



Investment timing and vertical relationships[☆]

Etienne Billette de Villemeur^a, Richard Ruble^{b,*}, Bruno Versaevol^b

^a EQUIPPE, Université de Lille, France

^b EMLYON Business School & GATE, France



ARTICLE INFO

Article history:

Received 5 July 2012

Received in revised form 20 June 2013

Accepted 23 June 2013

Available online 2 July 2013

JEL classification:

C73

D92

G31

L13

Keywords:

Irreversible investment

Preemption

Real options

Vertical relations

ABSTRACT

We show that the standard analysis of vertical relationships transposes directly to investment dynamics. Thus, when a firm undertaking a project requires an outside supplier (e.g., an equipment manufacturer) to provide it with a discrete input to serve a growing but uncertain demand, and if the supplier has market power, investment occurs too late from an industry standpoint. The distortion in firm decisions is characterized by a Lerner-type index. Despite the underlying investment option, greater volatility can result in a lower value for both firms. We examine several contractual alternatives to induce efficient timing, a novel vertical restraint being for the upstream to sell a call option on the input. We also extend the model to allow for downstream duopoly. When downstream firms are engaged in a preemption race, the upstream firm sells the input to the first investor at a discount such that the race to preempt exactly offsets the vertical distortion, and this leader invests at the optimal time. These results are illustrated with a case study drawn from the pharmaceutical industry.

© 2013 Elsevier B.V. All rights reserved.

1. Introduction

In dynamic models of irreversible investment under uncertainty, such as market entry or R&D, the investment cost (which constitutes the strike price of a so-called investment option) is often tacitly taken to reflect economic fundamentals closely. This assumption seems reasonable in industries such as real estate development, or when the investment is performed largely in-house, as may occur with R&D. However, there are many other cases in which a firm contemplating investment depends on an outside firm with market power to provide it with a discrete input (e.g., a key equipment) it needs to start producing and selling. Thus, a local hospital must decide when to buy diagnostic imaging equipment from an outside firm, an oil company that decides

to drill offshore must acquire a platform from a specialized supplier, or an aeronautics firm will coordinate aircraft development with an engine manufacturer. In addition, strategic issues can arise if several firms seek to invest in an industry, and call upon the same supplier. To illustrate, at the end of the paper we outline the case of a market for a new vaccine, where demand is related to the diffusion of an emerging pathogen, and firms must invest in a factory constructed to exact specifications before starting operations.

This paper uses advances in irreversible investment and in duopoly investment games to build a model of vertical relationships in which the cost of a firm's investment is endogenous. Thus, our aim is to contribute in a growing research area that straddles industrial organization and corporate finance. We believe our key originality lies in the integration of two research streams that had seemed heretofore distinct: modern treatments of irreversible investment choices, as in Dixit and Pindyck (1994), and the classic representation of vertical relationships as described, e.g., by Tirole (1988). Also, we extend this framework to include similar strategic specifications downstream to those of models by Smit and Trigeorgis (2004), Mason and Weeds (2010), and Boyer et al. (2012),¹ but with an upstream equipment supplier that prices with market power. The most closely related work we have identified is in corporate finance and studies the impact of agency on option exercise,

[☆] This paper was completed while Etienne Billette de Villemeur was visiting the University of Montreal whose hospitality is gratefully acknowledged. We benefited from comments at the 2010 annual conference of the Canadian Economics Association (Quebec City), the 2010 International Conference on Real Options (Rome), the 2011 Econometric Society European Meeting (Oslo), the 2011 conference of the European Association for Research in Industrial Economics (Stockholm), and seminars at Paris School of Economics, Fudan University (Shanghai), ESMT (Berlin) and at GATE (Lyon). We are indebted to Antoine Alarcon and Dominique Carouge (Sanofi Pasteur), Nicolas Giry (2Ctec), and to Andrew Farlow (University of Oxford), for very useful discussions on vaccine markets. Special thanks are addressed to Marcel Boyer, Benoît Chevalier-Roignant, Pin-Huei Chiang, Thomas Jeitschko, Pierre Lasserre, Robert Pindyck, Lenos Trigeorgis, and Helen Weeds for insightful comments or help in various forms. All remaining errors are ours.

