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Schmitz, Patrick W.

University of Cologne

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Patrick W. Schmitz

University of Cologne, Germany, and CEPR, London, UK

Abstract

Consider a buyer and a seller who have agreed to trade an intermediate good. It is ex-post efficient to adapt the good to the prevailing state of the world. The seller has private information about the costs of adapting the good. In the case of non-integration, the buyer has no possibility to verify claims that the seller makes about her costs. In the case of vertical integration, the buyer can verify evidence about the costs that the seller might be able to provide. Even though we assume no further differences between the ownership structures, it turns out that the parties may prefer non-integration.

Keywords: Incomplete contracts; Make-or-buy decision; Property rights approach; Private information; Outsourcing

JEL Classification: D23; D86; D82; L24; M11

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1 Introduction

Consider a producer of a final good who needs an intermediate product. Should the producer make the intermediate good in-house, or should he buy it from another firm? What are the costs and benefits of outsourcing; i.e., what are the optimal boundaries of the firm?

The "make-or-buy" decision has been discussed by economists since the path-breaking work by Coase (1937). Further progress was made in the literature on transaction cost economics (TCE), see in particular Williamson (1975, 1985). According to the view expressed in this literature, vertical integration can reduce ex-post transaction costs. In the present paper, we consider asymmetric information as a source of transaction costs. Indeed, we find that under some circumstances vertical integration can mitigate the ex-post inefficiencies caused by asymmetric information. Yet, there are also circumstances under which ex-post inefficiencies that would arise under vertical integration can be avoided under non-integration. We thus present a formal model in which the costs and benefits of vertical integration stem from the same force.

Our contribution builds on the formal property rights theory (PRT) pioneered by Grossman and Hart (1986), Hart and Moore (1990), and Hart (1995).[1] The central assumption in the PRT literature is that contracts are incomplete, so parties bargain ex-post over decisions that are not ex-ante contractible. The outcome of the negotiations depends on the prevailing ownership structure, where ownership confers control rights. Most contributions to the PRT literature assume that the parties are symmetrically informed, such that bargaining leads to an ex-post efficient outcome. Ownership matters, because the ex-post division of the surplus determines the incentives to make ex-ante investments. Hence, the optimal ownership structure is the one that best mitigates the hold-up problem.[2] However, Hart (1995, p. 87) has already pointed out that ex-ante investments are not a crucial ingredient of

[1] See Hart (2011) for a concise literature survey on the theory of the firm. See also Segal and Whinston (2013) for a comprehensive review of the literature on property rights.

[2] In contrast, Williamson (2000, 2002), Gibbons (2005), and Tadelis and Williamson (2013) have emphasized the central role of ex-post inefficiencies in TCE.

PRT models, and he has mentioned asymmetric information at the ex-post stage as a potential source of inefficiency which could be influenced by the allocation of control rights.

In the present paper, we study the choice between vertical integration and outsourcing in an incomplete contracts model without ex-ante investments. Specifically, we consider a buyer who negotiates with a seller about the delivery of an intermediate good. Initially, only the characteristics of a basic version of the good are contractible. Once the state of the world has been realized, the seller can incur costs to adapt the good to the prevailing state. However, the seller has private information about the costs, so the ex-post negotiations might fail and only the basic version of the intermediate product might be traded, which would be ex-post inefficient. Following the PRT literature, we assume that the ownership structure determines who has the relevant control rights.

In the case of non-integration (i.e., outsourcing), the seller has the control rights regarding the production of the intermediate good. When the seller is in control, she can e.g. manipulate transfer prices or choose among different depreciation methods, so profits can be shifted between divisions of the seller's firm or between different periods. The buyer has no possibility to verify claims that the seller makes about her costs, because the buyer cannot cleanly disentangle the costs associated with the intermediate good from other business activities of the seller. Since in the case of non-integration the seller is free to manufacture evidence about her costs, the buyer would simply disregard any evidence provided by the seller.

In contrast, under vertical integration the buyer has the relevant control rights. In this case, the buyer can make sure that the seller has not manipulated any evidence that she might be able to provide with regard to her costs. Thus, if the seller can provide evidence to the buyer, the buyer is able to verify that the evidence is true.[3]

Following the contract-theoretic literature on "hard" information started by Tirole (1986), we assume that evidence is obtained by the seller with a probability

[3]The fact that informational asymmetries may sometimes be removed within a firm was emphasized as a defining characteristic of integration by Arrow (1975) and Riordan (1990).

strictly smaller than one only.[4] Thus, the seller can always claim that she has no evidence.[5] Of course, if the seller obtained evidence with probability one, then vertical integration would clearly be optimal, because it would always allow to remove the informational asymmetries. At first sight, one might guess that vertical integration remains to be superior when the seller obtains evidence only stochastically, because vertical integration at least sometimes allows to remove the informational asymmetry, and there are no further differences between the ownership structures. Yet, in what follows we will show that under some circumstances the expected total surplus can actually be strictly larger in the case of non-integration.

