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Real options with ex-post division of the surplus

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ABSTRACT

This paper examines a real option model where two vertically related firms are involved in a specific investment project that is subject to an uncertain payoff. While ex-post bargaining between a seller and a buyer leads to underinvestment by the seller in a standard model where timing of the seller's investment is exogenous, we show that this need not be the case when the seller's timing of investment is endogenous. However, bargaining with a buyer leads to excessive waiting. More severe holdup and higher uncertainty will lead to vertical integration of activities to avoid timing inefficiencies.

1. Introduction

Investment projects are often rather complex and involve more than just one firm. Due to specialization, a firm will rely on specific investments by a supplier to buy the inputs that are needed to enter a market. As it is generally difficult to write complete contracts that foresee all possible external factors, making idiosyncratic investments with no alternative use incurs the risk of holdup. As such, these idiosyncratic investment projects are irreversible and often subject to large uncertainty about the surplus after investment, yielding an option value of flexibility regarding the timing of investment. Notable examples are large infrastructure projects where a firm invests in some basic infrastructure (e.g., a building or a network) and another firm exploits the building (e.g., a hotel) or a network (e.g., an internet provider). Casual observation shows frequent delays in the start of these infrastructure projects. It is not clear a priori, however, why such delays occur and if the possibility of holdup has an impact on the amount of investments once projects are started.

Though such investment projects are common, studies that examine the option value of flexibility when there is more than one party involved in the investment project are rare. This paper tries to fill this gap by first considering the decision of an upstream firm making an idiosyncratic investment in order to trade with a downstream firm. As the investment of the seller is specific for the relation with the buyer, the investment cost is sunk. Standard models with ex post negotiation over the division of the surplus consider firms with a now-or-never decision. In these models with exogenous timing of investment, it is well known that the possibility of holdup will make the seller underinvest. Underinvestment is relative to an integrated firm, which faces no problems of holdup.

However, there is ample evidence that firms time their investments when they are most profitable. We will show that the endogenous timing of the seller's sunk cost investment qualifies the underinvestment result. Taking into account the option of waiting, we show that ex post negotiation does not necessarily have an impact on the level of investment, but has an adverse impact on the timing of investment. So, with post-investment negotiation, the traditional result of underinvestment appears only in the form of excessive waiting. If we consider the level of investment as quality of the final good, quality is not necessarily affected by an actor who seizes part of the profit post investment, but there will be less frequent investment; e.g., firms who pay high taxes to the government will not necessarily lower the level of investment but will invest less often.

The main contribution of the paper is to integrate two seminal streams of literature that up to now have been considered in isolation.

The literature on investment under uncertainty claims that the classic net present value (NPV) rule saying that investing is optimal as soon as the NPV is positive is not always valid. It argues that the option to wait in order to be better informed has to be taken into account. The existence of such an option value requires three features: first, postponement of the investment must be feasible; second, there must be some uncertainty concerning the value of the project in the future, and finally, the investment decision has to be irreversible. The last condition means that the investment cost is sunk. McDonald and Siegel (1986) were among the first to give an expression for the option value. Moreover, they showed that the optimal investment strategy is a trigger strategy: invest as soon as the investment value is greater than a thresh-

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old, the value of which increases with uncertainty (see also Dixit and Pindyck (1994)). Recent contributions have looked at strategic interactions where two firms compete in the marketplace and the option value of waiting gets reduced (e.g., Pawlina and Kort, 2006; Mason and Weeds, 2010) and have undertaken empirical studies as to test several predictions from real option theory (e.g., Guiso and Parigi, 1999; Bloom et al., 2007).

The literature on ex-post negotiation departs from the observation that, in bilateral trade, an economic agent, after making a relationship specific investment, is vulnerable to ex post negotiation with its trading partner. A complete contract, avoiding ex-post negotiation, is considered impossible due to several circumstances, which are hard to predict but affect efficient trading after investment has been sunk. When trading partners negotiate to divide their trade surplus after making a relationship-specific investment, a holdup problem arises, which leads to ex ante underinvestment (Williamson, 1985). Contracting theory has searched for several remedies as safeguards against holdup. A standard remedy against holdup is vertical integration (Acemoglu et al., 2009; Klein et al., 1978; Williamson, 1979), though this is not always possible and normally gives rise to other costs. Other remedies have been found in simple (incomplete) contracts that solve the holdup problem by allocating the entire bargaining power to the party making the investment decision (Aghion et al., 1994; Chung, 1991; Nöldeke and Schmidt, 1995). As a result, this party becomes the residual claimant to the transaction and has the incentive to invest optimally.

