Department of Economics

Three Essays in Industrial Organization and Corporate Finance

Emanuele Tarantino

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

Florence, November 2010

EUROPEAN UNIVERSITY INSTITUTE
Department of Economics

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To my parents, Giuseppina and Francesco, for believing in an uncertain future.

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Part I

Introduction

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This thesis develops in three chapters.

The first Chapter analyzes the relationship between bankruptcy law and the time horizon of corporate investment decisions. The paper stems from the wave of bankruptcy law reforms that have been taking place in Europe early after year 2000 to introduce insolvency procedures analogous to the US Chapter 11. In the model, a "soft" bankruptcy law gives more power to the distressed entrepreneur to restructure its venture with respect to a "tough" procedure, and the contracting environment is characterized by asymmetric information and repeated moral hazard on the side of the entrepreneur. The research question analyzed concerns how the type of bankruptcy affects the choice between two investment projects: the efficient one, which leads to high returns in the long-run but exposes the entrepreneur to the risk of bankruptcy, and the inefficient one, which leads to low but safe payoffs early on. The main result of the paper is that "soft" bankruptcy may cause a problem of inefficient investment. More specifically, in the model soft bankruptcy brings about a problem of "short-termism", that is a bias towards the choice of the investment project that privileges the achievement of short-term safe payoffs. The model is extended to deliver a number of policy recommendations on the design of a "soft" bankruptcy procedure that would not be affected by the "short-termism" problem: in particular, it is stressed that, during the phase of reorganization in bankruptcy, the entrepreneur should be closely supervised by the court and incentivized to undertake a process of technological restructuring.

The second Chapter analyzes the scope for inefficient exclusion in Standard Setting Organizations. Voluntary Standard Setting Organizations (SSOs) are consortia of industry operators devoted to the achievement of an agreement on the rules that define the design of a final product or process. The economic literature has typically undertaken a cooperative approach to analyze the decision process behind technology standardization, however such a cooperative stance overlooks the inherent conflicting interests that characterize operators with different business structures in SSOs. Such conflicts arise, for example, between vertically integrated firms and vertically specialized firms.[1] The model embeds two vertically integrated firms and a pure upstream firm. Each firm holds a patented technology; the first vertically integrated firm holds an "essential" technology, the second integrated firm holds a technology that competes with the one of the upstream firm for the employment in the production of a final good, but is less efficient. The paper shows that "exclusionary effects"

[1]Integrated organizations join SSOs to achieve coordination among industry participants in the adoption of a technology platform, thus they aim at paying low rates for standards' components. Instead, specialized firms raise most of their revenue from the technology licensing market, by levying royalty rates on the users of their technologies.

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may distort the technology choice taken by manufacturers, leading to market outcomes in which the technology of the stand-alone firm is inefficiently excluded from the upstream market.

The third Chapter stems from the analysis conducted in the second chapter and studies the profitability of vertical integration in settings with complementary inputs. The literature on vertical integration and foreclosure has typically focused on settings with substitute inputs, showing that after integrating downstream an upstream firm has incentive to try and monopolize the downstream market. The analysis of the consequences of vertical integration in a model with complementary inputs gives rise to distinct effects. The main twist to the received literature consists in introducing a market for a complementary input that the integrated company has to acquire to produce a final good. The model shows that the integrated organization may still find profitable to foreclose a downstream competitor from the market. However, the presence of the complementary input supplier introduces an expropriation effect that is not present in settings with only substitute inputs and that operates at the expenses of the merged company. This expropriation incentive leads to two novel results: first, the integrated firm may depart from foreclosure when setting the input price to the competing manufacturer and, second, integration itself may turn out to be unprofitable.

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Part II

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Chapter 1

Bankruptcy Law and Corporate Investment Decisions

1.1 Introduction

The literature in the fields of law and economics has traditionally distinguished the American "soft" approach to bankruptcy from the "tough" one of European legislators. Recently, this dichotomy has been put at stake by a process of convergence due to the adoption, in major European countries, of bankruptcy codes inspired by U.S. Chapter 11. The European Commission has undertaken important actions to support this process, based on the presumption that a harsh approach to failure would deter risk taking, experimentation and innovation:[1] the belief of the Commission is that bankruptcy favors entrepreneurial initiative if it treats failure in a "soft" fashion.

