A Model of Cooperative Investments with Three Players

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Abstract
We consider a model with three players in which one of them has the possibility to make a relationship-specific investment which produces an innovation. The innovation affects only the payoff of the other two players – hence, a cooperative innovation. We show that, in some cases, the presence of a third player reduces the hold-up problem, but when the competition becomes too fierce it may lead to overinvestment. In contrast to the prevailing literature on contract theory, we show that, even with a cooperative innovation, the possibility to sign a simple (incomplete) contract can still influence the ex-ante incentive to invest. The model is then applied to investigate the separation of regulatory powers where a monopolistic firm can be regulated either by one or two regulators.

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Indice

1 Introduction 1
   1.1 Related literature ................................. 4
   1.2 Structure of the paper .............................. 5

2 Set up of the model 5
   2.1 First Best ....................................... 7
   2.2 Benchmark ....................................... 7
   2.3 Allocation Mechanism ............................... 8

3 Equilibrium analysis 9
   3.1 Opposite Externality ............................ 9
      3.1.1 Efficient Innovation ......................... 9
      3.1.2 Inefficient Innovation ....................... 13
   3.2 Common Externality .............................. 14
      3.2.1 Efficient Innovation ......................... 14
      3.2.2 Inefficient Innovation ....................... 15
   3.3 Summary of results ............................... 16

4 Incomplete contracts and the hold-up problem 16

5 Applications of the model 17
   5.1 Regulation of a firm by two regulators ............ 18
   5.2 Other applications .............................. 20

6 Concluding comments 21
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1 Introduction

The literature on relationship-specific investments has mainly focused on environments in which exactly two parties are involved. The seminal contributions of Klein et al. (1978) and Williamson (1975) show the possibility that in a long term relationship, when the gains from an action are ex-post bargained upon, the ex-ante incentive to make the action (investment) is lower than the first best.

The reason for the hold-up is the risk that the other party drops off the relationship – because of the realisation of some unforeseen contingencies – so that the investment is wasted. This situation could be improved upon with the use of long-term contracts, which lock the parties in the relationship. However, the fact that the relationship is long-term makes it likely that only incomplete contracts can be signed, i.e. contracts cannot cover all future contingencies. In this incomplete contract scenario, Che and Hausch (1999) show that if the investment is selfish, i.e. the investor does not need the cooperation of the other party to benefit from it, an ad hoc “simple” contract can eliminate the hold-up problem. They also show that when the investment is cooperative, i.e. when the investor needs the cooperation of the other party to benefit from it, there is no (incomplete) contract that can

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1 The theory of incomplete contracts, mainly developed by Hart and Moore, maintains that it is not feasible to write down in a contract all possible future contingencies (states of the world) either because it is not possible to forecast them or it would be too costly. The importance of future contingencies increases with the time span of the relationships, so that long-term contracts can hardly be complete. For an excellent discussion see Hart and Moore (1999).

2 For instance, in the case of price regulation, a firm’s investment to reduce production
eliminate the hold-up problem. In a situation with cooperative investments, the main goal of the present paper is to investigate whether the hold-up problem can be reduced with the introduction of a third player, and whether incomplete contracts can still play a role.

We believe this is worth exploring because there is a range of cases in which the relationship involves more than two parties. For instance, an investment which is specific to three agents – in the sense that they are in a relationship which is affected by the investment – retains a strong component of specificity if compared with perfect competition. This type of relationship is actually quite prevalent in reality. A clear example is represented by a monopolistic firm regulated by two separate authorities, so that any investment made by the firm is specific to both regulators. For instance, a firm that produces electricity can introduce an innovative production process that, at the same time, reduces costs and environmental pollution, so that both the economic and the environmental regulators’ payoff are enhanced. Another situation arises in “public-private-partnerships”, where private and public capitals jointly finance a project executed by a third party. In such a situation an action (investment) taken by the party who executes the project is specific to both sponsors.

The presence of the government does not exhaust all possibilities. Let us consider a situation in which three (or more) people reach a business agreement for the production of some kind of service/good. In this case, it might be that the action/investment taken by one of them is specific to that business relationship. Suppose a tycoon contacts a skipper and a cook for a 1-week cruise on the Aegean islands. Before the trip starts, the tycoon may make some changes to the boat that will affect both skipper and cook, i.e. a smaller kitchen to make room for a larger radio transmitter cabinet. The payoff of the cook is negatively affected while the payoff of the skipper could be positively affected.

All these situations share two common features: the action/investment of one player produces some effects (externality) on all players, and the relationship is long-term.

We first study a situation in which contracts are not available, i.e. there is no law enforcement, then we introduce the possibility to sign (incomplete) contracts. In order to do so we start by analyzing a two-stage game with three players, in which one agent (henceforth, the investor) makes an investment which results in a cooperative innovation and, in the second stage, all costs is selfish, because directly increases the firm’s profit; while, an investment to improve the quality of the product is cooperative, because the firm will benefit from it only if the regulator agrees to modify the price.

3This example is taken from Hart and Moore (1990).
three agents are involved in the surplus division exercise. The innovation is owned by the investor which can decide whether to use it or not. In the three-player scenario, the introduction of the innovation produces some externalities on the “non-investing” players: we distinguish between opposite and common externalities. The former type of externality arises when the innovation is good for one player’s payoff but bad for the other, i.e. players face externalities of opposite signs; in the latter case, externalities affect the two players in the same way.

