The 'Fundamental Transformation' Reconsidered: Dixit vs. Williamson

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Abstract

Comparing the literature on hold-up with the one on strategic entry deterrence leads to a puzzling role for sunk or specific investments in affecting investor's incentive. In one case, nonredeployable investments decrease investor's ex-post bargaining power, in the other they increase it. When the entry deterrence effect is acknowledged, the threat of hold-up against investor is largely weakened and assets specificity may even constitute an endogenous enforcement device for incomplete contracts. We conclude that the impact of asset specificity on investor's post-contractual power, far from being general, depends on the nature of contract-market interactions.

Keywords: Fundamental Transformation, Asset-specificity, Entry deterrence.

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1. Introduction

In this paper, we compare the literature on hold-up whose one of main exponents is Oliver Williamson to the literature on strategic deterrence originated from contributions by Avinash Dixit. We find that asset-specificity may act as entry deterrence strategy and then may constitute an endogenous enforcement device for incomplete contracts. In particular, we define the "Dixit-Williamson equilibrium", a circumstance where incumbent's specific investments under incomplete contracts may intimidate prospective entrant and then increase opportunity costs of its counterparty's opportunistic behaviour because alternatives to incumbent are reduced. In this respect, incumbent by specific investments may render counterparty's hold-up costly enough to be not credible.

In Avinash Dixit's article, *The Role of Investment in Entry-Deterrence*, one incumbent firm seller 1 faces one prospective entrant seller 2. If the entry occurs, agents will play a Cournot-like market. However, according to Dixit, incumbent's investments in capacity may deter competitors' entry because the incumbent is signaling her will to put into action an aggressive competition. According to this literature (see also Bain 1956, Spence 1977, Scherer 1980), sunk investments may act as a credible device to deter competitors' entry. Whenever an entrant's profits are adversely affected by the incumbent's sunk investments, the incumbent firm might decide to increase strategically her level of investments in order to reduce the probability of entry. When entry is deterred, the investor will maintain ex-ante bargaining power vis-à-vis her clients in the market. As a consequence, entry deterrence allows investor to maintain their pre-entry rents in the market. The incumbent maintains a competitive advantage in moving first to commit to non-contractible investments in durable capacity, having the effect of destroying or restricting the opportunities available to entrants. By committing to play an aggressive strategy after entry, incumbents send a signal to potential competitors in order to dissuade them from entering the market.

In about the same period, another stream of literature, predicted a quite opposite result. In the case of contractual incompleteness, level of specific investments may be threatened by opportunistic behaviour (Klein *et al.* 1978, Williamson 1985a, 1985b, Grossman and Hart

1986, Hart and Moore 1990, Hart 1995, Tirole 1999). The incomplete contracts literature argued that the efficient level of irreversible or specific investments might be inhibited under an incomplete contract relationship. When investments are observable but unverifiable, the owner of specific assets (i.e. the agent who makes investments specific to the contractual relationship with lower value in outside available opportunities) turns to be locked into the relationship, then becoming vulnerable to the counterparty's renegotiation of agreed upon contractual terms (i.e., hold-up). The point to note here is that with positive probability of opportunistic behaviours the return to non-contractible investments is only a contingent return. The main consequence is that contractual parties have strong incentives to underinvest in asset specificity, and the risk of counterpart's opportunistic behaviour reduces parties' incentives to generate potential quasi-rents.

Therefore, parties have to build complex institutional arrangements in order to deter hold-up and to provide appropriate incentives to investors in assets specificity. In particular, Oliver Williamson affirms that parties may choose to substitute market bargaining with a vertical integration, or more generally, with a bilateral monopolistic trade in order to maximize specific investments. Williamson refers to this 'substitution' as the fundamental transformation. Considering the entry deterrence effect of specific investments in the Williamsonian framework, allows comparing the 'fundamental transformation' occurring in contracts due to asset specificity with that occurring in markets due to the entry deterrence effect. An important consequence is that when the investor has some market power, eventually generated by the entry deterrence effect of his investments, the fundamental transformation occurring in the market implies that no safeguards are needed to protect her specific investments from the risk of counterpart's hold-up behaviour, as this risk is precisely reduced by the entry deterrence effect.

Surprisingly the literature on incomplete contracts has neglected – with some few exceptions, i.e. Spier and Whinston (1995) – the 'commitment' role played by asset specificity against competitors, i.e. the role played by asset specificity in affecting the outside option of the renegotiating party. However, as we argue, if we admit that specific investments may potentially deter investors' competitors, this result may affect incentives towards hold-up behaviour. For hold-up being a credible strategy it must be that the renegotiating party can credible exit the relationship without incurring in opportunity costs. This means that 'some' investor's competitors should be available in the market.