* Corresponding author. Tel.: +33 624796871.

E-mail address: ruble@em-lyon.com (R. Ruble).

¹ For recent surveys of game theoretic real options models, see Boyer et al. (2010), and Huisman et al. (2005).

most notably Grenadier and Wang (2005) (corporate governance), and Lambrecht (2004), Lambrecht and Myers (2007) (takeovers).²

Specifically, we show that the standard analysis of vertical relationships translates directly to investment timing, with the level of investment trigger replacing price as the decision variable of the downstream firm. When an upstream supplier exercises market power, a vertical effect akin to double marginalization causes the downstream firm to unduly delay its investment relative to the optimal exercise threshold for the industry. This distortion increases with both market growth and volatility and decreases with the interest rate. The industry earns lower value under separation than under integration. In contrast with the standard real option framework, greater volatility decreases upstream and downstream firm value near the exercise threshold, because of the simultaneous presence of two effects: the option value of delay is balanced by a greater mark-up choice by the upstream firm.

The study of vertical relationships typically examines contractual restraints, by which an upstream firm can improve on a fixed input price. We verify that an upstream firm that can contract on the state of final demand achieves the integrated outcome, but also find that, provided demand volatility is low, a simple time-dependent pricing rule suffices to approximate the industry optimum. Alternatively, if spacing out payments is feasible, an option or downpayment restores efficiency. This latter explanation of use of restraints appears to rationalize existing practices in some industries, notably Airbus' approach to marketing aircraft.

Without such contractual alternatives, the upstream firm benefits from the presence of a second downstream firm, although this possibly occurs at the expense of aggregate industry value. We find that the race between downstream firms to preempt one another exactly balances the incentive to delay caused by the upstream firm's mark-up, so the leader invests at the optimal integrated threshold (as in the reference case with a single integrated firm), whereas the follower invests at the separation threshold (for duopoly profits), a type of “no distortion at the top” result. The leader receives a discounted price, and this discount increases with volatility and decreases with competition in the downstream product market. The comparison of industry value under different structures reveals that the three-firm industry structure may be more desirable than both bilateral monopoly (even if adding a second downstream firm decreases downstream industry profits) and preemption between vertically integrated firms (even if double marginalization induces firms to delay entry).

The remainder of the paper is organized as follows. In Section 2 we describe the model, with one upstream supplier and one downstream firm, and investigate the basic vertical distortion. This is done by comparing the equilibrium outcomes in the integrated case, which we use as a benchmark, with the outcomes of the separated case. In Section 3, we discuss contractual alternatives that aim to restore the industry optimum and relate them to an industry case. In Section 4, we introduce a second downstream firm and study equilibrium pricing and investment decisions, and then compare with the outcomes under alternative industry structures. In Section 5, we illustrate the analysis by examining the case of an emerging market for a new vaccine. Section 6 concludes. All the proofs and derivations are in the appendix.

2. The basic vertical distortion

Investment in a discrete input is necessary to operate on a final market. It can be produced and used by the same firm (integration), or produced by an upstream supplier and used by a downstream firm (separation). The cost of producing the input is positive and denoted by I . The flow profit resulting from investment is $Y_t \pi_M$ where π_M is the instantaneous monopoly profit per unit of Y_t , and $Y_t > 0$ is a

scale parameter assumed to follow a geometric Brownian motion with drift, $dY_t = \alpha Y_t dt + \sigma Y_t dZ_t$. The non-negative parameters α and σ represent the market's expected growth rate (or “drift”) and volatility, respectively, and Z_t is a standard Wiener process.³ A lower-case $y = Y_t$ is used to denote the current level of the state variable, and it is assumed throughout the paper that the initial market size is positive and sufficiently small so firms prefer to delay rather than to invest immediately.⁴ We let y_i denote a decision variable which is a threshold that, when attained by Y_t for the first time and from below at a stochastic future date, triggers the investment in the discrete input. The discount rate $r > \alpha$ is common to all firms.⁵