Our main result is the characterization of the incentive to invest as a consequence of the type of externality the innovation generates. We show that, if it creates an opposite externality among players, the incentive to invest is enhanced. This result arises because the presence of an opposite externality generates competition between player 1 and 2, which, in turn, increases the share of surplus anticipated by the investor, and, hence, her incentive to invest. In a bilateral situation, the investor’s hold-up is due to the absence of alternative uses for the innovation, consequently increasing the number of players – i.e. increasing competition – should reduce the risk of wasting resources. In fact, we show that competition increases the incentive to invest, but, at the same time, too much competition may lead to the opposite of the hold up problem: overinvestment. The risk of overinvestment is particularly evident when dealing with inefficient innovations. We show that, even though an inefficient innovation would never be introduced in equilibrium, the competition among non-investing players may lead the investor to produce such an innovation, with a clear waste of resources.

In case of a common externality, since players are affected in the same way by the introduction of the innovation, they would not compete for the right to use it, they can actually free ride on each other. If the innovation produces positive externalities, each non-investing player has an incentive to wait and let the other player compensate the investor for the investment. In this case, we show that the ex-ante incentive to invest is no larger than in the two-player scenario (our benchmark). Trivially, if the innovation produces a negative externality, there would be no player willing to pay for it, and, hence, no investment will be made.

Once we introduce the possibility to sign an incomplete contract we show that, contrary to Che and Hausch (1999), a performance-contingent contract can still affect the investor’s incentives, as long as the externality is opposite. The intuition relies on the fact that players’ payoffs depend on whether all three players remain in the relationship, therefore a contract which make the

\footnote{An innovation which reduces the overall welfare.}
possibility of dropping-off contingent on some verifiable events, can affect the players’ payoff.

Finally, we present an application of our model to the case of regulation of a monopolistic firm. We argue that the possibility to improve the incentives to invest in a cooperative innovation, is a further\textsuperscript{5} motivation for the separation of regulatory powers. In contrast to the prevailing literature on regulation, this result is not driven by the presence of agency (information) problems, it is the regulator(s)’ commitment problem and the impossibility to write down complete contracts, which drives our results.

1.1 Related literature

This paper mainly relates to three strands of literature: the literature on incomplete contracts and hold-up problems, the literature on investment incentives in auctions, and, finally, the literature which analyse the effects of different degrees of specificity of the investment on the hold-up problem.

As to what regards the latter, Felli and Roberts (2001) consider the issue of whether competition can solve the hold-up problem. Their paper addresses two potential inefficiencies: a problem of hold-up and a problem of coordination. In their model agents can choose whether to invest in the first stage, while, in the second stage, they are matched through a non-cooperative Bertrand competition game. It is the emergence of coordination failure that induces players to “hold up” the initial investment strategy. The same type of issues are addressed also by Cole et al. (2001), which propose a game in which there are two pools of agents, say a pool of buyers and a pool of sellers; in the first stage they invest and then they are matched; their payoff depends on both their investment and the bargaining rule (which is exogenously given). In both papers the payoff of the investment choice depends on the matching game, as agents need to match with the “right” type in order to get the highest payoff. Our work differs from these two because there is no coordination problem, instead we model a business relationship with three players. Even though our model is quite different, we get similar results in terms of reduction of the hold-up problem when the investment is made less specific because of competition among players. Moreover, as in Cole et al. (2001), we show the possibility of both under and over-investment. However, our model allows to consider also the case of inefficient investment, i.e. an investment which reduces overall welfare.

The literature on auctions and investment is close to our paper as well. Arozamena and Cantillon (2004) consider a model in which the effect of

\textsuperscript{5}See Laffont (2005) for a review of reasons for the separation of regulatory powers.
the investment depends on the outcome of an auction. In particular, they consider a procurement auction in which sellers can make an investment which will reveal the cost of the contract. This will influence their behaviour in the auction. Our contribution differs for two main reasons: firstly, we consider symmetric information among players, that is, once the innovation is produced everybody knows the effect on each player’s payoff; secondly, is the auctioneer who invests and not the bidders. In our model the auction is used as a mechanism through which the investor can “sell” the innovation produced, thereby exploiting the competition among the other two players.

Lastly, also the literature on hold-up and incomplete contracts is linked to our contribution. We will discuss further in section 4 the role of contracts on our set-up. Notice that this literature deals, almost exclusively, with bilateral scenarios, while we have three players.

1.2 Structure of the paper

The paper is organized as follows: in sections 2 and 3 we present the basic model and we compare results with the first best; in section 4 we introduce the possibility to sign incomplete contracts and investigate their effect on the hold-up problem; finally, we present a detailed application to price regulation, and we sketch other possible applications of the model.

2 Set up of the model

We consider three risk neutral players, \( n = \{1, 2, 3\} \), engaged in a two-period relationship. Let us assume that only one player (player 3) can invest\(^6\). This investment produces an innovation according to the production function \( \gamma(i) \), where \( i \) represents the amount of investment and \( \gamma(\cdot) \) is strictly increasing and strictly concave in \( i \), with \( \gamma(0) = 0 \) (no investment equals no innovation); the cost of the investment is sunk and equal to \( i \in \mathbb{R}^+ \). The use of the innovation produces a direct externality\(^7\), which have either a common or an opposite effect on the two non-investing players. This situation is captured by the parameters \( \theta_1, \theta_2 \in \mathbb{R} \) for player 1 and 2, respectively.

The payoff of each player when the innovation is introduced looks like:

\[
R_1 = z_1 - \theta_1 \gamma(i) \quad R_2 = z_2 + \theta_2 \gamma(i) \quad R_3 = z_3 - i
\]

\(^6\)For simplicity, we also assume that they are not wealth-constrained and there is no discounting of the future.

\(^7\)The term “direct externality” is used in a broad sense to indicate the effect of the innovation on the other players’ payoff.
where \(z_1, z_2\) and \(z_3\) represent the payoffs of each player in case of a transaction without innovation; if no transaction occurs payoffs are equal to zero. The effect of the innovation on player 1 and 2 can be either positive or negative according to the signs of \(\theta_1\) and \(\theta_2\). We, therefore, define:

**Opposite Externality:** the externality which produces an opposite effect on the payoff of player 1 and 2; this is the case when \(\theta_1\) and \(\theta_2\) have the same sign;

**Common Externality:** the innovation which produces the same effect on both players; that is the case when \(\theta_1\) and \(\theta_2\) have opposite signs.