However, if specific investments also generate an entry deterrence effect, then asset specificity may play a countervailing effect on incentives towards hold-up. In this circumstance, asset specificity may indeed preserve investor's ex-post bargaining power and thus may serve as an endogenous enforcement devise for incomplete contract. When this is the case there is no need for granting further protection to investors, as they may even maintain strong incentives towards overinvestment in assets specificity. In the extreme case, indeed, the highest is the level of specificity of the investor the lower is the incentive towards renegotiation by the counterparty. An overinvestment in asset specificity, under an incomplete contract framework, may generate what Buehler and Schmutzler (2008) call an "intimidating effect" on prospective competitors, i.e. an investment that, if observed before entry, may endogenously discourage the entry of new entrant firm. By using the deterrence effect of non-contractible investment as an *enforcement device* for the incomplete contract, the incumbent seller may strategically overinvest in non-contractible investments in order to deter an efficient or perhaps a more efficient entrant. Such an overinvestment plays the role of an *intimidating strategy* against entry, even when contracts are with zero enforceable breach penalties.

It brings to an important consequence in terms of policy prescriptions: safeguards against hold-up should be granted when the investor faces a competitive market and there is no room for increasing her market power through entry deterrence strategies. When this is not the case, asset specificity acts as an endogenous enforcement device and any further protection assured to investors may even reduce, rather than increase total level of investments.

Moreover, taking into account the potential entry deterrence role of asset specificity clarifies the institutional context in which hold-up may occur. As Williamson outlined, it refers to situations in which parties in a contract face an outside competitive market, before the 'fundamental transformation' due to specific investments occurs.[1] That is, an underlying assumption of hold up theory is that the renegotiating party, facing a competitive environment outside the contract, can always exit the contract without incurring any loss. Thus, hold-up against the investor in specific assets is credible when

[1] The 'fundamental transformation' in market transactions, is defined as the process according to which transaction-specific investments reduce the field of available alternatives from a large number (i.e., the ex-ante bargaining situation) to a small number (i.e., the ex-post bidding situation).

exit is costless for the renegotiating party, i.e. when a large number of alternatives are available for the renegotiating party.

The paper is structured as follows. In section 2 we offer the intuition of our argument. Section 3 illustrates our simple model. Section 4 is devoted to the discussion of our results and the remarks of our relevant findings.

2. The puzzling role of irreversible investments

In his path-breaking article, *The Role of Investment in Entry-Deterrence*, Avinash Dixit (1980) argued that in the simplest case of one incumbent firm facing one prospective entrant, the incumbent firm could alter the market outcome to its advantage by investing in irreversible capacity. The main point raised by Dixit was the commitment role of irreversible or sunk investments in inducing entry deterrence by affecting the initial conditions in the post-entry game to the advantage of the incumbent firm. As Dixit pointed out (1980:95):

> *[t]he established firm's pre-entry decisions can influence the prospective entrant's view of what will happen if he enters, and the established firm will try to exploit this possibility to its own advantage.*

Namely, the incumbent firm can alter the post-entry outcomes to its advantage by changing the initial conditions. In particular, the incumbent firm would threaten to respond to entry with a 'war price' or a predatory increase in output. Indeed, an irrevocable choice of investment allows the incumbent firm to credibly affect the post-entry equilibrium.

In Dixit's example the rules of the game are as follows. The incumbent firm chooses a pre-entry capacity level $k \in \mathbb{R}_+$ (which might be a sunk investment, not redeployable in alternative uses). If entry does not occur at all, then the incumbent firm continues in the

pre-entry stationary state. If it occurs, the post-entry equilibrium is established in the resulting duopoly. By backward induction, the two players anticipate the outcomes and implement the solution immediately. If the other firm decides to enter, the two will achieve a duopoly equilibrium with quantity-setting *à la Cournot*. Otherwise the incumbent firm will prevail as a monopoly. The choice of the level of sunk investment, k, thus affects the shape of the marginal cost curve of the incumbent firm, which in turn affects its reaction curve. When two firms interact, the resulting duopoly equilibrium depends on k. If the profits for the new entrant are positive, entry will occur; otherwise the entrant will stay out of the market (see figure 1).