Several European countries have consequently reformed their bankruptcy codes. In Germany, the reform of 1999 introduced a system of corporate reorganization analogous to Chapter 11 in the balance of creditors' and debtors' rights. Like in Chapter 11, Germany's *Insolvenzverfahren* prescribes the right of the entrepreneur to open the reorganization phase, the automatic stay on creditors' claims, the super-seniority of lenders that fund the bankrupt firm and creditors' right to decide over the approval of the reorganization plan. Unlike Chapter 11, it is a court-appointed administrator that formulates the reorganization plan and not the bankrupt management. In Italy, before the 2006 reform, the insolvency procedure was

[1] See the website *http : //ec.europa.eu/enterprise/entrepreneurship/sme2chance/* for a detailed description of the initiatives undertaken since 2002 by the Commission to promote a more lenient cultural and legislative environment towards entrepreneurial failure.

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rather "tough" with debtors, as bankrupt entrepreneurs were subject to a long phase of rehabilitation before they could start a new enterprise. In the current regime, before the opening of the liquidation phase, the entrepreneur has the right to start a process of financial reorganization (*concordato preventivo*) and negotiate with creditors over the restructuring of outstanding liabilities, as in Chapter 11. In 2005, the French legislator reformed the insolvency law by introducing a *procèdure de sauvegarde*: the new system gives the right to the incumbent management to open the reorganization phase and retain control over the company while devising a restructuring plan under the protection of the automatic stay of creditors' claims.[2]

Overall, Germany, Italy and France implemented a "soft" regime and the main novelty introduced by respective laws is to give more power to the entrepreneur to restructure the terms of outstanding financial contracts. These reformed procedures are seriously challenged by the international financial meltdown triggered in the fall of 2008 by the failure of major US credit institutions, which has pushed a number of firms onto the verge of bankruptcy. Indeed, Standard & Poor's reports that the default rate related to European companies in its speculative-grade category have risen to 11.1% in 2009 and 2010, from 3.2% over the last fifteen years.[3]

This Chapter contributes to the analysis of the efficacy of the recent bankruptcy reforms by showing that, in the presence of a problem of repeated moral hazard and by giving a second chance to the entrepreneur, "soft" bankruptcy law may cause a problem of short-termism in investments, that is the choice of investment projects that privilege the achievement of short-term results.

I employ a principal-agent model with repeated moral hazard, in which a cash constrained entrepreneur can choose to undertake either a *short-term* project or a *long-term* project. The short-term project is completed in one period and returns a lower net present value than the long-term project. However, the long-term project requires two periods to be completed and exposes the entrepreneur to the risk of bankruptcy.[4]

[2]For a detailed overview of bankruptcy law and economics see Stanghellini (2007). Also, Brouwer (2006) provides a comparative analysis between the United States and Europe on the discipline of reorganization in bankruptcy. Finally, see Franks and Davydenko (2008) for an empirical study of how differences over creditors' rights among France, United Kingdom and Germany insolvency systems have an impact over banks' lending decisions to distressed companies.

[3]Data from *The Economist*, "Out of Pocket", December 2008 issue.

[4]In order to make things more concrete, in what follows the short-term project is designed as a risk-free investment, like a government bond. Instead, the long-term project is an investment that may deliver high long-run payoffs at the cost of early failures, like the investments in R&D.

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"Soft" bankruptcy is modeled through the implications that it imparts on entrepreneurs' future; throughout the paper, several bankruptcy games are analyzed, but at the core of each of them is a financial renegotiation game that resembles Chapter 11 in the balance of lenders' and entrepreneur's rights; on the one hand the entrepreneur's right to ask for the opening of bankruptcy proceedings in front of a court and devise a restructuring plan, on the other hand the lenders' power to approve or reject the plan.

My aim is to compare the impact on investment decisions of a "soft" bankruptcy game with respect to a benchmark case in which liquidation follows automatically in a case of insolvency. This benchmark case is designed to capture the main characteristics of relatively "tough" bankruptcy codes. In the pre-reform regimes of Italy, Germany and France the resolution of bankruptcy proceedings exhibited a clear bias towards the liquidation of the distressed company (see Brouwer (2006)). Moreover, in Italy the old bankruptcy law prescribed that the bankrupt entrepreneur's access to new credit had to be preceded by a long phase of recovery and this limited the chances to obtain new liquidity in the aftermath of a default. Finally, in the United Kingdom, where the procedure is creditor-oriented, Franks and Sussman (2005) show that lenders inhibit debt renegotiations to avoid strategic default. These pieces of evidence testify that "tough" procedures do distinguish from "soft" legal codes in two important ways: they discourage (ex-ante and ex-post) renegotiation and have a clear inclination towards liquidation.