We assume that the players’ payoff functions are such that \(z_1, z_2, z_3 > 0\), which assures the parties are interested in the transaction; and that \([z_1 - \theta_1 \gamma(i)] \geq 0, [z_2 + \theta_2 \gamma(i)] \geq 0\), so that each player wants to remain in the relationship after the innovation is introduced\(^8\).

The timing of the game is as follows:

**Date 1** Nature determines the value of \(\theta_1\) and \(\theta_2\) and, then, player 3 makes an investment \(i\);

**Date 2** The innovation produced is either introduced or not according to a mechanism (described below) for the allocation of the property right among the players.

We assume symmetric, but non verifiable information: the value of \(\theta_1\) and \(\theta_2\) are common knowledge, but they cannot be verified by a court of law\(^9\). We look for a Subgame Nash Equilibrium of this two stage game in which the date 2 subgame consists in the allocation mechanism and the decision on the introduction of the innovation.

Since player 3 sustains the cost of the investment before the surplus is allocated, this is the standard situation in which a hold-up problem may arise. We first develop our benchmark model, a bilateral bargaining model; then, we analyse the consequences of introducing and extra player.

\(^8\)This assumption is not strictly necessary. We could argue that once the parties reach an agreement, they cannot drop out if the observable and verifiable part of it, namely the transaction, takes place. It is quite difficult to verify the change in payoffs due to the introduction of the innovation, and therefore the parties would be locked in even if they receive a negative payoff. A more detailed discussion of this possibility is given in section 4.

\(^9\)This condition is sufficient to make any contract incomplete because the two parameters cannot be part of the contract.
2.1 First Best

The linear sum of the effects of the innovation on the two players can either be positive or negative: if it is positive we call the innovation efficient, i.e. \((\theta_2 - \theta_1) > 0\), otherwise the innovation is inefficient. Since we consider only the effects of the innovation and not the cost of the investment our concept actually refers to *ex-post* efficiency.

The ex-ante first best level of investment, is given by the value \(i^*\) which solves, \(\max_{i^*}[(\theta_2 - \theta_1)\gamma(i) - i]\).

In case of an efficient innovation we have an interior solution, which is the value of \(i\) that satisfies

\[
\gamma'(i^*)(\theta_2 - \theta_1) = 1 \tag{1}
\]

Equation (1) tells us that the marginal benefit of the innovation must equal the marginal cost of investing.

If the innovation is inefficient, the marginal benefit is always negative, leading to a corner solution, \(i^* = 0\).

2.2 Benchmark

As benchmark we consider the usual set-up in which the hold-up problem is investigated: bilateral trade. Our original scenario is modified so that player 3 faces only one player (it is as if player 1 and 2 were merged). The distinction between opposite and common externality is irrelevant.

We model this situation following Che and Hausch (1999), in which the negotiation between the two players depends on an exogenous bargaining parameter, so that the investor gets an exogenous share of the gains.

When the innovation is efficient, Player 3 decides to introduce the innovation because the unique player is willing to compensate player 3 for the investment. Ex-post payoffs are

\[
R = z + (\theta_2 - \theta_1)\gamma(i) - t \\
R_3 = z_3 - i + t
\]

where \(R\) is the payoff of the merged player and \(z = z_1 + z_2\). The value of the transfer \(t\) is the result of the negotiation between the two parties, where the bargaining power of player 3 is exogenously fixed and equal to \(\alpha\), so that the transfer \(t\) is \(t = \alpha(\theta_2 - \theta_1)\gamma(i)\). Player 3 anticipates this outcome and, at date 1, will set an ex-ante level of investment \(i^b = \arg\max_{i^b} [z_3 - i + \alpha(\theta_2 - \theta_1)\gamma(i)]\),

\[
\gamma'(i^b) = \frac{1}{\alpha(\theta_2 - \theta_1)} \tag{2}
\]
Notice that only if \( \alpha = 1 \), i.e. player 3 has full bargaining power, the first best level of investment is achieved. This result is in line with the literature on bilateral trade, where, as a general result, the hold-up problem does not emerge if the investor has full bargaining power; moreover, it is clear that an initial contract does not play any role, due to the cooperative nature of the investment, as in Che and Hausch (1999)'s bilateral trade model with pure cooperative investments.

**Lemma 1** When player 3 faces only one player, the ex-ante investment level is suboptimal, \( i^b < i^* \), unless he/she has full bargaining power.

In case of an inefficient innovation, i.e. \( (\theta_2 - \theta_1) < 0 \), player 3 will not introduce the innovation and will invest \( i^b = 0 \), because the merged player is not willing to pay for the introduction of the innovation. In other words, in a bilateral situation there is no risk of overinvestment.

### 2.3 Allocation Mechanism

A crucial issue of the paper is how to model the interaction among the three players at date 2.

In the case of an opposite externality, we assume that player 3 will offer the right to use the innovation via a competitive bidding (Bertrand competition). We consider the following procedure: the two non-investing players submit a bid for the right to use the innovation; the player who bids the highest value wins the right, and pays a transfer equal to the bid of the other player. This is the same mechanism as a sealed-bid second-price auction\(^{10}\).

We believe this mechanism is robust to various modifications. Notice that if we drop the hypothesis of symmetric information, and we assume that player 3 only knows the distribution function of \( \theta_1 \) and \( \theta_2 \), our mechanism would give the same result as in perfect information. The only difference is that player 3 would face an expected payoff at date 1, instead of a deterministic payoff – however, since he/she is risk neutral her equilibrium strategy would not change. Our mechanism exploits the fact that when player 1 and player 2 have a different (opposite) interest in the innovation, one player would like the innovation to be introduced while the other is willing to pay in order to avoid it.

