in order to induce the informed one for truthful revelation must give up some rents (known as information rents). These rents can be exploited by the informed party because it can always pretend to be inefficient (high cost) even though its actual cost is low. Since the uninformed party cannot extract all the profits of the informed one there is a distortion, a “distributional” distortion, compared to the full information benchmark case. In addition we know that the profits (information rents) of the informed party depends positively on the quantity or negatively on the retail price and a second distortion arises the “excessive price” distortion because the uninformed party must not give incentives to the informed party to lie. This second distortion can be interpreted as double marginalization, the wholesale price is higher than the one with complete information and this creates a welfare loss.

In our model we use an industry which consists of one upstream (U) and one downstream (D) firm under the presence of asymmetric information about the unit cost. The paper considers with two cases that we described above and the uninformed party (the principal) can be either the upstream or the downstream firm and in any case it is the principal who has the bargaining power. We demonstrate that a downstream principal can restrict information rents more effectively than an upstream principal but the final consumers remain indifferent between the two possible scenarios. Under wholesale price contracts still holds that a firm prefers to locate itself at the downstream sector. In this case though the consumers strongly prefer the powerful party to be the downstream firm. We find also that in a restricted environment with a single two-part tariff contract our results change and the less informed party prefers to be present at the upstream sector. Comparing the three pricing schemes we find that for the final consumers screening is superior scheme that the others.

Our paper is clearly related to the literature on vertical contracting and adverse selection. In contrast to the existing papers our main intention is to shed light on how the position of the less informed party - either upstream or downstream - affects the participating firms and the final consumers. Also, we focus on the importance of the contract type that is used and whether second degree price discrimination is desirable for the final consumers. We present below some well-known works in this field where all of them use successive monopolies and it is the upstream firm which has all the bargaining power. The first paper appeared in 1986 by Rey and Tirole where they compare three different regimes, one where the manufacturer decides what the retail price would be called RPM, one where it segments the downstream market creating local monopolies and a third one where pure competition between downstream units takes place. They demonstrate that even that the manufacturer can use vertical restraints it is unable to reproduce the first-best outcome. In an elegant study Gal-Or (1991)[9] where she uses successive monopolies under asymmetric information comparing two contract types quantity forcing (equivalent to FF contracts) with RPM contracts and focuses on the two main distortions that arise. In the same spirit Martimort and Piccolo (2007)[14] use the same contract types, compare them adding also a moral hazard issue. In addition Crocker (1983)[8] presents the advantages of vertical integration by underlying that a vertically integrated firm can reduce the distortions that arise due to the strategic use of the information. Blair and Lewis (1994)[3] has also presented a similar work with one

\footnote{It is the only paper where they do not use successive monopolies.}
upstream and one downstream firm but they use a general demand specification (the others used linear demand) with both adverse selection and moral hazard. They show that the optimal contract exhibit some form of RPM and quantity fixing. Finally, Corbett Zhou and Tang (2004)[7] find that two-part contracts and holding better information are strategic complements where achieving one increases the incremental value of the other.

In all the above mentioned works the principal (i.e. the uninformed party) is at the upstream level of the industry. What is novel in this paper is that we compare the case with the uninformed party at the upstream sector with the case where the uninformed party is at the downstream sector that none of the previous works has done. We investigate how a firm’s position in the vertical chain changes its profits by affecting the information rents that are necessary for a truthful report. This is crucial in the analysis of vertically linked firms since lately there is a strong evidence that the downstream firms have increased their power and it is often that due to countervailing power they set the terms of the transaction. In many cases downstream firms participate actively in the contracting procedure and a nice example comes from the food industry where large supermarkets are able to set the contract terms.\(^5\) Thus, by examining both cases, where either the upstream or the downstream firm has the bargaining power, our aim is to provide a complete analysis.

Our work is organized as follows; in section 2 we present the model specification and in section 3 we present the complete information solution. In section 4 which is the main part of the paper we solve the model under asymmetric information and extreme forms of bargaining power. Section 5 covers what happens when we switch from two-part tariffs to wholesale price contracts and section 6 shows how the results change with a single two-part tariff. Section 7 informs us about consumers welfare and under which pricing regime it gets its highest value and section 8 discusses the case with asymmetry of information about the demand and how we solve for the optimal contract with a continuum of types demonstrating that nothing is specific to the two-type model. Finally, section 9 concludes.

2. The model. The industry consists of two risk-neutral agents, one upstream and one downstream firm described as a bilateral monopoly. We distinguish two possible cases by analyzing different scenarios about the position of the powerful and at the same time less informed party in the industry: (i) U has all the bargaining power and makes take-it-or-leave-it offers, (ii) D has all the bargaining power and this firm makes take-it-or-leave-it offers. In the former case the upstream firm uses the downstream division in order to sell its product to the final consumers. \(U\) proposes the downstream division in order to sell its product to the final consumers. \(U\) proposes the optimal contract that brings the highest profit. In the latter case the downstream firm uses an upstream manufacturer to provide an input or an intermediate product. There is a principal-agent relationship where the principal delegates a task to the agent and we characterize one party as the principal if it is uninformed and acts first. Therefore, in case (i) the principal is the upstream firm while in case (ii) it is the downstream firm that takes the role of the principal. The asymmetry in information refers to the marginal cost of production. We assume for simplicity that the informed party (\(U\) or \(D\)) has a cost either high (\(c_H\)) or low (\(c_L\)) which is unknown to the other party.\(^6\) The less informed party knows only the cost

\(^5\)See e.g. Chen (2003)[5], (2007)[6] and Inderst & Mazzarotto (2006)[11].

\(^6\)See the Appendix for a brief description of the analysis with a continuum of types.
distribution \( \text{prob}(c_i = c_L) = \theta \) (\( \text{prob}(c_i = c_H) = 1 - \theta \)) and has a marginal cost equal to \( z \) that is common knowledge. We restrict our attention in two-part tariff contracts (or franchise fee FF contracts)\(^7\) that consist of a wholesale price \( w \) and a fixed fee \( f \). Two-part tariff contracts are equivalent to quantity fixing contracts as they described in Gal-Or (1991).\(^8\) The inverse demand is a linear one \( p(Q) = a - Q \). The agent who receives a contract offer has not the option for a counteroffer, if it rejects then its payoff would be zero.

The timing of the events is the following: Initially it is the principal who makes an offer and then the agent accepts or rejects the offer. If it rejects the game is over but if it accepts final price or quantity appears given the exact contract terms. Of course in cases like this using a direct truthful mechanism there is a communication stage where a message is sent by the informed party, but in our case here in this two type model we lay on standard revealed preferences arguments. In order to find the incentive feasible allocations we restrict attention to contracts which induce truthful reporting invoking the revelation principle (See Myerson (1979)).