Related literature. While most papers in the PRT literature assume symmetric information, some authors have also studied the role of asymmetric information, see e.g. Schmitz (2006, 2008a, 2017), Goldlücke and Schmitz (2014), and Su (2017a).[6] Yet, these papers do not allow for "hard" information (i.e., evidence that may be verified). Mohan (2014) studies investment incentives in an incomplete contracting model in which "hard" information may be revealed. However, in his model ex-post bargaining takes place under symmetric information. Mori (2020) studies a model

[4] See e.g. Martimort (1999, p. 933), Dewatripont and Tirole (1999, p. 17), and Laffont (1999, p. 654) for similar assumptions.

[5] As an illustration for our setting along the lines of Aghion and Tirole (1994), let the buyer (customer) be a pharmaceutical company (say, producing and distributing vaccines) and let the seller be a small biotech research unit (potentially adapting a vaccine to a mutated virus). When the research unit is an independent entity, it has discretion regarding its research strategy, so it could present to the customer ideas that would require large amounts of funding, even though it already knows that there might be more cost-efficient alternatives that it will ultimately choose. When the customer is in control, he decides about the research strategy, so the research unit has no room for diverting money, and early indicators that it might have about the costs of the strategy chosen by the customer will actually be relevant. Yet, due to the innovative nature of the task, there is still a positive probability that the research unit cannot yet present much evidence about the expected costs at the point in time when the pharmaceutical company has to decide whether or not to go forward with the project.

[6] On the role of asymmetric information in hold-up problems, cf. also Schmitz (2008b) and Goltsman (2011). Moreover, see also Rosenkranz and Schmitz (1999) on know-how transfer in an incomplete contracting framework.

to formalize a trade-off between ex-ante investments and ex-post adaptations. In contrast, ex-ante investments play no role in the present setup.[7] Finally, ex-ante investments also play no role in the more recent contributions to the PRT literature by Hart and Moore (2007, 2008).[8] Yet, these papers assume symmetric information and rely on behavioral assumptions, while in the present paper asymmetric information plays a central role and all parties are standard profit-maximizers.

2 The model

Consider two risk-neutral parties, a buyer (B) and a seller (S), who can trade an intermediate product. At some initial date 1, the parties agree to trade a basic version of the good. Let the buyer's valuation of the basic good be given by v_0, and let the seller's costs of producing the basic good be c_0, where $v_0 > c_0 > 0$. Moreover, at date 1 the parties choose an ownership structure $o \in \{VI, NI\}$, where $o = VI$ means vertical integration and $o = NI$ means non-integration. At this point in time, the parties are still symmetrically informed, so they agree on the ownership structure that maximizes the expected total surplus. The parties can specify a transfer payment t_0 from the buyer to the seller in order to divide the expected total surplus according to their ex-ante bargaining powers.[9]

At date 2, the state of the world is realized and modifications of the basic good become contractible. Specifically, when the seller adapts the good to the prevailing state of the world, then the buyer's valuation is increased from v_0 to $v_0 + v$. The seller's additional costs caused by adapting the good are $c \in \{c_L, c_H\}$, where $0 <$

[7] See also Mori (2017) for a model of ex-post haggling focused on third-party arbitration.

[8] Hart (1995, p. 88) already mentioned as a possible source of inefficiency that the parties might simply "not get along" at the ex-post stage, an idea that was formalized by Hart and Moore (2007, 2008). The central assumption is that contracts serve as reference points and parties are aggrieved if they do not get what they feel entitled to, which may lead them to engage in ex-post inefficient "shading" activities.

[9] In line with most contributions to the PRT literature, it is not necessary to specify the parties' ex-ante bargaining powers (and thus the payment t_0), because it is irrelevant for the optimal ownership structure how the parties divide the ex-ante expected total surplus.

$c_L < c_H < v$. Thus, it is always ex-post efficient to adapt the good to the state of the world. From an ex-ante point of view, the probability that the costs are low ($c = c_L$) is given by $p \in (0,1)$. Hence, the expected costs of adapting the good are $E[c] = pc_L + (1-p)c_H$. The parties negotiate at date 2 about whether or not the seller adapts the good in exchange for an additional payment t. With probability π, the buyer can make a take-it-or-leave-it offer to the seller, while otherwise the seller can make a take-it-or-leave-it offer to the buyer.[10] When the parties do not reach an agreement, only the basic version of the good is traded and the buyer pays t_0 to the seller. When the parties reach an agreement, then the adapted good is traded and the buyer pays $t_0 + t$ to the seller.