In the case of common externality players have no reason to compete, hence the competitive bidding mechanism is useless. When the effect of the innovation is positive, non-investing players have two possibilities: either

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\(^{10}\)Actually, since bidders know each others’ reservation value, a game in which each player pays her own bid would lead to the same outcome.
cooperate making a common offer to player 3 (so that we are back to the benchmark case), or try to free ride on each other. In the case of negative effects, non-investing players do not want the innovation to be introduced, therefore, player 3 would not invest\textsuperscript{11}.

3 Equilibrium analysis

We focus our attention on the case of opposite externality, which represents the main contribution of the paper. In this scenario we separately analyse the introduction of an efficient and of an inefficient innovation. After that, we briefly consider the case of common externality.

3.1 Opposite Externality

The introduction of the innovation produces an opposite effect on player 1 and 2, so that they compete for the right to use the innovation. Given the payoff functions, this situation is characterised by either $\theta_1, \theta_2 > 0$ or $\theta_1, \theta_2 < 0$. The two cases are specular, it only changes the identity of the player who receives a positive effect from the introduction of the innovation. Therefore, we assume that $\theta_1 > 0$ and $\theta_2 > 0$ so that the effect of the introduction of the innovation is negative for player 1 but positive for player 2. In this scenario we start analysing the case of an efficient innovation.

3.1.1 Efficient Innovation

The innovation is efficient if $(\theta_2 + \theta_1) > 0$. Since we assumed positive value of the $\theta_s$, the assumption of efficient innovation implies $\theta_2 > \theta_1$. We call this specification of the original game $\Gamma_1$.

In this situation, Player 3 can exploit the competition between player 1 and 2, offering the right to use the innovation through a competitive bidding. Player 3 sets up an auction in which the player who bids the highest value wins the right to decide what to do with the innovation. The transfer is equal to the bid of the other player.

Now the question is, what is the equilibrium strategy in such a game of perfect information? Let us analyze the payoffs in the competitive bidding game, where player 1 bids $b_1$ and player 2 bids $b_2$. Player 1’s payoff is

$$ R_1 = \begin{cases} z_1 - b_2 & \text{if } b_1 > b_2 \\ z_1 - \theta_1 \gamma(i) & \text{if } b_1 \leq b_2 \end{cases} $$

\textsuperscript{11}Notice that the threat to introduce the innovation is not credible because nobody is willing to pay to have it introduced.
while player 2’s payoff function is

\[ R_1 = \begin{cases} 
  z_2 + \theta_2\gamma(i) - b_1 & \text{if } b_1 \leq b_2 \\
  z_2 & \text{if } b_1 > b_2 
\end{cases} \quad (4) \]

In this situation, player 1 has a weakly dominant strategy, in bidding \( b^*_1 = \theta_1\gamma(i) \), which is her reservation value. Indeed, if player 2 bids \( b'_2 \) which is greater than \( b^*_1 \), the payoff of player 1 is zero – she loses the auction. Given this strategy of player 2, if player 1 unilaterally deviates from \( b^*_1 \), she cannot improve her payoff: in case of a value lower than \( b'_2 \) her payoff would remain zero, in case of a bid higher than \( b'_2 \), player 1 would win the auction but receiving a negative payoff because she would bid more than her reservation value. In case player 2 bids \( b''_2 \) lower than \( b^*_1 \), player 1 will win the competition and gain a positive payoff given by \( b^*_1 - b''_2 \); given this strategy of player 2, if player 1 deviates from \( b^*_1 \), she can only reduce her payoff.

Also, player 2 has a weakly dominant strategy in bidding her reservation payoff \( b^*_2 = \theta_2\gamma(i) \). The same kind of reasoning applies also in this case, player 2 cannot do better by unilaterally deviating from this strategy\(^{12}\).

**Lemma 2** In the game \( \Gamma_1 \), the equilibrium of the competitive bidding game is given by the strategies \( b^*_1 = \theta_1\gamma(i) \) and \( b^*_2 = \theta_2\gamma(i) \).

**Proof.** We omit the proof which is analogous to common proofs for the second-price sealed-bid auction.

Since \( \theta_2 > \theta_1 \), player 2 wins the competitive bidding. Player 2 pays player 3 a transfer \( t = \theta_1\gamma(i) \). Player 3 anticipates this result and will set the level of investment to maximize her payoff, \( R_3 = [z_3 + \theta_1\gamma(i) - i] \). As a result, the equilibrium ex-ante investment level is \( i^* \) such that

\[ \gamma'(i^*) = \frac{1}{\theta_1} \quad (5) \]

The Subgame Perfect Equilibrium of game \( \Gamma_1 \) is described in the following proposition.

**Proposition 1** The Subgame Perfect Equilibrium of the game \( \Gamma_1 \) is characterised by player 3 investing \( i^* \) such that \( \gamma(i^*) = \frac{1}{\theta_1} \), then at date 2, player 1 and 2 bid \( b_i = \theta_i\gamma(i) \) for \( i = 1, 2 \).

\(^{12}\)Notice that this is not the only weakly dominant strategy, as any bid larger than the reservation value of player 1 will produce the same outcome.
The implication of this result is straightforward: as $\theta_1$ increases (as long as $\theta_2 > \theta_1$), the firm invests more because the investment marginal revenue increases, while the marginal cost is fixed. The mechanism assures the firm a certain return from the investment, which depends on the level of competition between the other two players. An increase in $\theta_1$, given $\theta_2$, results in a more fierce competition. In other words, the closer $\theta_1$ and $\theta_2$, in absolute term, the stronger is the competition among the bidders and, hence, the higher the incentive for player 3 to invest.