The theory of ex-post negotiation and the literature on optimal timing of investment share two basic conditions: (i) uncertainty about future payoffs and (ii) sunk cost due to specific investments, so it seems natural to bring these theories together. Integrating the two streams of literature revisits the traditional result of underinvestment by demonstrating that the optimal level of the seller's investment equals the optimal investment of an integrated firm for payoff functions that are multiplicatively separable in time and the level of investment. The intuition behind this result is that the general result in real option models that the seller will only invest when the expected (post-bargaining) payoff exceeds a certain critical value remains valid. The bargaining power influences the expected post-bargaining payoff, but does not have an impact on the required expected payoff, which is a simple multiple of the investment cost. As the required expected post-bargaining pay-off is independent of the bargaining power, the optimal level of investment is also independent of the bargaining power, i.e. the optimal level of investment is the same whether ex-post bargaining takes place or not and matches the level of investment for an integrated firm. However, another inefficiency appears. The lower the bargaining power of the seller, the lower is the payoff and the longer is the expected time until the seller invests. Due to this excessive waiting the project value is negatively affected by ex-post bargaining. Moreover, this study shows that, if the seller can vertically integrate at some upfront cost, he will do so when his bargaining power is sufficiently weak or when uncertainty is sufficiently high.

Some papers have looked at relations between the discussed streams of literature. Li and Kouvelis (1999) examine time flexible contracts where a buyer can determine, within a given time window, when to buy from a supplier. In the model, price is uncertain while demand is fixed. Though the paper allows for endogenous timing of buying from a supplier, there is no investment by the supplier and no fear of holdup. In a model where timing is exogenous, Smirnov and Wait (2004) show that sequencing of investments may aggravate the holdup problem. Che and Sákovics (2004) examine dynamics and endogenous investment where a holdup problem exists. They set up a dynamic model of bargaining and investment where the buyer and the seller continue to invest until agreement is reached over the terms of trade. It shows that underinvestment will not appear when parties are sufficiently patient. Our paper is rather different, as in our basic model the seller only invests once and the buyer remains passive until the seller decides to invest. Related to their paper is Guriev and Kvasov (2005) in which contracting, investment and trade repeatedly take place in continuous time. Whereas their model focuses on the duration of contracts, our model examines the optimal timing of a relationship-specific investment, which is jointly determined with the optimal level of investment. As the investment may not be verifiable by a third party, the optimal timing of investment cannot be contracted upon in our model.

There are just a few papers that also use real option modeling to explain outsourcing decisions. Alvarez and Stenbacka (2007) examine the optimal fraction of outsourcing, where outsourcing involves a sunk cost and can be delayed. Their paper shows that an increase in uncertainty leads to more outsourcing and a later realization of the investment. Our model is different in that we examine the impact of ex-post bargaining on outsourcing versus the decision of an integrated firm. De Villemeur et al. (2014) analyze vertical relations in a real option model where the level of investment is fixed and there is no post-investment haggling over the surplus. As both the downstream and the upstream firm charge a markup over the cost, double marginalization in their model causes inefficient delay in the timing of investment. Finally, Lambrecht et al. (2016) examine in a real option model how operating leverage of a firm, its beta and expected returns depend on the firm's optimal procurement regime.

Other links to the financial literature, in addition to the latter paper, mainly relate to surplus sharing in real option models. For example, surplus sharing is also relevant for merger decisions and has been studied by Lambrecht (2004). He finds that surplus sharing excessively delays the timing of the investment decision when takeovers are hostile instead of friendly. Morellec and Zhdanov (2005, 2008) develop real option models where the timing and terms of the takeover depend on the information structure, intensity of competition and capital structure of a firm. Suboptimal timing decisions when equity and debtholders are involved in a firm's investment option is also shown by Mauer and Sarkar (2005) who show that an equity-maximizing firm makes a different investment decision than a value-maximizing firm.

This paper is organized as follows. The next section sets out the basic model and derives results for the case with no buyer's investment and for the case where the buyer makes a fixed investment. Section 3 discusses how our results are modified when we consider outside options for the buyer and a take-it-or-leave-it offer for the seller. Furthermore, we explore the implications of our results for optimal licensing (or taxation) and empirical analysis. Finally, Section 4 concludes the paper.

2. The model

One of the parties, the (potential) seller, is able to create one unit of an indivisible good. In order to sell the good on the market, a downstream activity is required, which can be carried out by the seller or a (downstream) buyer. Both parties are risk-neutral and there is no private information. We assume that the seller, by making an idiosyncratic investment s, creates a (joint) surplus $X(t)\pi(s)$ at time t when the good is sold on the market. The buyer makes no value-enhancing investment for the downstream activity. If the seller decides to integrate activities, it needs to incur a fixed cost in order to produce at the same cost as the seller would face when trading with a downstream firm, for example to acquire the same technology as a downstream firm has. As a result, the profit function π is the same for the seller, irrespective of whether it integrates the downstream activity or outsources, and only depends on the level of investment by the seller. The setting al lows us to

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