Suppose that regardless of the ownership structure o, the seller always privately learns the realization of c at date 2.[11] In addition, with probability $\lambda \in (0,1)$ the seller obtains evidence whether $c = c_L$ or $c = c_H$ has been realized. In the case of non-integration ($o = NI$), the buyer cannot verify any evidence provided by the seller; i.e., the realization of c can never be proved to the buyer. Yet, in the case of vertical integration ($o = VI$), the buyer is able to verify evidence provided by the seller. Hence, if $o = VI$, then with probability λ the seller can prove to the buyer whether $c = c_L$ or $c = c_H$ has been realized.

Observe that if the probability λ were equal to zero, there would be no difference between the two ownership structures. Moreover, if the probability λ were equal to 1, it is obvious that vertical integration would be optimal, since in this case the realization of c would always be verifiable and hence the parties would always agree on adapting the good.

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[10] This simple non-cooperative bargaining game has often been used in the related literature, see e.g. Hart and Moore (1999, p. 135) and Schmitz (2006).

[11] Note that the information structure is exogenously given. See Schmitz (2006) for a property rights model with costly information acquisition, albeit in a context with only "soft" information. On information gathering, cf. also Hoppe and Schmitz (2010, 2013), Iossa and Martimort (2015), Su (2017b), Ye and Li (2018), and the literature discussed there.

3 Non-integration

Let us start the analysis by considering non-integration ($o = NI$). First, suppose that at date 2 the buyer can make the offer.[12] Note that the buyer will offer to pay either $t = c_L$ or $t = c_H$ for the adaptation.[13] It is optimal for the buyer to offer $t = c_H$ whenever

$$v_0 - t_0 + v - c_H \geq v_0 - t_0 + p(v - c_L),$$

because the offer $t = c_H$ will always be accepted by the seller, while the offer $t = c_L$ will be accepted with probability p only. Hence, the buyer offers to pay $t = c_H$ whenever

$$p \leq \frac{v - c_H}{v - c_L}, \tag{1}$$

while he offers to pay $t = c_L$ otherwise.

Next, suppose that at date 2 the seller can make the offer. The seller will then ask the buyer to pay $t = v$, which the buyer is just willing to accept.[14]

Taken together, at date 1 the expected payoffs of the buyer and the seller are

$$u_B^{NI} = \begin{cases} v_0 - t_0 + \pi(v - c_H) & \text{if } p \leq \frac{v-c_H}{v-c_L}, \\ v_0 - t_0 + \pi p(v - c_L) & \text{otherwise,} \end{cases}$$

and

$$u_S^{NI} = \begin{cases} t_0 - c_0 + \pi(c_H - E[c]) + (1-\pi)(v - E[c]) & \text{if } p \leq \frac{v-c_H}{v-c_L}, \\ t_0 - c_0 + (1-\pi)(v - E[c]) & \text{otherwise,} \end{cases}$$

[12] Throughout, we make the standard assumption that a party that is indifferent between accepting and rejecting an offer will accept the offer.

[13] To see this, observe that an offer strictly smaller than c_L would always be rejected. Offers weakly larger than c_H would always be accepted, so c_H is optimal for the buyer among these offers. Moreover, offers weakly larger than c_L and strictly smaller than c_H would be accepted if and only if $c = c_L$, so the offer c_L is optimal for the buyer among these offers.

[14] It should be noted that our focus on posted-price contracts is without loss of generality. If the seller can make the offer, she extracts the full surplus, so she cannot do better. By invoking the revelation principle (cf. Myerson, 1982), it is straightforward to show that also if the buyer can make the offer, he cannot do better. Specifically, the optimal direct revelation mechanism would yield the same outcome as the optimal posted-price contract; see e.g. Fudenberg and Tirole (1991, chapter 7) and Riley and Zeckhauser (1983).

respectively. Therefore, under non-integration the expected total surplus at date 1 reads

$$S^{NI} = \begin{cases} v_0 - c_0 + v - E[c] & \text{if } p \leq \frac{v-c_H}{v-c_L}, \\ v_0 - c_0 + \pi p(v - c_L) + (1-\pi)(v - E[c]) & \text{otherwise.} \end{cases}$$

Observe that if condition (1) is satisfied, the first-best solution is attained, because the parties always trade the adapted good. Yet, if condition (1) does not hold, there is an ex-post inefficiency with probability $\pi(1-p)$. Specifically, when at date 2 the buyer can make the offer, the seller's costs are high, and condition (1) does not hold, then the parties trade the basic good only, which is ex-post inefficient.