2.1. Integrated case

Suppose that a single firm produces the discrete input, is able to observe the current market size, and thus may decide at which future threshold to invest so as to earn the subsequent flow profit. Given the investment cost I and the current market size y , the value of a firm that decides to invest when the market reaches size $y_i \geq y$ is:

$$V(y, y_i, I) = \left(\frac{\pi_M}{r - \alpha} y_i - I \right) \left(\frac{y}{y_i} \right)^\beta, \quad (1)$$

where $\beta(\alpha, \sigma, r) \equiv \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt{\left(\frac{\alpha}{\sigma^2} - \frac{1}{2} \right)^2 + \frac{2r}{\sigma^2}}$ is a function of parameters, referred to as β for conciseness, that occurs throughout the paper. The expressions of $V(y, y_i, I)$ in Eq. (1), and of β , are standard in real option models (see Dixit and Pindyck (1994), Chapter 5, or Chevalier–Roignant and Trigeorgis, Chapters 11–12).⁶ We will use the property that β is decreasing in α and in σ , and increasing in r , throughout the paper.

The integrated firm's decision problem is $\max_{y_i \geq y} V(y, y_i, I)$. Since the objective is quasiconcave, differentiating Eq. (1) gives the value-maximizing investment trigger, $y^* = \frac{\beta}{\beta-1} \frac{r-\alpha}{\pi_M} I$, which serves as a benchmark throughout the analysis. The current value of the firm that invests at the optimal threshold y^* is:

$$V(y, y^*, I) = \frac{I}{\beta-1} \left(\frac{y}{y^*} \right)^\beta. \quad (2)$$

2.2. Separated case

Suppose that the input production and investment decisions are made by distinct firms. In this case a vertical distortion arises. The following assumptions are made in order to describe this externality simply and distinctly. First, the upstream firm, as an input producer on the intermediate market, does not observe the state of the system (the downstream market size y) at any date, including $t = 0$. However it knows the structural parameters of the demand process. Its only choice consists of the input price $p_s \geq I$ (thereby determining the terms of the downstream firm's investment option). The input price is taken to be constant, although the upstream may generally prefer to have its price increase over time in order to hasten downstream investment (see Section 3.2). Second, the downstream firm is assumed to be a price-taker in the intermediate market.⁷ Given p_s , it observes the current size of the final

³ The geometric Brownian motion is derived from $Y_t = Y_0 \exp[(\alpha - \frac{1}{2}\sigma^2)t + \sigma Z_t]$ by using Itô's lemma.

⁴ Specifically, we suppose that $Y_0 < \frac{\beta}{\beta-1} \frac{r-\alpha}{\pi_M} I$, where β is a function of parameters defined in Section 2.1.

⁵ A firm may delay investment indefinitely if $r \leq \alpha$.

⁶ The term $\left(\frac{y}{y_i} \right)^\beta$ in Eq. (1) reads as the expected discounted value, measured when $Y_t = y$, of receiving one monetary unit when Y_t reaches y_i for the first time. In the certainty case $\sigma = 0$, we have $\beta = \frac{r}{\alpha}$ and $\left(\frac{y}{y_i} \right)^\beta = e^{-r(t_i - t)}$, which is the standard continuous time discounting term.

⁷ As in Tirole (1988) it is “for simplicity” that we “assume that the manufacturer chooses the contract” (p. 173).

² See also Lambrecht et al. (2012) and Patel and Zavodov (2010) for alternative approaches to real options in vertical structures, and Yoshida (2012) for a discussion of the impact of strategic complementarity on investment timing.

Download English Version:

<https://daneshyari.com/en/article/5078006>

Download Persian Version:

<https://daneshyari.com/article/5078006>

[Daneshyari.com](https://daneshyari.com)