In order to guarantee that the shutdown policy is not optimal in all the following cases we assume the following throughout the paper:\(^9\):

**Assumption 1.** \( 0 \leq \theta \leq \frac{(a - c_H - z)^2}{(a - c_L - z)^2} \).

3. **The complete information (benchmark) case.** This section deals with the complete (symmetric) information scenario, presents a detailed analysis of the two possible cases - one with an upstream powerful party and the other extreme with a downstream powerful party - and shows explicitly the “equivalence” that exists. It is shown that always the party who has the right to make take-it-or-leave-it offers appropriates the whole surplus, while the consumers are indifferent.

**U has all the bargaining power.** Whenever U has all the bargaining power and in addition there is symmetric information, everything is common knowledge, then it can appropriate the monopoly profit. It knows whether the agent’s cost is high or low and it can propose the optimal contract in each case. The mechanism works as follows: U uses a sell-out contract by proposing a wholesale price equal to its cost \( w = z \). In this way makes the downstream firm the “residual claimant” because it does not add any mark-up with the respective pricing decision. Then D behaves optimally and maximizes its profits - given that \( w = z \) - with a final price equal to the monopoly price. Consequently, the total industry profits are equal to the monopoly profits escaping from the double marginalization problem (reduced total profits) and finally U gets this profit by using a side payment, the fee \( f \). This happens because the principal (here the upstream firm U) has two instruments available and it is able to make the agent’s participation constraints binding. This of course breaks down in the presence of asymmetric information since the informed party can use its private information in order to secure some rents. The principal is not able to make both type’s participation constraints binding. Therefore U will propose in any case a wholesale price equal to its marginal cost and the appropriate fee is determined by the value of D’s marginal cost \( \{ f_L = \)

\(^{7}\)In section 5 we also analyze wholesale price contracts.

\(^{8}\)See the appendix for a proof.

\(^{9}\)We need a condition for the probability \( \theta \) in order to guarantee that trade takes place for any type of the informed party. If \( \theta \) is very high (almost equal to one) then the best strategy for the principal, in order to avoid loosing some rents, is to offer only one contract to the efficient type.
\[
\left(\frac{a-z-c_L}{4}\right)^2 > f_H = \left(\frac{a-z-c_H}{4}\right)^2 \}
\]
Consumers face a monopoly price and the monopoly profits are extracted by the party who has all the bargaining power. \(^{10}\)

**D has all the bargaining power.** The other extreme is with a powerful downstream firm that makes take-it-or-leave-it offers to the upstream party. \(^{11}\) Having all the bargaining power the downstream firm can achieve the monopoly profit by following two different ways. One option for D is to propose a wholesale price equal to the marginal cost of U \((w = c_L \text{ or } w = c_H)\) and a zero fee \(f = 0\). \(^{12}\) In this way keeps U in the market by covering its cost and in addition D can get the highest profit. The second option it has is to propose a wholesale price equal to the monopoly price \((w = p^m = \frac{a+c+z}{2})\) \(^{13}\) combined with a negative fee (known as “slotting” fee) equal to the monopoly profit. In both cases there is not a second mark-up and the final industry surplus is the highest one. One important observation is that the downstream firm can get the monopoly profit even without the second instrument because it is located at the last stage of the production chain and the only thing it needs is to restrict the parties in the previous stages not to add a mark-up.

It is clear then that the total industry profits are the same in both cases but they can be appropriated by the party who has the bargaining power. Consumers suffer in both cases by facing a monopoly price and total welfare is the same. We can conclude that there is an “equivalence” between the two cases because welfare is unchanged and the party with the bargaining power gets the same profit. Does

\[^{10}\]To see this argument clearer we can solve for the optimal two-part tariff contract.

Solving backwards for a subgame perfect equilibrium we must first find the optimal choice of the downstream firm given \(w\) and \(f\) and that \(c \in \{c_L, c_H\}\) that is known to U:

\[
\max_Q \Pi_D = (a - Q - w - c)Q - f
\]

After maximizing with respect to \(Q\) the first order condition gives rise to the following optimal values expressed in terms of the wholesale price:

\[
Q^* = \frac{a - w - c}{2}
\]
\[
p^* = \frac{a + w + c}{2}
\]

U anticipates the behavior of D and taking the optimal values of \(Q\) and \(p\) maximizes its profits taking into account the participation constraint of D since U cannot coerce D to participate in the market.

\[
\max_{w,f} \Pi_U = (w - z)Q^* + f
\]

\(s.t. f \leq (a - Q^* - w - c)Q^*
\]

The participation constraint is binding \(f = (a - Q^* - w - c)Q^*\) and U’s program can be rewritten in the following way:

\[
\max_{w} \Pi_U = (a - Q^* - c - z)Q^*
\]

After substituting D’s optimal choice \(Q^*\) and maximizing with respect to \(w\) we obtain:

\[
w^* = z
\]

Indeed U’s optimal choice is no mark-up combined with a fixed fee \(f = (a - z - c)^2\) equal to the monopoly profit. In this case U is powerful having two instruments and it has the opportunity to eliminate the double marginalization problem.

\[^{11}\]In order to be able to compare easier the two cases we use the same notation for both parties. The downstream firm (with the bargaining power) has a marginal cost equal to \(z > 0\) and the upstream one a marginal cost equal to \(c \in \{c_L, c_H\}\).

\[^{12}\]We assume that a positive fee is what U gets and a negative one what D gets by U.

\[^{13}\]The monopoly price is the one that a vertically integrated firm (with marginal cost \(c + z\)) would charge to the final consumers.
this hold under the presence of asymmetric information? We give an answer in the section which is cited below.

4. **Asymmetry in information.** Asymmetry in information brings the uninformed party in a worse position since the informed party has the opportunity to use this information advantage in a strategic way. Even though the principal has all the bargaining power and the right to use non-linear pricing it cannot achieve the monopoly profits due to the "distributional" distortion, it must give up some rents. Moreover, there is some form of double marginalization the “excessive” price (reduced output) distortion which arises because the principal tries to balance the information rents (loss) by sacrificing some efficiency (gain). Consumers in the presence of asymmetric information seem to be indifferent between the two cases - a powerful upstream versus a powerful downstream firm - therefore welfare is unchanged but what changes is the information rents that the informed party can get. A firm in an environment like this would prefer to be closer to the final consumers, in the downstream level, since in this way it can get higher profits extracting more rents by the informed firm. This is so because a firm having the bargaining power which is closer to the final consumers does not need a second instrument the fixed fee to extract the profits of the other firm. We proceed now into the main part analyzing these ideas.

4.1. **U has the bargaining power.** U has the bargaining power, it is the less informed player who acts first with a marginal cost equal to \( z > 0 \), while D has a private information advantage about its marginal cost \( c \in \{ c_L, c_H \} \). Given that U has the right to use two-part tariff contracts, it tries to screen the different types of the agent by maximizing its expected profits by taking into account apart from the participation constraints of the agent, the incentive compatibility constraints in order to elude from transferability of demand between the different types of the agent. The principal uses a menu of two-part tariffs one directed to the low type \((w_L, f_L)\) and one to the high one \((w_H, f_H)\) and manages to force each possible type to select the contract that is designed for him. The principal is forced to impose truth-telling constraints due to its desire to screen effectively the different types. The informed party should tell the truth only if it has the incentive to do it (i.e. to secure some rents).