**Corollary 1** In case of game $\Gamma_1$: if $\theta_1 < \frac{1}{2} \theta_2$ the level of investment $i^s$ is lower than the first best $i^*$; if $\theta_1 = \frac{1}{2} \theta_2$ the level of investment is equal to the first best; otherwise it is greater than the first best.

**Proof.** Given the concavity of $\gamma(i)$, the level of investment $i^s$ is equal of lower than the first best if $\frac{1}{\theta_1} \leq \frac{1}{\theta_2 - \theta_1}$. This inequality is satisfied if $\theta_1 \leq \frac{1}{2} \theta_2$.

In other words, there is under investment if the difference $(\theta_2 - \theta_1)$ is “sufficiently” large and over investment if the difference is “sufficiently” small.

We now turn to compare the equilibrium level of investment $i^s$ with our benchmark $i^b$.

**Lemma 3** In case of opposite externality and efficient innovation, if $\theta_1 \geq \frac{\alpha}{\alpha + \theta_2}$ the introduction of a third player increases the incentive to invest, $i^s \geq i^b$.

**Proof.** The proof comes from the concavity of $\gamma(i)$. In order to have $i^b \leq i^s$ we need $\frac{1}{\alpha(\theta_2 - \theta_1)} \leq \frac{1}{\theta_1}$, which is satisfied as long as $\theta_1 \geq \frac{\alpha}{\alpha + \theta_2}$.

This lemma shows that for particular values of the parameters $\theta_1$ and $\theta_2$, the presence of three players reduces the hold-up problem – that is the case when $i^b < i^s < i^*$.

Notice that if $\alpha = 0$, i.e. player 3 has no bargaining power in the benchmark model, the condition in lemma 3 is always satisfied, and therefore the investment level with three players is always larger than the investment with player 1 and 2 merged.

\[13\text{This situation reminds the analysis in Averch and Johnson (1962) where a firm facing a “rate of return” regulation, is likely to overinvest. If the remuneration exceeds the cost of capital the firm has an incentive to invest more than the efficient amount. In our case the remuneration of the agent is fostered by the externality imposed on the player who loses the competitive bidding.}\]
Figura 1: Effect of competition on the equilibrium levels $i^*(=\text{first best}), i^b (=\text{benchmark}), i^s (=\text{bidding eq})$, in case of $\theta_1, \theta_2 > 0$ and $\theta_2 \geq \theta_1$, for a given value of $\theta_2 = \bar{\theta}_2$

Given lemmas 1 and 3 and corollary 1, we can state the following proposition which summarizes the results obtained with respect to the ex-ante incentive to invest,

**Proposition 2** With opposite externalities and ex-post efficient innovation,

(i) in case $0 < \theta_1 \leq \frac{\alpha}{1+\alpha} \theta_2$ the equilibrium is characterized by $i^s \leq i^b \leq i^*$;

(ii) if $\frac{\alpha}{1+\alpha} \theta_2 \leq \theta_1 \leq \frac{1}{2} \theta_2$ then $i^b \leq i^s \leq i^*$;

(iii) lastly, if $\frac{1}{2} \theta_2 \leq \theta_1 < \theta_2$ then $i^b \leq i^* \leq i^s$.

This proposition is illustrated in Figure 1, where the level of investment $i$ is plotted against the level of $\theta_1$, the marginal impact of the innovation on player 1, for a given value of $\theta_2$. The graph in Figure 1 shows three curves: the curve $i^s$ which represents the level of investment in the model with three players; the curve $i^*$ which represents the first best level of investment; and the curve $i^b$ which represents the level of investment in the benchmark model and it is drawn for a given value of $\alpha \in [0, 1]$ – with $\alpha = 1$, the curves $i^b$
and $i^*$ coincide. Both the first best and the benchmark level of investment are decreasing in $\theta_1$, crossing the horizontal axes at $\theta_1 = \bar{\theta}_2$. An increase in $\theta_1$ means that the negative impact of the innovation increases, up to the point where it is equal to the positive impact, so that the optimal (and the benchmark\textsuperscript{14}) level of investment is zero. The curve $i^*$ is increasing in the level of $\theta_1$, showing that as $\theta_1$ approaches $\bar{\theta}_2$ the competition increases, enhancing player 3’s incentive to invest.

There is only one level of $\theta_1$ such that $i^* = i^*$, which is when $\theta_1$ is exactly half of $\theta_2$, i.e. $\theta_1 = \frac{1}{2} \bar{\theta}_2$. Therefore, when $\theta_1 < \frac{1}{2} \bar{\theta}_2$, competition is good, it pushes $i^*$ towards the first best; as competition becomes more fierce, $\theta_1 > \frac{1}{2} \bar{\theta}_2$, it leads to an overinvestment.

The graph shows that the possibility to achieve a more efficient result than in a model with only two players also depends on the distance between $\theta_1$ and $\theta_2$. The closer the two values, the higher the competition and hence the higher the performance of the model with three players. We can see that, in the range of values $\frac{\alpha}{1+\alpha} \bar{\theta}_2 \leq \theta_1 \leq \frac{1}{2} \bar{\theta}_2$, the introduction of a third player improves the incentives to invest, with respect to a bilateral situation. Notice, however, that the $i^b$ curve is plotted for a given $\alpha$, so that the performance of the benchmark model in terms of incentives also depends on $\alpha$, i.e. player 3’s bargaining power: if $\alpha = 1$ the curve $i^b$ coincides with the first best.

To sum up, our model seems to suggest that in medio stat virtus\textsuperscript{15}, competition is good for society as a whole as long as it is not too fierce.