4 Vertical integration

Now let us analyze the case of vertical integration ($o = VI$). First, suppose that at date 2 the buyer can make the offer. Note that the buyer will still offer to pay either $t = c_L$ or $t = c_H$ for the adaptation. Yet, the buyer can make his offer dependent on whether or not the seller provides evidence regarding her costs. Therefore, the best the buyer can do at date 2 in order to maximize his expected payoff is to choose between the following two alternatives. Alternative (a) is to offer to pay $t = c_H$ for the adaptation. Alternative (b) is to offer to pay $t = c_L$, unless the seller proves that $c = c_H$ has been realized, in which case the buyer offers to pay $t = c_H$. The buyer prefers alternative (a) whenever

$$v_0 - t_0 + v - c_H \geq v_0 - t_0 + \lambda(v - E[c]) + (1-\lambda)p(v - c_L).$$

The left-hand side shows the buyer's payoff under alternative (a). When the buyer offers to pay $t = c_H$, the seller always agrees to trade the adapted good. The right-hand side shows the buyer's expected payoff under alternative (b). Note that with probability λ the seller can prove the realization of her costs. In this case, the seller is just reimbursed for her costs and the adapted good is always traded. With probability $1-\lambda$, the seller cannot prove the realization of her costs. In this case, the seller agrees to trade the adapted good if and only if $c = c_L$ has been realized.

Observe that the buyer prefers alternative (a) whenever

$$p \leq \frac{(1-\lambda)(v-c_H)}{v-c_L-\lambda(v-c_H)} \tag{2}$$

holds.

Next, suppose that at date 2 the seller can make the offer. The seller will then ask the buyer to pay $t = v$, which the buyer is just willing to accept.[15]

As a consequence, the expected payoffs of the buyer and the seller at date 1 are

$$u_B^{VI} = \begin{cases} v_0 - t_0 + \pi(v-c_H) & \text{if } p \leq \frac{(1-\lambda)(v-c_H)}{v-c_L-\lambda(v-c_H)}, \\ v_0 - t_0 + \pi\lambda(v-E[c]) + \pi(1-\lambda)p(v-c_L) & \text{otherwise,} \end{cases}$$

and

$$u_S^{VI} = \begin{cases} t_0 - c_0 + \pi(c_H - E[c]) + (1-\pi)(v-E[c]) & \text{if } p \leq \frac{(1-\lambda)(v-c_H)}{v-c_L-\lambda(v-c_H)}, \\ t_0 - c_0 + (1-\pi)(v-E[c]) & \text{otherwise,} \end{cases}$$

respectively. Thus, under vertical integration the expected total surplus at date 1 reads

$$S^{VI} = \begin{cases} v_0 - c_0 + v - E[c] & \text{if } p \leq \frac{(1-\lambda)(v-c_H)}{v-c_L-\lambda(v-c_H)}, \\ v_0 - c_0 + \pi(1-\lambda)p(v-c_L) + (1-\pi+\pi\lambda)(v-E[c]) & \text{otherwise.} \end{cases}$$

Notice that the first-best outcome is achieved if condition (2) is satisfied, because then the parties always trade the adapted good. Yet, if condition (2) does not hold, there is an ex-post inefficiency with probability $\pi(1-\lambda)(1-p)$. In particular, when at date 2 the buyer can make the offer, the seller's costs are high but the seller has no evidence to prove it, and condition (2) does not hold, then the parties trade the basic good only.

[15] Our focus on posted-price contracts is again without loss of generality. While this is obvious if the seller can make the offer, it is also true if the buyer can make the offer. In the latter case, it follows from Green and Laffont (1986) that the revelation principle is valid and it is straightforward to adapt the optimal direct revelation mechanisms for the case of "hard" information derived in Schmitz (2007, 2021) to the present setup in order to show that the same outcome is attained as by the optimal posted-price contract.