In a backward spirit U can anticipate agent’s optimal choice given the contract terms:

The downstream firm maximizes its profits:

\[
\max_{Q} \Pi_D = (p - w_i - c_i)Q - f_i = (a - Q - w_i - c_i)Q - f_i
\]

After maximizing (1) we obtain the optimal choice of the quantity and the price respectively which are expressed in terms of the wholesale price:

\[
Q^*(w_i, c_i) = \frac{a - w_i - c_i}{2}, \quad p^*(w_i, c_i) = \frac{a + w_i + c_i}{2}
\]

The optimal choices by the downstream firm depend on the marginal cost, so we have the corresponding values for the quantity with cost either high or low. The principal maximizes its expected profits subject to two type of constraints,
participation and truth-telling constraints:

\[
\max_{w_L, f_L, w_H, f_H} \Pi^U = \theta(w_L - z)Q^*(w_L, c_L) + \theta f_L + (1 - \theta)(w_H - z)Q^*(w_H, c_H) + (1 - \theta)f_H
\]

s.t.

\[
(p^*(w_H, c_H) - w_H - c_H)Q^*(w_H, c_H) - f_H \geq 0 \quad (3)
\]

\[
(p^*(w_L, c_L) - w_L - c_L)Q^*(w_L, c_L) - f_L \geq 0 \quad (4)
\]

\[
(p^*(w_H, c_H) - w_H - c_H)Q^*(w_H, c_H) - f_H \geq (p^*(w_L, c_H) - w_L - c_H)Q^*(w_L, c_H) - f_L \quad (5)
\]

\[
(p^*(w_L, c_L) - w_L - c_L)Q^*(w_L, c_L) - f_L \geq (p^*(w_H, c_L) - w_H - c_L)Q^*(w_H, c_L) - f_H \quad (6)
\]

Constraints (5) and (6) refer to the incentive compatibility constraints which ensure that each type prefers the contract that was designed for him.\(^{14}\) The full solution of the problem employing all constraints becomes a cumbersome approach. Yet, by neglecting the non-binding constraints and focusing on the binding ones, a relaxed problem can be solved. In problems like this (constrained maximization) whenever a binding constraint is being satisfied, that ensures that the same holds for the nonbinding ones and we check them ex-post. As is always the case in two type adverse selection problems\(^ {15}\) the binding constraints include the participation constraint of the inefficient type (3) (high cost) and the incentive compatibility constraint of the efficient type (6) (low cost).\(^ {16}\) After all the substitutions (see the appendix for more details) maximizing with respect to \(w_L\) and \(w_H\) we obtain:

\[
w_L = z
\]

\[
w_H = z + \frac{\theta(c_H - c_L)}{1 - \theta}
\]

with corresponding quantities

\[
Q^L = \frac{a - z - c_L}{2}
\]

\[
Q^H = \frac{a - c_H - z - \theta(c_H - c_L)}{2(1 - \theta)}
\]

Substituting the optimal values into (2) we obtain the principal’s expected profits:

\[
\Pi^U = \frac{(a - z)^2(-1 + \theta) + (-1 + \theta - \theta^2)c_H^2 - \theta^2c_L^2 + 2c_H(-(a - z)(-1 + \theta) + \theta^2c_L)}{4(-1 + \theta)}
\]

The solution of the above program shows explicitly that there is no distortion at the efficient type’s wholesale price but the principal distorts the inefficient type’s offer by trading-off efficiency and rent extraction. The information rents of that the informed party can secure depend on \(Q^H\), that is why the principal offers an optimal contract with \(Q^H < \frac{a - c_H - z}{2}\).

\(^{14}\) These constraints refer to the final choices of the agent and are reminiscent of the revealed preferences arguments from standard consumer theory.

\(^{15}\) For a detailed presentation of these ideas see Laffont and Martimort (2002)[13], Salanié (2005)[20] or Bolton and Dewatripont (2005)[4].

\(^{16}\) See Appendix for proof.
Lemma 1. The optimal contract entails “no distortion at the top’ with \( w_L = z \), and a higher wholesale price for the inefficient type compared to the full information case \( w_H = z + \frac{\theta(c_H - c_L)}{1 - \theta} > z \).

According to Lemma 1 an upstream principal cannot get the monopoly profit even though it can use non-linear two-part tariff contracts, a standard result in adverse selection models. It distorts only the inefficient type contract because only the efficient type wants to mimic the inefficient one. In its final decision the principal takes into account a trade-off between rent-extraction and efficiency. On the one hand it wants to be as close as possible to the contracts offered under complete information but on the other hand it prefers “some” distortion to restrict the information rents.

4.2. D has the bargaining power. In this case D takes the role of the principal proposing the exact contract terms with a marginal cost \( c > 0 \). The agent U accepts or rejects the offer having private information about its marginal cost \( c \in \{c_L, c_H\} \).

As in the previous case the principal would try to screen the different types of the agent. In this case though it does not need both of the available instruments of the two-part tariff contracts. In this particular situation the principal is at the last stage of production facing the final consumers and it does not need to use a side payment in order to make the participation constraint binding. As we have already discussed in the complete information case the downstream firm can choose between two different options, either with \( f = 0 \) or with \( f < 0 \) (a slotting fee). Here for simplicity we use the first one where \( f = 0 \). The upstream firm can get any profit only through the wholesale price \( w \) given that \( f \) is always zero.

The downstream firm maximizes its expected profits by considering both types of constraints, the participation and incentive compatibility constraints:

\[
\max_{Q^L, Q^H} \Pi_D = \theta(a - Q^L - w_L - z)Q^L + (1 - \theta)(a - Q^H - w_H - z)Q^H \tag{7}
\]

s.t.

\[
\begin{align*}
(w_L - c_L)Q^L &\geq 0 \\
(w_H - c_H)Q^H &\geq 0 \\
(w_L - c_L)Q^L &\geq (w_H - c_L)Q^H \\
(w_H - c_H)Q^H &\geq (w_L - c_H)Q^L
\end{align*}
\tag{8, 9, 10, 11}
\]

As is always the case the binding constraints are (9) and (10), therefore in this case \( w_H = c_H \) the inefficient type gets no rents. From (10) we can find that \( w_L = c_L + \frac{(c_H - c_L)Q^H}{Q^L} \). Substituting \( w_H \) and \( w_L \) (see the appendix for details) and maximizing with respect to \( Q^L \) and \( Q^H \) we finally get:

\[
Q^L = \frac{a - z - c_L}{2} \quad Q^H = \frac{a - c_H - z - \theta(c_H - c_L)}{2(1 - \theta)}
\]

After substituting the above expressions into (7) we obtain the principal’s expected profits in this case:

\[
\Pi_D = \frac{(a - z)^2(1 - \theta) + c_H^2 + \theta c_L^2 - 2c_H[(a - z)(1 - \theta) + \theta c_L]}{4(1 - \theta)}
\]

\(^{17}\) The analysis is exactly the same if instead of a zero fee we use a negative fee for a downstream principal.
Proposition 1. Consumer surplus is being unaffected whenever we turn from the one case to the other since the final prices are the same in both cases.