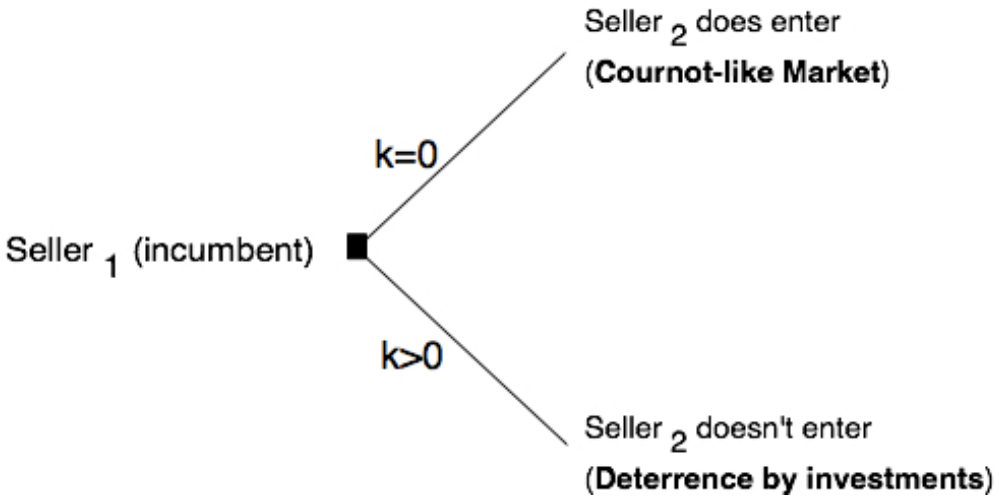

Figure 1. *Dixitian* deterrence by irreversible investments

The level of *k* is decisive for ex-post competition. When the commitment is deemed to be credible, in terms of post-entry aggressive strategy, irreversible investments allow the investor to maintain ex-post the pre-entry profit level. To be credible, however, the commitment strategy should generate an equilibrium with entry deterrence.

Now, let us consider a scheme of incomplete contracts in which asset specificity level is indicated with k (Williamson, 1985a, 1985b). The general-purpose investments are represented by $k = 0$, where unassisted market contracting, leads to Pareto efficiency. Parties have an incentive to define appropriate safeguards to protect investments in

transactions sustained by asset-specificity $k > 0$. Let s denote the magnitude of any of such safeguards. When $s = 0$, no safeguards are provided. Figure 2 displays the contracting outcomes corresponding to this description.