### 3.1.2 Inefficient Innovation

In this case, the introduction of the innovation has an overall negative effect, i.e. $(\theta_2 - \theta_1) < 0$. The negotiation is ex-post efficient if, as a result, the innovation is not introduced, and the ex-ante optimal level of investment is $i^* = 0$. Since we assumed $\theta_1, \theta_2 > 0$, it must be that the negative effect on player 1 is greater (in absolute terms) than the positive effect on player 2.

As in the case of efficient innovation, player 3 exploit the presence of an opposite externality by devising a competitive bidding. The only difference with the previous section is that now player 1 has the highest reservation value, therefore what we have said before for the strategy of player 2 applies to player 1.

**Proposition 3** The equilibrium is characterized by player 1 bidding $b_1^*$ and player 2 bidding $b_2^*$, such that $b_1^* = \theta_1 \gamma(i)$ and $b_2^* = \theta_2 \gamma(i)$.

\textsuperscript{14}Notice that in the benchmark player 1 and 2 are merged, hence the social impact of the innovation coincides with the impact of the innovation on the merged player.

\textsuperscript{15}“Virtue stands in the middle”, as pointed out by Aristotle in the *Nicomachean Ethics*. 
Also in this case the player with the lowest reservation value has a weakly dominant strategy in bidding $b_2 = \theta_2 \gamma(i)$. The other player can play any bid above $\theta_2 \gamma(i)$. If player 1 bids $b_1 = \theta_1 \gamma(i)$ the equilibrium is characterized by the two bids in the previous proposition. As a result of the competitive bidding the innovation is not introduced, i.e. player 1 wins the competition and decides not to introduce the innovation because it causes a negative effect on his payoff.

Anticipating this outcome player 3 would choose the level of investment $i$ which maximises $z_3 + \theta_2 \gamma(i) - i$, which results in the following condition

$$\gamma'(i) = \frac{1}{\theta_2}$$

The implicit equation 6 implies a level of investment higher than the first best. This is interesting because player 3 invests resources for an innovation that is inefficient and he/she knows is never going to be implemented. It represents a clear example of competition that leads to an overinvestment. Notice that in this case any level of competition would lead to overinvest.

### 3.2 Common Externality

In this case the introduction of the innovation produces the same effect on both non-investing players. Player 3 cannot use a competitive bidding to allocate the right to use the innovation, because there is no competition among player 1 and 2. Given the payoff functions we use this case requires $\theta_1$ and $\theta_2$ of opposite signs. In other words the effect is either positive or negative on both players.

#### 3.2.1 Efficient Innovation

The introduction of the innovation has a positive effect on both players’ payoff, if $\theta_2 > 0$ and $\theta_1 < 0$.

We are in a situation in which both players would like the innovation to be introduced. In this case the competitive bidding mechanism suffers from lack of competition. The bidders have no incentive to overbid each other, for them it does not matter who wins as long as the innovation is introduced. The innovation is like a public good, hence they can free ride and offer low
bids. The payoff of player 1 and 2, in the second-price auction would be,

\[ R_1 = \begin{cases} 
z_1 - \theta_1(i) - b_2 & \text{if } b_1 > b_2 \\
z_1 - \theta_1(i) & \text{if } b_1 \leq b_2
\end{cases} \]  \hspace{1cm} (7)

\[ R_2 = \begin{cases} 
z_2 + \theta_2\gamma(i) - b_1 & \text{if } b_1 \leq b_2 \\
z_2 + \theta_2\gamma(i) & \text{if } b_1 > b_2
\end{cases} \]  \hspace{1cm} (8)

If we solve the indeterminacy on the behavior of player 3 when both bids are zero, in favour of introducing the innovation, both players have a (weakly) dominant strategy in bidding \( b_i = 0 \) for \( i = 1, 2 \). Notice that by the time the auction is held the investment has already been made and the relative cost is sunk, hence the outcome of the auction does not directly influence the level of investment. The outcome of the auction, however, would be anticipated by player 3 and would lead to an under-investment in the first stage. That would happen any time players cannot credibly commit to pay for the innovation. In fact, if player 1 and 2 could credibly commit to negotiate with player 3 as a unique player, a bilateral situation would arise in which the gains would be split according to the parties bargaining power, as in our benchmark case. The problem is that collusion between player 1 and 2 is difficult to sustain because of the free-riding incentive each one faces.

A similar result could be reached if player 3 could commit to negotiate only with one of the other two players, because there would be no chances for the “chosen” player to free ride. In this case player 3 would pick the player with the highest absolute value of \( \theta \) and bargain with him. For instance if \( \theta_2 > |\theta_1| \), player 3 would bargain with player 2, and eventually get a transfer of \( t = \frac{1}{2}\theta_2\gamma(i) \). This would lead to an investment lower that the first best, but (possibly) higher than the competitive bidding.

We can say that the efficient innovation is always introduced regardless of the hypothesis on the negotiation stage. However, the incentive to invest is lower than in the case of bilateral trade. The presence of an extra player is useful only if it introduces competition, in fact, in the case of common externality the extra player introduces a free riding problem which intensifies the hold-up problem player 3 faces.

### 3.2.2 Inefficient Innovation

In this case the innovation is not welcomed by anybody, i.e. \( \theta_2 < 0 \) and \( \theta_1 > 0 \). There is no incentive for player 3 to invest. In particular, the threat to introduce the innovation is not credible: player 1 and 2 could offer player 3 any small amount \( \varepsilon > 0 \), and player 3 would grab it and dump the innovation.
3.3 Summary of results

The model shows the importance of an extra player when dealing with relationship-specific investments. In the case of cooperative investments the effect depends on the sign of the externalities among the non-investing players. The presence of an extra player is important when there is an opposite externality, because players would compete for the right to use the innovation. It is important to highlight that competition is not always good, when it is very fierce, it may lead to overinvestment. However, there are some cases in which competition results in a reduction of the hold-up problem.