We observe that the quantities induced by the optimal contract (i.e. by the respective wholesale prices) are the same in both cases. Consequently, according to Proposition 1, consumers are in fact indifferent whether the less informed party is at the upstream or at the downstream level. This result holds because by offering a menu of contracts the principal always gets the highest possible profit, hence either on the upstream or on the downstream sector it has no incentives to change the final prices.\textsuperscript{18} Therefore, the position of the less informed party in the vertical production chain does not affect the excessive pricing distortion which is responsible for the welfare detrimental attribute that comes from the presence of asymmetric information. The principal’s position in the industry affects only the distributional distortion that is responsible on how the two transacted parties split the surplus.

Proposition 2. Whenever the less informed party is at the downstream level it can restrict the information rents more effectively compared to the other extreme case where the principal is at the upstream level. The “distributional” distortion that arises compared to the symmetric information case is less severe.

In Proposition 2 we establish one of the main results of this paper, that a principal can screen the agent’s types more effectively when its position is at the downstream level of the industry. This is so since the informed party’s information rents are being reduced given that the total profits in the industry are the same but the principal’s expected profits in that case are strictly higher. The intuition behind this result is that a downstream principal is able to make the participation constraint of the inefficient type and the incentive constraint of the efficient type binding by using only one instrument, the wholesale price. In contrast an upstream principal must use all the available instruments of a two-part tariff contract, the wholesale price and the fixed fee. An upstream principal has two things in mind, one is to use the wholesale price in a way to restrict information rents and the second is to use the fixed fee to extract downstream’s profit because it doesn’t set the final prices. A downstream principal uses the wholesale to restrict informational rents but at the same time it is this party that sets the final prices and in this way it is able to restrict information rents. This result disclose that in the event of asymmetric information the distributional distortion is not so intense with a downstream principal, that is the total outcome comes closer to the complete information outcome.

5. Wholesale price contracts.

5.1. Complete information case. In an environment with complete information and without any asymmetry in information, there is always double marginalization when the upstream principal does not use a two-part tariff contract but instead it uses a wholesale price contract with only one instrument. When the principal is at the downstream level things work as in section 3. It is able to extract the whole surplus of the agent while consumers are better off avoiding double mark-ups.

When the upstream firm is the powerful party in the transaction then it acts as a Stackelberg leader and takes as given the optimal choice of the other firm the

\textsuperscript{18}Final prices are being affected either in an indirect way (i.e. through the wholesale prices) by an upstream principal or directly since a downstream principal chooses them.
follower. The downstream firm’s optimal choice by maximizing its profits is the usual quantity choice in terms of the wholesale price:

$$Q_i^* = \frac{a - w - c_i}{2}$$ (12)

Then given (12) the upstream firm maximizes its profits:

$$\max_w \Pi U = (w - z)Q_i = (w - z)\left(\frac{a - w - c_i}{2}\right)$$

The first order condition results in:

$$w(c_i) = \frac{a - c_i + z}{2}$$

The optimal wholesale price depends on the actual marginal cost. So, if \(c = c_L\) then \(w(c_L) = \frac{a - c_L + z}{2}\) and if \(c = c_H\) then \(w(c_H) = \frac{a - c_H + z}{2}\). In this case a double marginalization always takes place since both parties impose their own mark-up.

Therefore, the profits they get are positive \(\Pi U = \frac{(a - c_i - z)^2}{8}\) and \(\Pi D = \frac{(a - c_i - z)^2}{16}\) and represent the profits of the leader and the follower respectively.

When instead the downstream firm is the powerful party then double marginalization does not occur since D can squeeze upstream’s mark-up to zero. As in the section 3, D can propose to U either \(w = c_L\) or \(w = c_H\) according to U’s cost inflicting only its own mark-up.

**Corollary 1.** From the consumer’s viewpoint in this case it is better the powerful firm to be at the downstream level. Moreover, if such a firm could choose its position in the vertical chain, it would prefer to be at the downstream level too.

According to Corollary 1 the consumers and the firm with the bargaining power are better off when the latter party is located in the downstream level of the production chain. This holds since - as it is standard in the vertical relations literature - in this case we escape from the double marginalization problem.

### 5.2. Asymmetric information case.

Suppose now that the less informed party has not the right to use nonlinear pricing but only a wholesale price without a fixed fee. In this case things work differently if the principal is at the upstream level but remain the same if it is at the downstream level. An upstream principal with one instrument cannot offer a menu of contracts, one directed to each type, because it cannot make any participation constraint binding. The only option it has, is to use a single wholesale price for both types and double marginalization that is excessive pricing is aggravated. A downstream principal can screen the different types exactly in the same way as in the previous section and gets higher profit together with higher level of efficiency.

In more details an upstream principal perfectly awaits the behavior of D and thus it knows that the optimal choice is \(Q_i^* = \frac{a - w - c_i}{2}\) (either \(Q_L = \frac{a - w - c_L}{2}\) or \(Q_H = \frac{a - w - c_H}{2}\)) and the expected demand is \(Q = \theta Q_L + (1 - \theta)Q_H\). Given the expected demand U maximizes its profits:

$$\max_w \Pi U = (w - z)(\theta \frac{a - w - c_L}{2} + (1 - \theta)\frac{a - w - c_H}{2})$$ (13)

\(^{19}\Pi U + \Pi D\) is lower than the profit of a vertically integrated firm \(\Pi_{V.I} = \frac{(a - c_i - z)^2}{4}\) due to the double marginalization problem.
The first order condition gives rise to the following equilibrium wholesale price:

\[ w^* = \frac{\theta(a - c_L + z) + (1 - \theta)(a - c_H + z)}{2} \] (14)

Substituting (14) into (13) U obtains the following equilibrium profits:

\[ \Pi_U = \frac{1}{8} \left( a - z + (-1 + \theta)c_H - \theta c_L \right)^2 \]

On the other extreme a downstream principal is able to screen the different types of the agent as in subsection 4.2 and gets exactly the same profits. The screening activity makes the double marginalization problem less intense bringing the final consumers at a better position.

**Proposition 3.** Under wholesale price contracts consumers prefer the less informed party to be at the downstream level. The excessive pricing distortion is much more intense in the opposite case.