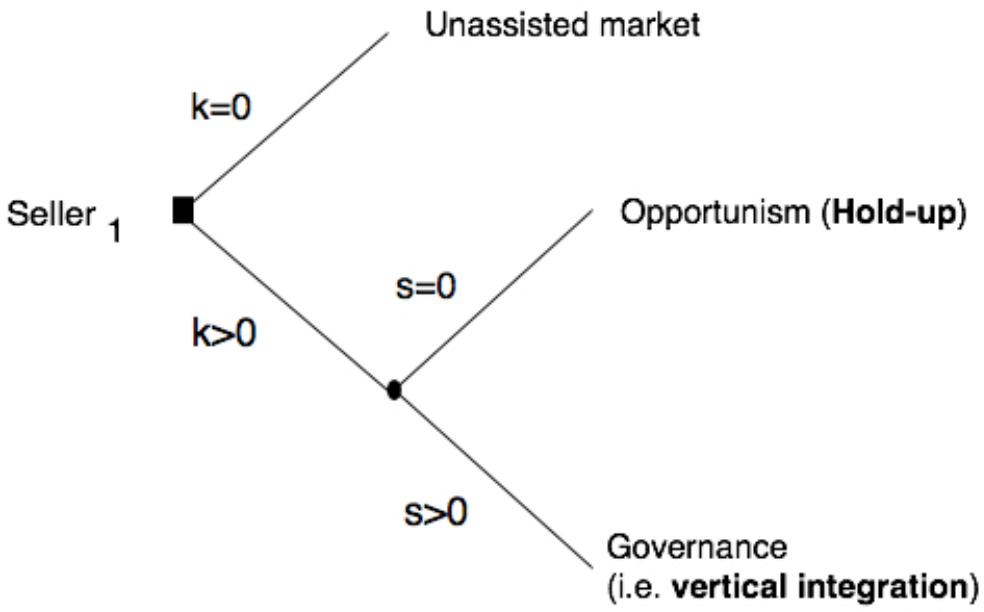

Figure 2. *Williamsonian* contracting scheme with specific investments

"Unassisted market" represents the general-purpose technology ($k = 0$) supply relation for which an efficient transaction is verified. Given that safeguards are costly, the case of general-purpose technology with positive safeguards represents an inefficient legal context because some resources are wasted. "Opportunism" occurs when the contract is supported by transaction specific-assets ($k > 0$) for which no safeguard is offered, viz. $s = 0$. Here a typical opportunistic behavior is the holdup. This type of transaction is apt to be unstable contractually: it may imply the abandonment of specific investments or the introduction of contractual safeguards that would encourage the continued use of the $k > 0$ technology. In other words, given parties cannot sign "complete" contracts, which specify efficient trade for each possible state of the world, renegotiation is always possible. Consequently, a party who made specific investments will be exposed to adverse renegotiation (hold-up) due to her increased opportunity cost to redeploy assets in alternative uses with lower

value, outside the relationship. Thus, specific investments 'reduce' the investor's ex-post bargaining power. This literature suggests that the occurrence of holdup leads to underinvestment in specificity, generating inefficiency.

Therefore, with a specific purpose technology $k > 0$, governance is required ($s > 0$). In Williamson's words, 'governance' means organizing transactions so as to economize costs deriving from bounded rationality and hazards of opportunism. Hence, "despite best efforts, nonstandard contracting still experiences great governance strains, market contracting may eventually be supplanted by unified ownership (*vertical integration*)" (Williamson 1985b: 185, emphasis added). In particular, "[t]ransactions that involve significant investments of a transaction-specific ($k > 0$) kind are ones for which the parties are effectively engaged in bilateral trade" (Williamson 1985b: 187).

Williamson refers to this vertical integration as *fundamental transformation*: with incomplete contracts characterized by specific investments, the ex-ante competitive transaction is ex-post "transformed" into a bilateral monopoly. Then, the fundamental transformation indicates a market configuration (i.e. bilateral monopolistic trade) in which, to ensure contractual performance, contractual parties save a consistent portion of economic resources (contractual costs) required under asset specificity conditions.

However, with the concept of fundamental transformation Williamson has confined his analysis to the case in which an ex-ante competitive transaction is ex-post transformed into a monopolistic one. In particular, 'fundamental transformation' acts only in one way: from market exchange to a bilateral monopolistic trade. In other words, investment decisions are affected by the ex-ante market configuration, but they do not affect each agent's ex-post competitors. The 'market' is implicitly supposed to be an equilibrium market and hence for contractual parties it is not possible to affect (and to be affected by) competitors' strategies.

We are interested in analysing those situations in which specific investments, by playing a deterrence role may affect the market configuration and hence the exit costs of the renegotiating party. The intuition here, is that when specific investments generate an

entry deterrence effect or, a market foreclosure effect, i.e. when they affect the level of non-investors' ex-post outside option, this effect has a countervailing impact on the hold-up risk. Indeed, the deterrent effect on competition of specific investments will 'increase' the investor bargaining power vis-à-vis the non-investing party, reducing the probability of hold-up.