4 Incomplete contracts and the hold-up problem

In this section we relate our model to the incomplete contract literature which deals with the hold-up problem. According to Bolton and Dewatripont (2005), this literature can be classified according to the degree of specificity of the investment. If it were possible to commit to specific “default options”, the contract could be contingent on some threshold level to be respected ex-post. In this case, Aghion et al. (1994) show that the first best level of investment is still achievable, the reason being that the parties fully commit to a specific performance level, which will be traded in case of disagreement, and one of the players gets full bargaining power. As a result, the default payoff can be set at a level which gives the player without bargaining power the right incentive to invest, while the other player incentive to invest is guaranteed by the fact that she is now the residual claimant - no fear to be held up\textsuperscript{16}. This important result rests mainly on two conditions, however. Firstly, if courts of law cannot enforce a specific performance contract and cannot distinguish who is responsible for the event (trade/notrade), we are stuck with Hart and Moore (1988)'s hold up result. Secondly, Aghion et al. (1994)'s model considers only a particular type of investments which directly benefit only the investor. This point was brought up by Che and Hausch (1999) that introduced a classification of investments according to whom gets the benefits, the two extreme cases being: selfish investments and pure cooperative investments. Their claim is that Aghion et al. (1994) consider only the former type of investments, and that is why they can solve the hold-up problem.

\textsuperscript{16}For instance, the regulation by price-cap can be considered a specific-performance contract, the incentive of the firm to invest in cost reduction is full, because the regulator is committed to pay a specific price regardless the cost of production. Of course, it is important that the regulator is committed to respect the contract.
problem. Che and Hausch (1999) show that in the case of cooperative investment a specific-performance contract cannot improve the ex-ante incentive to invest of the players, because to receive any benefit, the cooperation of the other player is needed\textsuperscript{17}.

The above mentioned models consider only bilateral trade, though. We argue that in a model with three players (our model) there is an important role for a performance-specific contract even with “pure” cooperative investments. In order to achieve this result in our model we need to drop one of the restrictions imposed on the values of $\theta_1$ and $\theta_2$. We allow the payoff of a player to be negative as a consequence of the introduction of the innovation, i.e. $z_j + \theta_j \gamma(i) \geq 0$ for $j = 1, 2$. In case $\theta_1$ and $\theta_2$ are such that the payoff of one player is negative, i.e. $z_j + \theta_j + \gamma(i) < 0$ it is no more possible to fully dump the negative externality on that player. In this case, we should distinguish two situations:

(a) the case in which the presence of all players is necessary for the transaction to occur;

(b) the case in which the transaction can still occur even with less players.

In the first case, it would not be possible to fully dump the negative externality on one player: the player who dislikes the innovation can threat to exit the relationship and have all players earn zero. This would lead to transfers among all players and not only between two of them, with a reduction on the ex-ante investment incentive. In the second case, we basically have bilateral bargaining, between the investor and the remaining player – the one who is positively affected by the innovation.

In this situation, a performance specific contract, which is contingent on some verifiable aspect of the relationship, can force a player to stay in the relationship even if her payoff is negative, so that the non-investing players compete for the right to use the innovation, providing an higher ex-ante incentive to invest in the innovation. Therefore, in contrast to Che and Hausch (1999), even in the presence of a pure cooperative investment a relationship-specific contract can change the ex-ante incentives to invest.

5 Applications of the model

The model can be applied to any situation characterized by a long term relationship and specific investments, in which the introduction of an innovation

\textsuperscript{17}De Fraja (1999) shows that this result can be overturned if the investments are sequentially made and both parties are risk neutral. In our model, however, there is no scope for sequential investments since only one party invests.
changes the payoff of all players. The fact that the relationship is long-term makes the hypothesis of incomplete contracts even more appealing, because over a long period many contingencies can occur that were not foreseen in the original contract. For instance, this is the case of regulatory contracts with a monopolist.

5.1 Regulation of a firm by two regulators

The regulation of a monopolist is quite an interesting application because the government can actually choose whether to have a bilateral or a multilateral situation. By devising a system of independent regulators it creates an institutional framework in which the regulation process involves more than two parties. Indeed, independent regulators usually care for different aspects of the production process of the firm, and along with the regulated firm are bound in a long-term relationship. An innovation in the production process represents a cooperative investment if it increases consumers’ surplus without any direct benefit to the firm. If we think about two independent regulators, an Economic one and an Environmental one, there might be some innovations that are beneficial only to one of the two regulators. Consider, for instance, the adoption of a technology that reduces pollution emissions but increases the risk of service disruptions at peak hours. In this case an integrated regulator, who cares for both issues, would introduce the innovation only if it is ex-post efficient, and the firm is help-up in her incentive to invest by the risk the integrated regulator would not fully compensate the investment costs. In case the introduction of the innovation produces an opposite effect on the two issues, two separate regulators gives the firm more incentive to invest. One of the two regulators would compensate the firm, without considering the negative externality imposed on the other. In section 2 we showed that introducing competitive bidding as an allocation mechanism increases the incentive to invest of the firm, when the introduction of the innovation has an opposite effect on the non-investing players.

In the literature, and in practice, one of the most interesting regulation methods is the price-cap mechanism. Its main virtue is the powerful incentive for the firm to be efficient, i.e. given the fixed revenue, the more the firm reduces costs the higher her payoff would be. This benefit is limited to cost-reduction investments, however. Consider the case of cooperative investments, for instance an investment that enhance the quality of the product, in this case the firm does not get any direct benefit from it\textsuperscript{18}. Hence, price-cap

\textsuperscript{18}Actually, there might be an increase in the demand which may lead to a higher profit for the firm, however, in most of the utility services the demand is quite rigid.
regulation does not provide any incentive for cooperative investments.