According to Proposition 3, under wholesale price contracts, the position of the less informed party in the industry does play an important role for the consumers. In this particular case the welfare detrimental distortion due to the asymmetry in information is aggravated if the principal is at the upstream level of the industry compared to the opposite case. This is true since as we have described above a downstream principal is able to screen the types of an upstream agent even with one instrument available and in this way it makes the excessive pricing distortion less severe. With a downstream informed firm double marginalization always occurs since it adds its own mark-up and leads to higher final prices. Consequently, it should be better for the consumers the principal, that is the less informed party, to be at the downstream level and avoid double mark-ups.

**Proposition 4.** The less informed party wants to be at the final production stage either under a menu of two-part tariff contracts or under wholesale price contracts.

From the firms’ viewpoint, under asymmetric information, the party who has all the bargaining power prefers to be at the downstream level. That holds on the screening case (i.e. with a menu of two-part tariffs) and on the wholesale prices case. The profits that the principal gets are higher if it is closer to the final consumers because it has the advantage of choosing the final price. When only wholesale price contracts are available this holds independent of the information regime (i.e. complete or incomplete), but under two-part tariff contracts things do not work alike. Under complete information a powerful party is indifferent between an upstream or a downstream position but under asymmetry in information it strongly prefers to be at the downstream level.

6. **Single (two-part tariff) contract.** In our analysis we have implicitly assumed that the principal (i.e. the uninformed party) has the right to discriminate in a second-degree price discrimination sense. Indeed whenever U is able to discriminate is always optimal to proceed in a screening activity offering a menu of contracts. But what happens if discrimination is not a option (e.g. illegal)? In this case the principal must offer a single contract and its only concern must be to ensure the participation of both types. Let’s treat the two extreme cases separately.

**U has all the bargaining power.** Assuming that U wants to trade with both types (no shutdown policy), then it must offer a fixed fee equal to the profits of the
inefficient type \( f = (a - Q_H - w - c_H)Q_H \).\(^{20}\) \( U \) maximizes its expected profits:

\[
\max_w \Pi^U = \theta(w - z)Q_L + (1 - \theta)(w - z)Q_H + f
\]  

(15)

The first order condition results in:

\[
w^* = z + \theta(c_H - c_L)
\]  

(16)

Substituting (16) into (15) we obtain the equilibrium profits of the upstream firm:

\[
\Pi^U = \frac{1}{4}[(a - z)^2 + (1 + \theta^2)c_H^2 + \theta^2c_L^2 - 2c_H(a - z + \theta^2c_L)]
\]

The optimal two-part tariff contract is:

\[
\{w, f\} = \{z + \theta(c_H - c_L), \frac{1}{4}(a - z - (1 + \theta)c_H + \theta c_L)^2\}
\]

**D has all the bargaining power.** When D has the role of the principal being uninformed should propose a contract with \( w = c_H \) combined with \( f = 0 \) in order to ensure the participation of both types. D maximizes its profits and differentiating with respect to \( Q \) we obtain the following equilibrium quantity:

\[
Q^* = \frac{a - z - c_H}{2}
\]

The downstream principal obtains the following profits:

\[
\Pi_D = \frac{(a - z - c_H)^2}{4}
\]

**Proposition 5.** (i) Under a single two-part tariff contract the principal strongly prefers to be at the upstream level of production.

(ii) Consumers are better off when the principal is located upstream.

According to Proposition 5 (i), without a menu of contracts the less informed party gets higher profit if it is positioned on the upstream sector of the industry. This result comes in contrast to the previous one in Proposition 2 when second-degree of price discrimination is legal. Therefore, we can conclude that price discrimination is pivotal in our model. If the party with the information disadvantage could choose its position in the industry, this choice should heavily depend on whether price discrimination is legal or not. As we have already described, if it is legal, the optimal choice for a principal is on the downstream level and this choice reverses if it is not. Proposition 5 (ii) informs us about the consumers preference for the position of the principal. It makes clear that under a single two-part tariff contract consumers surplus is higher than in the opposite case. Proposition 5 (i) and (ii) holds because by observing the optimal wholesale prices only when the principal is upstream this depends on both values of the marginal cost (\( c_L \) and \( c_H \)). A downstream principal makes binding the participation constraint of an upstream inefficient agent but that leads to a wholesale price that depends only on \( c_H \) and thus to higher final prices.

---

\(^{20}\)D maximizes its profits given the contract \( \{w, f\} \):

\[
\max(p - w - c_i)Q - f = (a - Q - w - c_i)Q - f
\]

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\[
Q : Q^i = \frac{a - w - c_i}{2} \text{ and } Q^H = \frac{a - w - c_H}{2} \text{ and } Q^L = \frac{a - w - c_L}{2}.
\]
7. Consumers welfare. As we saw in the previous sections firms propose the optimal contract(s) given the available instruments and their position in the industry. In any case the contracts affect the final prices - quantities and hence the consumer surplus. It is then quite useful to understand in which of the above cases consumers face lower prices. Computing the consumer surplus in all cases we arrive to the following result.

**Proposition 6.** From the consumers point of view the screening case (i.e. a menu of two-part tariffs) is equivalent to the best case (i.e. with a downstream principal) under wholesale price contracts and dominates the single two-part tariff case.

Proposition 6 informs us about the desirability of each pricing scheme for the final consumers. Comparing them we find that two-part tariff screening weakly dominates wholesale prices but strictly dominates single two-part tariffs. It is conventional wisdom that in adverse selection models the less informed party gets the higher profits when it offers a menu of contracts (i.e. direct mechanisms). Proposition 6 tells us that the enforcement of direct mechanisms leads also to higher consumer surplus. In particular screening leads to higher consumer surplus than a single two-part tariff since the use of a menu of contracts alleviates allocative inefficiency and push the final outcome closer to the efficient one. On the other hand consumers are indifferent between screening and the best case scenario under wholesale prices. This is true since a downstream principal is able to screen the possible types even with one instrument and hence in this situation we obtain equivalent outcomes.

8. Discussion. (i) Information asymmetry regarding the demand

Somebody should wonder how the whole mechanism works if instead of asymmetry of information about the unit cost this was about the real demand. For instance, the downstream firms may be better informed about the level of demand since they are closer to final consumers. In this particular case there is an important difference because an upstream principal is able to screen the possible types of a downstream agent (facing high or low demand) but a downstream principal just restricts the upstream agent’s mark-up since the marginal cost is known and then it maximizes the expected profits. If the informed party is upstream it cannot use its private information strategically since it is always the downstream party who sets the final prices. In particular, consumers are better off with an upstream principal because by offering a menu of contracts it avoids high final prices than a downstream monopolist whose pricing decision depends on the expected demand. Regarding the firms’ preference where to be located that depends on the parameter values and there is no clear preference.