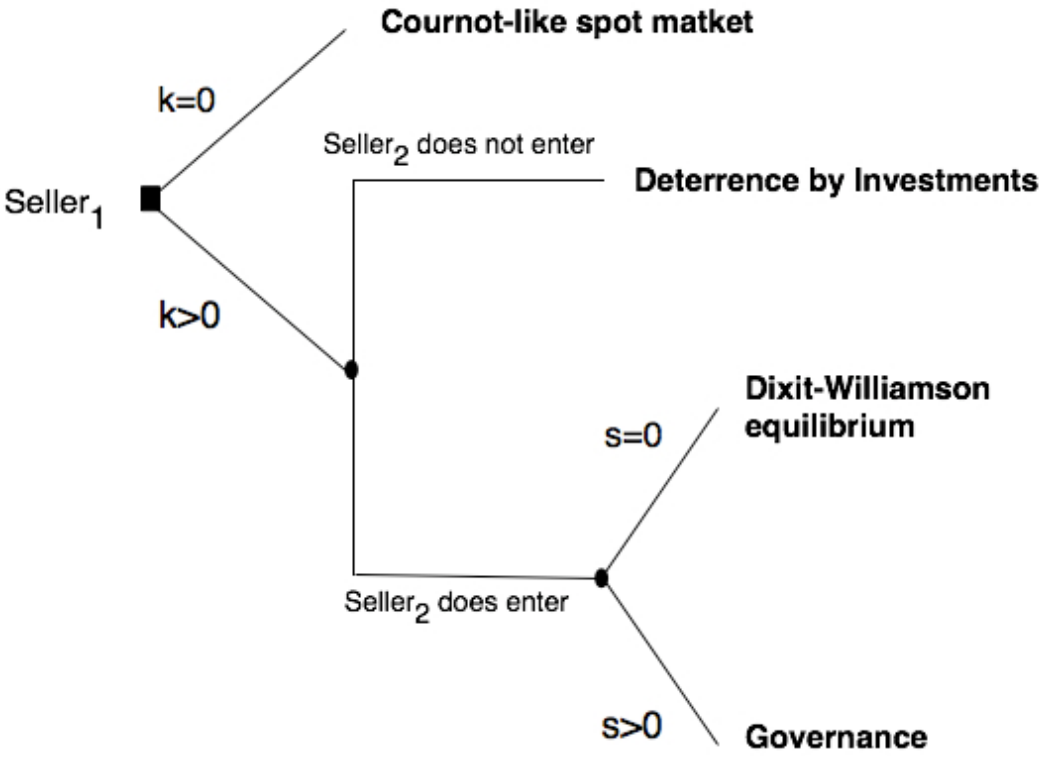

Figure 3. Dixit-Williamson scheme with strategic asset-specificity

Figure 3 illustrates this point. The potential situation indicated as "Cournot-like spot market" and "Deterrence by Investments" derive by the Dixitian approach while "Governance" is the case of standard literature on asset-specificity. When the specific investment is high enough to deter competition, then even without safeguards, opportunism is deterred. In this case, providing a positive level of safeguards $s>0$, is a social waste, as the contract will be implicitly enforced through entry deterrence. When the specific investment is insufficient to deter entry, safeguards are needed to protect investor against hold-up, as in the standard Williamson case.

The "Dixit-Williamson equilibrium" (with $k>0$, $s=0$ and no entry) represents a new interesting, and so-far neglected, equilibrium: when the level of the ex-post competition is internalized by the investor, the degree of specific investment might be *strategically* determined in order to reduce ex-post competition and, consequently, to *endogenously* control the counterparty's ex-post outside options and enforce incomplete contracts. As a result, in the Dixit-Williamson equilibrium specific investments reduce competition 'in other side of the market', relative to the standard fundamental transformation considered by Williamson.

In the next section we formalize this case through a simple model, showing how ex-post competition on the seller's side affects her decision to make efficient specific investments. In particular, we show that when the asset-specificity acts as an entry deterrence device, it prevents hold-up. In this respect, ex post competition may work as an ex-ante coordination of agents' behaviours.[2] Our results reverse some of the main conclusions of standard hold-up theories; we obtain an overinvestment rather than underinvestment equilibrium and asset-specificity acts as an enforcement device against hold-up.

3. A simple model of incomplete contracts with deterring investments

Consider a textbook situation in which a buyer B and an incumbent seller S_1 initially contract for the delivery of a widget, while facing the possibility that the buyer may later wish to buy from a potential new entrant S_2. Let us assume the demand of widget is found by $p(Q) = \alpha - Q$ where Q is the total quantity of the widget delivered. At $t = 1$, the incumbent seller makes a non-contractible investment $k_1 > 0$ that reduces her cost $c_1(k_1)$ of serving the buyer, i.e. an investment in capacity (cf. Frasco, 1991). In particular, we assume that $c_1 = c - k_1$ and that he cost of investment is given by $f(k_1) = (k_1)^2$. At

[2] Pagano (1992, 2007) offers an analysis of different streams of literature (including Marx, Lange and Hayek) concerning the role of command and competition in ex-ante and ex-post mechanisms of coordination of economic choices.

$t = 2$, there is the possible entry of a new seller. At $t = 3$, the trade is realized. The following timeline sums up the events.

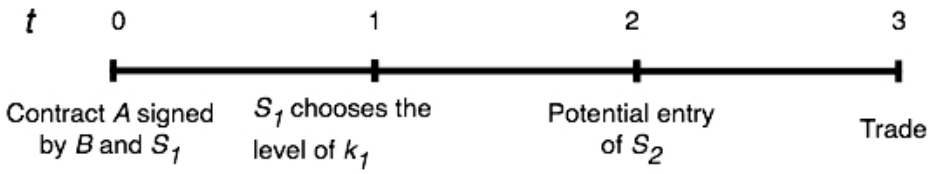

Figure 4. Timeline

We sum up our main assumptions as follows.