Our model shows that the separation of regulatory powers produces an increase in the incentive to invest in cooperative investments, which may lead to a second best solution with respect to the integrated regulator case. This represents a motivation for the separation of regulatory powers never considered before\textsuperscript{19}.

As an example consider the following game:

\textbf{Date 0} a benevolent government decides whether to have a unique regulator or two separate regulators;

\textbf{Date 1} the regulated firm invests;

\textbf{Date 2} the firm and the regulator (regulators) negotiate the introduction of the innovation.

The innovation affects two characteristics of the good/service the firm is supposed to deliver. These two characteristics along with the firm surplus constitute the social welfare, $W$. We assume the government is benevolent and, therefore, cares for the social welfare,

$$ W = B + E + \pi $$

where $B$ and $E$ represent the two characteristics affected by the innovation and $\pi$ is the firm’s profit. In case of two separate regulators, each one cares for one characteristic of the good/service,

$$ B = B_0 - \theta_1 \gamma(i) \quad \text{Regulator 1} $$

$$ E = E_0 + \theta_2 \gamma(i) \quad \text{Regulator 2} $$

where $B_0$ and $E_0$ represents the characteristics of the good/service without the innovation. We can think about an economic regulator which is concerned with the quality, $B$, of the service and an environmental regulator concerned with the environmental impact, $E$, of the service.

Let us assume that the firm has to produce a certain quantity of the service and receives a compensation $R_0$. The disagreement payoff would be

$$ \pi = R_0 - i $$

where $i$ is the cost for producing an innovation of magnitude $\gamma(i)$. Of course the firm will invest only if one of the regulators is willing to compensate her.

\textsuperscript{19}See Laffont (2005) for a recent survey on separation of regulatory powers.
As we have seen in the previous section, the solution of this model depends on the signs of $\theta_1$ and $\theta_2$, which are assumed to be non verifiable. Given $\theta_1$ and $\theta_2$, the government will choose the institutional set up that maximizes $W$. In case $\theta_1$, $\theta_2$ and $\alpha$ are such that $i^b < i^s < i^*$, the social welfare is maximized with separate regulators, as shown in proposition 2.

We want to draw attention to the following three remarks. Firstly, note that we would expect a benevolent government to go for a unique regulator, because it internalizes all the externalities. Our model, however, shows that there are some cases in which the social welfare is maximized by the separation of regulatory powers. This result arises because of the regulators’ lack of commitment which leads the firm to hold its investment up.

Secondly, the literature on regulation maintains that with no agency problems there would be no reason for the regulator to create an independent authority. Our model introduces a role for independent regulators even without agency problems. The importance of this result lies in providing another possible explanation for separation of regulatory powers.

Thirdly, our model is collusion-proof. Basically all models of separation of regulatory powers rely on the assumption of no collusion. When the innovation produces opposite effects, the two regulators have no incentive to collude because they have opposing interests. In particular, the regulator that wants the innovation to be introduced could offer a transfer to the other regulator in order to compensate for the negative effect on his payoff. This would eliminate any competition for the right to introduce the innovation. However, the transfer should be equal to the negative effect on the regulator, which is exactly the transfer the winner of the competitive bidding would pay. Hence, the regulator which is positively affected by the introduction of the innovation is indifferent between competing in the auction or reaching an agreement with the other regulator. In other words, if we consider the agreement as collusion, the regulator with the highest valuation would be indifferent between colluding or not.

5.2 Other applications

Below we identify other possible applications of our model:

- **Different levels of government**
  For instance, in the USA, Federal agencies and State agencies can jointly finance, and supervise, a project carried out by a third party at the local level; the three players are likely to have different objectives. Consider, as an example, the Springfield Wastewater System that has been managed through a partnership among two public bodies, the Spring-
field Water and the Sewer Commission, and a private company, the United Water.

- **Public Private Partnerships (PPP)**
  We can think of PFI (public finance initiatives) where the government and a private party agree on the provision of a good/service; if the private party subcontracts part (or all) of the work, a third party enters in the relationship. The subcontractor can introduce innovative production methods that may have a different impact on the payoff of the original two parties. This is the case of many PFI in England. Another example occurs when public and private funds finance a project carried out by a third party. For instance, the construction of a bridge (or an hospital) can be financed by both private and public funds, and the firm who builds the bridge may introduce an innovation which makes the realization of the bridge more profitable for the private partner than the public one.

- **Common provider**
  Two firms can contact the same provider to produce a particular input for their production lines. The input produced might be improved so that it is more suitable for just one of the contractors (for example, Sweden’s Ericsson and Finland’s Nokia used to purchase a chip for mobile handsets from the same company). It is sensible to argue that if one party does not like the object can refuse it, but this possibility depends on the degree of substitutability of the input.

6 Concluding comments

The model proposed shows the influence of a third player on the ex-ante incentive to invest. In the case of an efficient innovation, the competition between players increases player 3’s incentive to invest, and this leads, under certain conditions, to a reduction of the hold-up problem. This is important also in the case of incomplete contracts because, as noted by Che and Hausch (1999), contracts cannot reduce the hold-up problem when investments are cooperative, the presence of an extra player seems to reach that goal. However, we showed that competition is not always good, in the case of an efficient innovation, as competition becomes too fierce player 3 tends to overinvest. In the case of inefficient innovation, competition always leads to a waste of resources, as player 3 has a perverse incentive to invest in an innovation that will not be implemented.
In case of common externalities, the innovation represents a kind of public good (or bad), both player 1 and 2 benefit (suffer) from the same innovation. We showed that in case of efficient investments the ex-ante incentive is no higher than in case of a bilateral relationship.

The results we obtained are restricted to the case in which only one player invest, we acknowledge this limitation and leave for future research to check the robustness of our results as the number of players who can invest increases.
Riferimenti bibliografici


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