(ii) The optimal contract with a continuum of types

In this section we analyze the case with an upstream principal as in subsection 4.1 but we generalize it since the cost of the informed agent belongs to the interval between $c_L$ and $c_H$, $c \in C = [c_L, c_H]$ with density $g(c)$ and cumulative distribution $G(c)$. Nothing of the previous results is specific to the discrete type case and we are able to apply the revelation principle also under a continuum of types. In this case we must solve an optimal control problem where $\pi$ (the total profits) is the state variable and $w$ (the wholesale price) the control variable. First we should identify the exact form of the incentive compatibility constraint which takes the form of a differential equation.
Incentive compatibility constraints: For a truthful reporting it must hold the following

\[ (a - Q(c) - w(c) - c)Q(c) \geq (a - Q(\hat{c}) - w(\hat{c}) - c)Q(\hat{c}) \text{ for any } (c, \hat{c}) \text{ in } C^2 \] (17)

From (17) we get the first order condition for the optimal response \( \hat{c} \) by type \( c \) that it must hold but we should take into account the optimal choice of the agent with respect to quantity, that is

\[ Q(c) = \frac{a - w(c) - c}{2} \]

and

\[ \frac{(a - w(c) - c)}{2} (-w'(c)) - f'(c) = 0 \] (18)

For a truth to be optimal we obtain from (18)

\[ \frac{(a - w(c) - c)}{2} (-w'(c)) - f'(c) = 0 \] (19)

Additionally, the local second order conditions must be satisfied

\[ \frac{(w'(c))^2}{2} - w''(c)(\frac{a - w(c) - c}{2}) - f''(c) \leq 0 \]

or alternatively

\[ \frac{(w'(c))^2}{2} - w''(c)(\frac{a - w(c) - c}{2}) - f''(c) \leq 0 \] (20)

Now by differentiating (19) we can write the above condition (20) as

\[ w'(c) \geq 0 \] (21)

Therefore, \( w(c) \) must be nondecreasing so as to ensure that the local incentive compatibility constraints are satisfied. Since we impose that \( w(c) \) is nondecreasing that ensures that global incentive constraints are also hold\(^\text{21}\). The profits of the downstream agent are denoted by \( \pi(c) \) as

\[ \pi(c) = \frac{(a - w(c) - c)^2}{4} - f(c) \] (22)

Differentiating (22) we obtain

\[ \pi'(c) = \frac{(a - w(c) - c)}{2} (-w'(c) - 1) - f'(c) \] (23)

Plugging (19) into (23) we obtain the incentive compatibility constraint\(^\text{22}\)

\[ \pi'(c) = \frac{(a - w(c) - c)}{2} = -Q(c) \] (24)

\(^{21}\)See for example Laffont and Martimort (2002)[13].

\(^{22}\)Alternatively following Gal-Or (1991)[9] we should write down the agents’ maximization problem:

\[ \max_{c, \hat{c}, Q} \pi(c, \hat{c}, Q) = [a - Q - w(\hat{c}) - c]Q - f(\hat{c}) \]

Given that the optimal quantity results into \( Q(\hat{c}, c) = \frac{a - w(\hat{c}) - c}{2} \) the maximization problem becomes

\[ \max_c \pi(c) = \frac{(a - w(c) - c)^2}{4} - f(c) \]

From the envelope theorem we obtain

\[ \pi'(c) = -Q(c) \]
Solving for the optimal contract: Given the IC constraint, the nondecreasing requirement of \( w(c), Q(c) = \frac{a-w(c)-c}{2} \) and from (22) \( f(c) = -\pi(c) + \frac{(a-w(c)-c)^2}{4} \) the program of the upstream principal is as follows:

\[
\max_{w, \pi} \int_{c_L}^{c_H} [(w(z) - z)Q(c) + f(c)]dG = \int_{c_L}^{c_H} [(w(z) - z)(\frac{a - w(c) - c}{2}) - \pi(c) + \frac{(a - w(c) - c)^2}{4}]g(c)dc \quad (25)
\]

s.t.

\[
\begin{align*}
\pi'(c) & = -Q(c) \\
w'(c) & \geq 0 \\
\pi(c) & \geq 0
\end{align*}
\]

Using the Pontryagin principle we form the Hamiltonian where \( \lambda \) is the co-state variable

\[
H(w, \pi, \lambda, c) = [(w(z) - z)(\frac{a - w(c) - c}{2}) - \pi(c) + \frac{(a - w(c) - c)^2}{4}]g(c) - \lambda(\frac{a - w(c) - c}{2})
\]

The first order conditions are the following:

\[
\begin{align*}
\frac{\partial H}{\partial w} & = 0 \\
\frac{\partial H}{\partial \pi} & = -\lambda(c)
\end{align*}
\]

We should also consider the transversality condition which implies that \( \lambda(c_L) = 0 \). The solution is as follows:

\[
\begin{align*}
w(c) & = z + \frac{\lambda}{g(c)} \\
\lambda(c) & = g(c)
\end{align*}
\]

Finally, we obtain that\(^\text{23}\)

\[
w(c) = z + \frac{G(c)}{g(c)}
\]

Given that \( w(c) \) must be nondecreasing we usually impose conditions on the distribution function (monotone hazard rate property), but if we assume that the marginal cost is uniformly distributed then \( w(c) = z + (c - c_L) \) which is nondecreasing for any \( c \in [c_L, c_H] \). Thus, we verify our previous results in section 4 and indeed for the most efficient type there is no distortion compared to the symmetric information case \( w(c_L) = z \), and the wholesale price is distorted as the cost becomes higher with the maximum distortion for the least efficient type since it is the only type which gets no rents. We can identify the equilibrium profits and the fixed fee by plugging the optimal wholesale price into (25) and (22) respectively.

(iii) Dynamic adverse selection

An interesting issue should be how dynamics will affect the vertical relationship described. Of course this is something that goes beyond the scope of the analysis of...

\(^{23}\)Integrating \( \lambda(c) = g(c) \) we obtain:

\[
\int_{c_L}^{c} \lambda(c) = \int_{c_L}^{c} g(c) \iff \lambda(c) - \lambda(c_L) = G(c) - G(c_L)
\]

And from the transversality condition and the fact that \( G(c_L) = 0 \)

\[
\lambda(c) = G(c).
\]
this paper but we cannot ignore its importance. In a repeated/dynamic context we should distinguish between two cases, one with a fixed agent’s type and one where there is an independent (type) draw every period. In the first one, we should deal with the fact that asymmetric information should gradually disappear. Given that, the informed party and basically the efficient type should be reluctant in selecting a contract that reveals information anticipating something more favorable in future periods. Thus, an enduring relationship under a fixed type shouldn’t lead to a better outcome for the uninformed party, under an optimistic scenario it will lead to the optimal static contract. In the second one, we can conjecture that significant gains can be obtained since the informed party does not care if its type is being revealed in one period since this does not affect future contracting. It seems that both the distributional and the excessive pricing distortions can be curbed and potential gains form trade can be shared among the two parties.