A. *Asset-specificity*. The widget has no use value outside the relationship for S_1, while the buyer values the widget more than the cost for any level of investment k. Asset specificity refers to investments in which the full productive values are obtained only in the context of an ongoing relation between the original parties to a transaction. Putting it differently, such assets cannot be transferred to alternative uses or users without a loss of productive value.

B. *Contractual incompleteness*. Contracts are "incomplete" (Williamson, 1985; Hart and Moore 1990) as all the payoffs and investments are observable by the parties (the seller, the buyer and the entrant), but un-verifiable by the enforcer (the judge).

C. *Symmetry in investment costs.* Analogously to the incumbent, the entrant is characterised by the cost of production c_2, which includes the non-contractible investments k_2, as follows: $c_2 = c - k_2$ and $f(k_2) = (k_2)^2$.

D. *Positive barriers to entry.* The entrant must sustain some fixed cost $F > 0$.

E. *Renegotiation game and outside option principle.* Renegotiation takes the form of an ultimatum game where the non-investor makes a *take-it-or-leave-it* offer to the counterparty. In this case, the renegotiating party obtains all the quasi-rent. In this respect, binding outside options play a role in surplus division, since, following the outside option principle, outside options act as a threat point in the bargaining game (cf. Sutton 1986, Osborne and Rubinstein 1988, MacLeod and Malcomson 1993, Lyon and Rasmussen 2004). In other words, the outside option of the non-investor acts as a constraint on the

equilibrium division of the surplus. Thus, at $t = 2$, the seller offers a price and the buyer may accept the incumbent price (in this case the monopolistic price) or propose a renegotiation.

F. *Breach penalties.* Safeguards for specific investments take the form of verifiable breach penalties (Frasco, 1991; Klein 1988; Aghion and Bolton 1987, Spier and Whinston 1995; Segal and Whinston, 2000). Breach penalty affect the disagreement point for renegotiation (Grossman and Hart, 1986; Hart and Moore, 1990). Denote as *s* the breach penalty. We assume that the sanction s is a fixed cost, which is not transferred from seller 2 to seller 1.

G. *Cournot post-entry equilibrium*. We assume, as in Dixits example, that after entry a Nash equilibrium will be established after entry in quantities 'as in Cournot.

Given the above assumptions,

Proposition 1. Under seller 2's entry at t=2, the incumbent seller will be induced to under-invest at t=1 along with Williamsonian scheme.

Proof. (See annex)

Proposition 1 says that, given ex-post the incumbent seller pays the full investment cost but ex-post she captures only a part of her marginal return (the rest is expropriated by the buyer), by anticipating this outcome, the incumbent seller will be induced to under-invest in the event of entry.

Let's consider now the Dixitian perspective, under the assumption that the level of specific investments may act as a deterrence device.

Proposition 2. Incumbent seller 1 may be induced to overinvest in order to deter entry along with Dixitian scheme.

Proof. (see annex)

Given the entrant's payoff negatively depends on barriers to entry, on breach penalties and, on the level of investment of the incumbent, the proposition 2 shows that non-entry decision might be 'induced' by the level of investment of the incumbent seller, k_1. We indicate with k_1^D the level of seller 1's investment which generates entry deterrence, that is, the apex D indicates this deterrent effect.

Moreover, the higher breach penalties, the lower incumbent's level of investments for deterring entry. That is,

Proposition 3. Barriers to entry and breach penalties may have a countervailing effect on incumbent seller 1's investment.

Proof. (see annex)

In particular,

Lemma 1. When the level of safeguards s is high enough to prevent entry, seller 1 will optimally invest. Otherwise the seller will over-invest or under-invest according to the profit levels associated respectively with each decision.

Proof. (see annex)

A general consequence is that the incumbent may strategically invest (or overinvest) with the purpose of deterring entry, even under (or because of) incomplete contracts. Figure 5 outlines the case we analyze. R_2^C represents the reaction curve when the new seller has chosen the level investment k_2^C in Cournotean equilibrium. Similarly, R_1^C represents the reaction curve when the incumbent seller chooses an accommodating strategy and does not (endogenously) deter the entry of seller 2. Instead, the reaction curve R_1^D represents the case in which the incumbent chooses to deter endogenously the entry. We could have two Nash equilibria. A first one is indicated by $N^C = N(k_1^C, s)$ and represents the case in

which entry is not deterred neither exogenously by s, nor endogenously by incumbent's investments. The other, equilibrium $N^D = N(k_1^D, s)$, represents the case in which the incumbent's investments in asset-specificity acts as an enforcement device against hold-up (together with barrier entry s). This latter is the representation of Dixitian-Williamsonian equilibrium.