5 Optimal ownership

Recall that at date 1 the parties agree on the ownership structure that maximizes the expected total surplus. Note that

$$0 < \frac{(1-\lambda)(v-c_H)}{v-c_L-\lambda(v-c_H)} < \frac{v-c_H}{v-c_L} < 1$$

must hold for all $\lambda \in (0,1)$. Thus, a comparison of S^{VI} and S^{NI} leads to the following conclusion, which is illustrated in Figure 1.[16]

Proposition 1 *(i) If* $p > \frac{v-c_H}{v-c_L}$*, then vertical integration is optimal* ($S^{VI} > S^{NI}$)*.*
(ii) If $\frac{(1-\lambda)(v-c_H)}{v-c_L-\lambda(v-c_H)} < p \leq \frac{v-c_H}{v-c_L}$*, then non-integration is optimal* ($S^{VI} < S^{NI}$)*.*
(iii) If $p \leq \frac{(1-\lambda)(v-c_H)}{v-c_L-\lambda(v-c_H)}$*, then ownership does not matter* ($S^{VI} = S^{NI}$)*.*

In case (i) of the proposition, neither condition (1) nor condition (2) holds. In this case, non-integration leads to an ex-post inefficiency with probability $\pi(1-p)$, while vertical integration leads to an ex-post inefficiency with probability $\pi(1-\lambda)(1-p)$ only. The fact that under vertical integration the buyer can verify evidence that the seller might be able to provide with regard to the realization of her costs thus makes vertical integration more attractive, as one might have expected.

In case (iii), the conditions (1) and (2) both hold, so the first-best outcome is attained regardless of the ownership structure.

The remaining case (ii) is the most interesting one. In this case, condition (1) is satisfied, while condition (2) does not hold. Hence, vertical integration leads to an ex-post inefficiency with probability $\pi(1-\lambda)(1-p)$, while non-integration yields the first-best outcome. Thus, the potential presence of verifiable evidence in the case of vertical integration can actually be harmful. To see this, observe that when the buyer can make the offer at date 2, in the case of non-integration making the offer $t = c_H$ (which will always be accepted) is more attractive than the alternative (i.e., an offer $t = c_L$, which would be accepted with probability p only). In contrast,

[16] Note that the figure depicts under what ownership structure the expected total surplus is maximized, but it does not show by what amount the surplus levels differ between $o = VI$ and $o = NI$. Specifically, recall that the difference between the ownership structures disappears when λ goes to zero, while the first-best outcome is always attained under $o = VI$ when λ goes to one.

in the case of vertical integration the offer $t = c_H$ is less attractive for the buyer than the alternative (offering $t = c_L$ unless the seller proves that $c = c_H$ has been realized, which will be accepted with probability $\lambda + (1-\lambda)p > p$). Thus, under non-integration the buyer makes an offer that always covers the seller's costs, even when the costs are high, so ex-post efficiency is attained. Under vertical integration, the buyer is willing to make such a large offer only if the seller proves that the costs are high. As a consequence, there is an ex-post inefficiency with a positive probability, because the seller may have no evidence to prove that the costs are high.

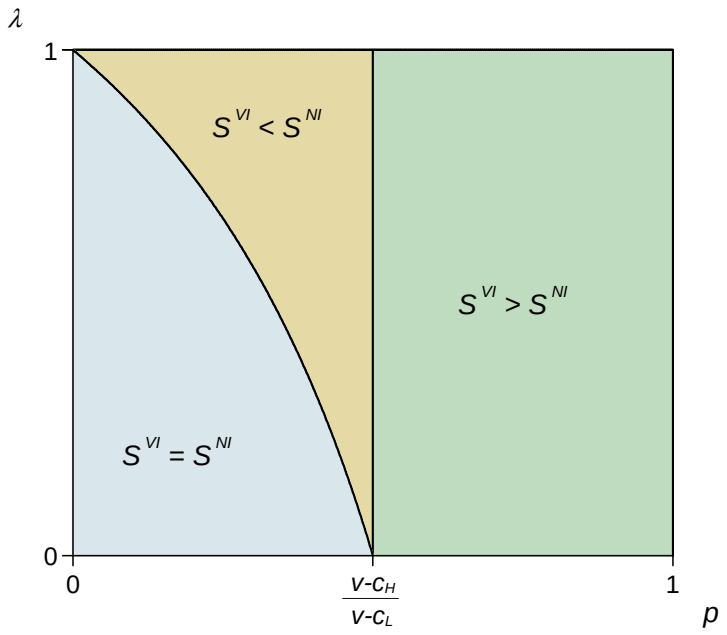

Figure 1. The optimal ownership structures. The curve between the blue region and the brown region depicts the combinations of p and λ for which condition (2) holds with equality.

6 Conclusion

In our model, in the case of vertical integration the buyer can verify evidence that the seller might be able to provide with regard to her costs. In the case of non-integration, the buyer cannot verify evidence presented by the seller. There are no

further differences between the two ownership structures. We have shown that it depends on the parameter constellation whether vertical integration or non-integration is optimal. Hence, in our model there is a single force working in two ways. The pros and cons of outsourcing are two sides of the same coin, since they both follow from the fact that vertical integration may allow the buyer to verify evidence provided by the seller.

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