9. Concluding remarks. In this paper, we have shown that the equivalence that holds between the two extreme cases of bargaining power under complete information breaks down when asymmetry in information occurs. Under complete information in both cases the party who has the bargaining power gets the same profit. In the presence of asymmetric information the major difference between the two possible cases is that the less informed party can always get higher (expected) profits if it is at the final stage of the production process. This is true because it is easier for this firm to restrict upstream’s information rents. From a normative point of view consumers are indifferent about the principal’s position when two-part tariffs are available but they prefer its position to be at the downstream level when only wholesale price contracts are used. When the principal cannot use a menu of contracts the results are exactly the opposite and it prefers to be at the upstream level. We believe that nothing of the analysis is related to the specific form of the demand since the results are driven by the different position of the principal - the uninformed party - along the vertical chain as well as the various contractual forms. Thus, the economic intuition described above should hold even with more general demand forms.

Some possible extensions for future research should be to investigate the case where ex-a ante contracting takes place and when downstream competition takes place. In the former one we can find out how the contracting activity is being affected by the fact that the contracts are offered before any asymmetry in information has occurred. In the latter case the interesting issue is how a principal can screen the types in a multiagent model while competition between them is taking place. We should also note that it should be quite interesting to investigate how our results may change if there is a repeated interaction instead of an one-shot relationship.

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Appendix. (1) Equivalence between two-part tariff and quantity forcing contract. Suppose that instead of a two-part tariff contract the principal has
available a quantity forcing contract which specifies the quantity and the total payment (with contracting variables \(\{q, T\}\)). In the bilateral monopoly situation we can pay attention to direct-truthful mechanism with contracting variables \(\{q, T\}\) and the message space \(M\) is equal to the type space \(C = \{c_L, c_H\}\). We denote \(q_L = q(c_L)\) & \(q_H = q(c_H)\) and \(T_L = T(c_L)\) & \(T_H = T(c_H)\). Information rents or “profits” for the downstream firm is \(\Pi_D = (a - q_i - c_i)q_i - T_i\).

Upstream’s program:

\[
\max \Pi^U = \theta(T_L - zq_L) + (1 - \theta)(T_H - zq_H)
\]

s.t. \((a - q_L - c_L)q_L - T_L \geq 0\) \hspace{1em} (1)  
\((a - q_H - c_H)q_H - T_H \geq 0\) \hspace{1em} (2) 
\((a - q_L - c_L)q_L - T_L \geq (a - q_H - c_L)q_H - T_H\) \hspace{1em} (3) 
\((a - q_H - c_H)q_H - T_H \geq (a - q_L - c_H)q_L - T_L\) \hspace{1em} (4)

(1) & (2) are the participation constraints and (3) & (4) the incentive compatibility constraints. The binding (relevant) constraints are (2) and (3), so \((a - q_H - c_H)q_H = T_H\) and \((a - q_L - c_L)q_L - T_L = (a - q_H - c_L)q_H - T_H\). Substituting \(T_L\) and \(T_H\) in the expected profits of \(U\) we have:

\[
\max \Pi^U = \theta((a - q_L - c_L)q_L + (c_L - c_H)q_H - zq_L] + (1 - \theta)((a - q_H - c_H)q_H - q_L]) \]

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\[
q_L : \theta(a - 2q_L - c_H - z) = 0 \implies q_L = \frac{a - c_H - z}{2} \quad q_H : \theta(c_H - c_H) + (1 - \theta)(a - 2q_H - c_H - z) = 0 \implies q_H = \frac{a - c_H - z}{2} + \frac{\theta(c_L - c_H)}{2(1 - \theta)}.
\]

We observe that the optimal allocation is the same under both contract types.

(2) The optimal contract when \(U\) has the bargaining power.

Upstream’s program

\[
\max \Pi^U = \theta(w_L - z)Q^*(w_L, c_L) + \theta f_L + (1 - \theta)(w_H - z)Q^*(w_H, c_H) + (1 - \theta)f_H
\]

s.t. \((p^*(w_H, c_H) - w_H - c_H)Q^*(w_H, c_H) - f_H \geq 0\) \hspace{1em} (1)  
\((p^*(w_L, c_L) - w_L - c_L)Q^*(w_L, c_L) - f_L \geq 0\) \hspace{1em} (2) 
\((p^*(w_H, c_H) - w_H - c_H)Q^*(w_H, c_H) - f_H \geq (p^*(w_L, c_L) - w_L - c_L)Q^*(w_L, c_L) - f_L\) \hspace{1em} (3) 
\((p^*(w_L, c_L) - w_L - c_L)Q^*(w_L, c_L) - f_L \geq (p^*(w_H, c_H) - w_H - c_H)Q^*(w_L, c_H) - f_H\) \hspace{1em} (4)

With \(Q^*(w_i, c_i) = \frac{a - w_i - c_i}{2}\), \(p^*(w_i, c_i) = \frac{a + w_i + c_i}{2}\).

The relevant constraints are:

\[
\frac{(a - w_L - c_L)^2}{4} - \frac{(a - w_H - c_H)^2}{4} = f_H
\]

After the substitutions \(U\)’s expected profits become:

\[
\max \Pi^U = \theta(w_L - z)\left(\frac{(a - w_L - c_L)^2}{4} + (1 - \theta)\frac{(a - w_H - c_H)^2}{4}\right) + \frac{(1 - \theta)(w_H - z)\left(\frac{(a - w_L - c_L)^2}{4} + (1 - \theta)\frac{(a - w_H - c_H)^2}{4}\right)}{1 - \theta} \]

\(w_L : z \theta = \theta w_L \implies w_L = z\)

\(w_H : z - z \theta + \theta c_H - \theta c_L - w_H + \theta w_H = 0 \implies w_H = z + \frac{\theta(c_H - c_L)}{1 - \theta}\)

(3) The optimal contract when \(D\) has the bargaining power.