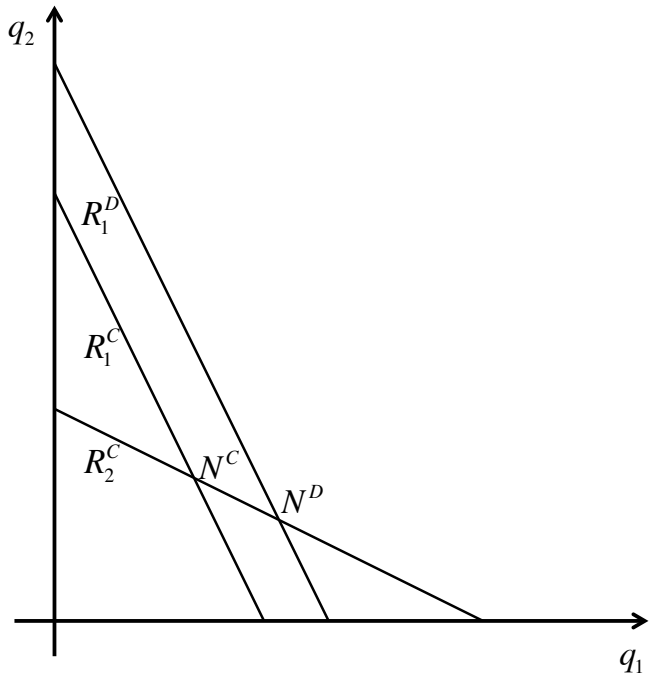

Figure 5. Dixitian-Williamsonian Equilibria (re-adapted by Dixit, 1980)

Actually, our simple model depends on a series of assumptions, such as the assumed form of the renegotiation game. Since the non-investing party receives at least her outside option, the investor can keep all the quasi-rent generated by a specific investment. A buyer will ask for renegotiation only when her outside option turns out to be binding. Here, we assume that a contract can be renegotiated ex post whenever trading with other agents is efficient. Under this renegotiation game, it is easy to see why renegotiation will be credible only when a buyer's outside option is binding at $t = 2$.

Another main assumption is the post-entry market as a Cournotean structure. In general, an equilibrium with overinvestment should always be possible since the deterring effect of investments. The assumption of positive fixed costs is that the transaction will take place in a market characterized by high entry costs. This is a reasonable assumption in our

setting, as we describe a transaction for which the widget to be produced requires costly non-contractible investments by an original seller. Thus the fact that even the entrants have to face relevant entry costs in order to exchange with the buyer captures the idea that the transaction requires – at least initially – a relevant economic effort also on the new entrants' side. However, our results hold also in absence of fixed cost assumption.

4. Conclusions

We have considered a case of incomplete contracts sustained by specific investments which have the potential to affect the ex-post degree of competition on the seller's side. This is actually an extension of the traditional hold-up problem, in which it is assumed that specific investments may deter investor's competitors and consequently the outside options of the non-investing party. When this happens the fundamental transformation in the market will outweigh the one occurring in the contract. In this case, contracts are enforceable without safeguards, and providing safeguards towards investors who are able to deter ex-post competition will represent a social waste.

Our results is important in several respects. First it shows how the hold-up problem only apply to the standard setting studied by Williamson, i.e. to a fundamental transformation in which outside options are associated to competitive markets whose configuration is never affected by parties' investments. Second, it suggests that the relevance of hold-up problem is largely weakened when specific investments are made by firms with (ex-ante or ex-post) market power. In this case providing safeguard to the investor may constitute a social waste. Third, it shows how in some circumstances, specific investment may act as an enforcement device and over-investment rather than under-investment could be chosen by investors. Indeed, when seller's non-contractible investment adversely affects the entrant's payoff, there is an equilibrium in which (over-)investment in specificity generates a deterrence effect.

Hence, reconciling Dixit with Williamson implies that (i) deterring investments can solve hold-up problem, and (ii) the impact of legal safeguards on investor's incentives is ambiguous as it may increase deterrence on the on side, but also it may reduce (over)investments in deterrence on the other side. In conclusion, the argument for protection against hold-up is not applicable to every institutional context, but it rather depends on the impact of asset specificity on investor's post-contractual power and thus on the nature of contract-market interactions.

Annex

Proof (Proposition 1). When the buyer B may trade with only one seller at the starting date of the contract, $t = 0$, we have a bilateral monopoly. The net profit of seller $\pi_1^M = (\alpha - q_1 - c_1)q_1 - (k_1)^2$ is maximized with $q_1^M = \frac{\alpha - c + k_1}{2}$. Considering $r = \alpha - c$, the monopolist payoff and the optimal level of investment k_1^M are given by $\pi_1^M = \frac{(r+k_1)^2}{4} - (k_1)^2$ and $k_1^M = \frac{1}{3}r$.

In the case of entry, incumbent's and new entrant's profits are, respectively

$$\pi_1^C = (\alpha - q_1 - q_2 - c_1)q_1 - (k_1)^2 \text{ and } \pi_2^C = (\alpha - q_1 - q_2 - c_2)q_2 - (k_2)^2 - s - F,$$

where the apex C indicates the Cournotean oligopoly. The intersection of two reaction curves determines quantities of Cournot equilibrium: $q_1^C = \frac{r + 2k_1 - k_2}{3}$, $q_2^C = \frac{r - k_1 + 2k_2}{3}$. Then sellers' profits are, respectively,

$$\pi_1^C = \frac{(r+2k_1-k_2)^2}{9} - (k_1)^2 \quad \text{and} \quad \pi_2^C = \frac{(r-k_1+2k_2)^2}{9} - (k_2)^2 - s - F.$$

Profits in a Cournot equilibrium are maximized with $k_1^C = \frac{2}{5}(r - k_2)$ for incumbent and, analogously, with $k_2^C = \frac{2}{5}(r - k_1)$ for new entrant. Note that in equilibrium the level of incumbent's investment is given by $k_1^C = \frac{2}{7}r$; that is, the investment in Cournotean equilibrium for the seller 1 is lower than the level in monopoly, $k_1^M = \frac{1}{3}r$.

Q.E.D.

Proof (Proposition 2). Along with Dixit's argument, let us assume first that $s = 0$ and $F = 0$. In this case non-entry decision might be 'induced' *only* by the level of investment of the incumbent seller, k_1. Define as k_1^D the level of seller 1's investment which generates entry deterrence. With $k_1^D > r - k_2^C$, we have in the new entrant's profit formula that $\frac{(r-k_1+2k_2)^2}{9} < (k_2)^2$, accordingly the entrants obtains at this level of investments a negative profit. (For the robustness of result is also necessary the reasonable condition that $k_1^D < r + k_2^C$. If the entrant investment is such that $k_2 < \frac{1}{3}r$, then the incumbent seller will be induced to overinvest. Given that $k_1^D > r - k_2$ and $k_2 < \frac{1}{3}r$, then $k_1^D > \frac{1}{3}r$ may occur.

Q.E.D.

Proof (Proposition 3). Considering positive breach penalties, *s*>0 and positive entry barriers F>0, the level of investments which deters entry is given by $k_1^D > r + 2k_2^C - 3\sqrt{s + F + (k_2^C)^2}$. Indeed, with such deterring level of investments, we have that the new entrant's profit is negative because

$\frac{(r-k_1+2k_2)^2}{9} < s + F + (k_2)^2$. Note that breach penalties reduce the level of investments necessary to deter entry.

Q.E.D.

Proof (Lemma 1). The incumbent's optimal level of investment is $k_1 = \frac{1}{3}r$, that is the level in bilateral monopolistic trade k_1^M. Instead, the new entrant is expected to invest her Cournotean level of investment, $k_2 = \frac{2}{5}(r - k_1)$. In equilibrium with incumbent investing optimally, new entrant's level of investment will be $k_2 = \frac{2}{5}\left(r - \frac{1}{3}r\right) = \frac{4}{15}r$. With $k_2 = \frac{4}{15}r$, the safeguard s that deters the entry (that makes $\pi_2^C < 0$) is $s \geq \frac{4}{25}r^2 - F$.

On the contrary, when $s < \frac{4}{25}r^2 - F$, entry is not deterred. In this case, incumbent may invest in deterrence. In particular, if incumbent's profit with over-investment in deterrence is higher than Cournotean profit with Cournotean investments, that is, when $\Pi_1^M(k_1^D) > \Pi_1^C\left(k_1^C = \frac{2}{7}r\right)$, incumbent will maintain incentive to overinvest at t=1. Instead, when incumbent's profit with over-investment in deterrence is lower than Cournotean profit with Cournotean investments, that is when $\Pi_1^M(k_1^D) < \Pi_1^C\left(k_1^C = \frac{2}{7}r\right)$, then the incumbent will under-invest.

Q.E.D.

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