Downstream’s (principal’s) program:

\[
\max \Pi_D = \theta(a - Q_L - w_L - z)Q^L + (1 - \theta)(a - Q_H - w_H - z)Q^H
\]

s.t. \((w_L - c_L)Q^L \geq 0\) \hspace{1em} (1)  
\((w_H - c_H)Q^H \geq 0\) \hspace{1em} (2) 
\((w_L - c_L)Q^L \geq (w_H - c_L)Q^H\) \hspace{1em} (3) 
\((w_H - c_H)Q^H \geq (w_L - c_H)Q^L\) \hspace{1em} (4)
The relevant constraints are (2) and (3). So, \( (w_H - c_H) Q^H = 0 \) (but \( Q^H \neq 0 \)), \( w_H = c_H \) and \( (w_L - c_L) Q^L = (w_H - c_L) Q^H, w_L = c_L + \frac{c_H - c_L}{Q^L} \).

\[
\max \Pi_D = \theta(a - Q^L - c_L - \frac{c_H - c_L}{Q^L} Q^H - z) Q^L + (1 - \theta)(a - Q^H - c_H - z) Q^H
\]

\[
Q^L: \theta(a - 2Q^L - c_L - z) = 0 \Rightarrow Q^L = \frac{a - c_H - z}{2\theta}
\]

\[
Q^H: -(\theta(c_H - c_L) + (1 - \theta)(a - 2Q^H - c_H - z) = 0 \Rightarrow Q^H = \frac{a - c_H - z - \theta(c_H - c_L)}{2(1 - \theta)}
\]

(4) **Proof of Proposition 1.** Solving for the optimal contract in both cases we conclude that the final quantities (allocations) are the same (\( Q^L = \frac{a - c_H - z}{2\theta} \), \( Q^H = \frac{a - c_H - z - \theta(c_H - c_L)}{2(1 - \theta)} \)). Industry profits remain unchanged when we turn from the one case to the other. Consequently, final prices that consumers face would be exactly the same coming from the demand function \( p(Q) = a - Q \).

(5) **Proof of Proposition 2.** This is true since the expected profits that a principal can get at the downstream level are higher than in the opposite case while the total industry profits remain unchanged. If we get the difference \( \Pi_D - \Pi_U = \frac{1}{4}\theta(c_H - c_L) > 0 \) the result is always positive, independent of \( \theta \), for \( 0 < \theta \leq 1 \).

(6) **Proof of Corollary 1.** With linear pricing and complete information consumers prefer the position of the uninformed party to be at the downstream level in order to avoid double mark-ups. In addition the uninformed party prefers to be positioned downstream because total industry profits are higher (avoiding double marginalization) and can be exploited by him.

(7) **Proof of Proposition 3.** With linear pricing and asymmetric information a downstream principal is able to screen the different types of the agent (even with one instrument) but this does not hold for an upstream principal. Therefore in the former case the principal can avoid more often double marginalization with lower final prices on average. The net consumers surplus (NCS) is equal to gross one

\[
GCS = \int Q^2 (a - Q) dQ \text{ minus the total payment } pQ, \text{ } NCS = \frac{Q^2}{2}.
\]

Computing the net consumers surplus in each case we find that either with a low or with a high cost it is higher when the principal is downstream:

\[
NCS_D(c_L) = \frac{(a - c_L - z)^2}{8} > NCS_U(c_L) = \frac{1}{32}(a + c_H - z + c_L(-2 + \theta) - c_H\theta)^2
\]

\[
NCS_D(c_H) = \frac{(c_H + z + a(-1 + \theta) - (c_L + z)\theta)^2}{8(-1 + \theta)^2} > NCS_U(c_H)
\]

\[
= \frac{1}{32}(a - c_H - z - S)^2
\]

where \( S = (c_H - c_L)\theta \).

(8) **Proof of Proposition 4.** If a principal could choose its position in the vertical chain it is like a “dominant* strategy to be at the last production stage. Using two-part tariffs it can restrict agent’s informational rents (see proposition 2) while with linear pricing it can appropriate a higher surplus by avoiding double mark-ups since the difference \( \frac{(a - z)^2[1 - \theta] + 2\theta(1 - \theta)c_H(a - z) + \theta^2 c_L - 2c_H(a - z + \theta^2 c_L)}{4(1 - \theta)} - \frac{1}{8}(a - z + (-1 + \theta)c_H - \theta c_L)^2 \) is always positive.

(9) **Proof of Proposition 5.** (i) Computing the difference \( \frac{1}{4}[(a - z)^2 + (1 + \theta^2)c_H^2 + \theta^2 c_L^2 - 2c_H(a - z + \theta^2 c_L)] - \frac{(a - z - c_H)^2}{4} \) is always positive.
(ii) The expected $NCS^U$ is higher than the $NCS_D$

$$\theta NCS^U(c_L) + (1-\theta)NCS^U(c_H) = \frac{1}{8}(c_H - c_L)^2(1-\theta)\theta > NCS_D = \frac{(a-c_H - z)^2}{8}$$

(10) **Proof of Proposition 6.** The screening net consumer surplus ($SNCS$) is higher in any case:

$$SNCS - \theta NCS^U(c_L) + (1-\theta)NCS^U(c_H) = -\frac{2(a-c_H - z)^2 - 4(a-c_H - z)(a-c_L - z)\theta + 2B\theta^2 + (c_H - c_L)^2\theta^3}{8(-1+\theta)} < 0$$

$$SNCS - WNSC = -\frac{(c_H + z + a(-1+\theta) - (c_L + z)\theta)^2}{4(-1+\theta)} < 0$$

where $B = (a-c_H - z)(a-c_H - 2c_L - z)$ and $WNSC$ is the expected wholesale price contract $CS$.

(11) **The relevant-binding constraints.** Every time we try to solve for the optimal contract under asymmetric information as in section 4 we use both participation and incentive compatibility constraints. One of the major difficulties is to find the relevant constraints (the binding ones at the optimum). We analyze the constraints from subsection 4.1 but in all cases the arguments are the same. We have the following four constraints:

1. $p^*(w_H,c_H) - w_H - c_H)Q^*(w_H,c_H) - f_H \geq 0$  
2. $p^((w_L,c_L) - w_L - c_L)Q^*(w_L,c_L) - f_L \geq 0$  
3. $p^*(w_H,c_H) - w_H - c_H)Q^*(w_H,c_H) - f_H \geq (p^*(w_L,c_H) - w_L - c_H)Q^*(w_L,c_H) - f_L$  
4. $(p^*(w_L,c_L) - w_L - c_L)Q^*(w_L,c_L) - f_L \geq (p^*(w_H,c_L) - w_H - c_L)Q^*(w_H,c_L) - f_H$

We argue that the binding ones are (1) and (4), let’s see why:

Using (1) and (4) we can see that (2) is strictly satisfied because the low cost firm can always mimic the high cost agent.

$$ (p^*(w_L,c_L) - w_L - c_L)Q^*(w_L,c_L) - f_L \geq (p^*(w_H,c_L) - w_H - c_L)Q^*(w_H,c_L) - f_H > (p^*(w_H,c_H) - w_H - c_H)Q^*(w_H,c_H) - f_H $$

Moreover (1) must be binding, if not then the contract is not the optimal because the principal could decrease $f_L$ and $f_H$ by the same amount in order to increase his profits without violating the incentive compatibility constraint. On the other hand (3) seems irrelevant because the main problem comes from the fact that the efficient type can pretend to be inefficient. Also, suppose that (4) is not active:

$$ (p^*(w_L,c_L) - w_L - c_L)Q^*(w_L,c_L) - f_L > (p^*(w_H,c_L) - w_H - c_L)Q^*(w_H,c_L) - f_H$$

The principal could decrease $f_L$ until it makes it binding, therefore the contract could not be optimal.

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