The short-termism result is derived in two steps. Firstly, I prove that lenders' behavior is characterized by limited commitment under "soft" bankruptcy. Indeed, if bankruptcy is designed by the law as pure financial renegotiation, then it reduces the room for entrepreneur's punishment in case of bad performance, because the lender would be tempted to allow continuation when this is profitable. This mechanism is borrowed from the literature on the "soft budget constraint" problem,[5] but in this model it leads to the opposite result that *softening the budget constraint generates short-termism.* If the bankrupt entrepreneur finds new funds to carry on the project during the phase of financial restructuring, existing lenders are tempted to approve the project's continuation and renegotiate the prescription of termination contained into the initial contract. On the one hand, this increases ex-post efficiency because investors improve recovery rates, but on the other hand it decreases ex-ante efficiency because the prospect of renegotiation raises the agency rent that investors need to bear to restore entrepreneur's incentives.

Secondly, I show that the problem of limited commitment produces the choice of short-

[5]This literature highlights the *costs* to a principal from the lack of commitment to remain tough with an agent. See the seminal paper by Dewatripont and Maskin (1995) and Kornai et al. (2003).

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term projects. To induce appropriate incentives, the lender must reduce the repayment he requires in the financial contract and such reduction may make the project ex-ante unprofitable. Consequently, the entrepreneur would choose projects that are not subject to the risk of bankruptcy, and deliver positive results early on, in order to get funded.[6]

In the paper, I analyze the robustness of the short-termism mechanism and present four additional results. The first is that the bias towards the achievement of short-term results may be offset if the bankrupt entrepreneur undertakes a process of technological restructuring. In the extension with bankruptcy and technological restructuring, the two conflicting forces triggered by the "soft budget constraint" effect are put in contrast. Firstly, the one proposed by Dewatripont and Maskin (1995) and von Thadden (1995), where it is shown that hardening the budget constraint may bring to an end valuable, but slow, projects. Secondly, the one put forward by this model, where I show that softening the budget constraint also causes an increase of agency costs. The result of this extension is that the long-term investment is chosen if the probability that a low outcome is caused by adverse shocks is high enough. Otherwise, and if the moral hazard problem is relatively severe, the short-termism bias still arises.

The second additional result regards the effect of the degree of financial markets' competition on investments: in a context with monopoly lending, I show that the short-termism problem is further reinforced with respect to the environment with competitive financial markets. In the case with competitive lending, the entrepreneur is able to fully squeeze the net value of the long-term project and therefore, the project is always undertaken if implementable. Instead, the monopoly lender must take into account entrepreneur's agency rent when comparing projects' profitability and as such, the rent increases in the "soft" bankruptcy framework to make the long-term project unprofitable, independently from recovery rates.

The third result is that the existence of collateral alleviates the soft-budget constraint problem and facilitates the choice of the long-term project. Intuitively, collateral increases recovery rates in the event of project's failure and reduces the rent that the entrepreneur can extract by misbehaving. The fourth result consists in showing that by introducing a threat of management substitution in case of poor performance, the lender can restore investment's

[6]The mechanism by which short-termism arises in this model is different than the one in Diamond (2004). Diamond (2004) shows that in weak legal environments and with multiple lenders, short-term debt is the contract that allows a creditor to minimize the deadweight loss that he would suffer from a run on a borrower by the other lenders. In other words, Diamond (2004) shows that holding the right to neglect refunding, and keep the budget constraint tight, a lender is less exposed to the negative externality imposed by other lenders when these require an early stage repayment.

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efficiency. As for the case with collateral, the threat of turnover reintroduces a stick that the lender can use to punish the manager in place of the refunding decisions.

Several pieces of empirical evidence support my conclusions. The first, and more important, is due to John et al. (2008), in which it is shown that strong creditor rights induce firms' insiders and managers to choose more valuable investment projects by hampering the opportunities of rent extraction generated by opportunistic conduct. The second is in a number of empirical analyses showing that risk-premiums and short-term lending are positively correlated with bankruptcy law degree of "leniency" (see Blume et al., 1980; Corbett, 1987; Poterba and Summers, 1995; Qian and Strahan, 2007). The third is in Bharath et al. (2007), where it is shown that, consistently with the results of the extension with management turnover, the replacement of the incumbent management in Chapter 11 is steadily increased in the last 20 years, leading to a more efficient development of bankruptcy proceedings.[7]

The article proceeds as follows. Section 1.2 gives a short introduction to Chapter 11, Section 1.3 compares my findings with those established in related papers and Section 1.4 presents the main model. In Section 1.5, I discuss the benchmark case in which the lender can commit to the optimal initial contract with the entrepreneur and liquidates the firm in case of project's failure, while in Section 1.6 I relax the assumption of full commitment and study the effects of "soft" bankruptcy. Section 1.7 proves that the main result carries over even if the entrepreneur is allowed to undertake a process of technological restructuring in bankruptcy. In Section 1.8, I solve the model under the assumption of monopolistic lending. Section 1.9 and Section 1.10 analyze two extensions in which the lender can, respectively, pledge collateral and threat to substitute the incumbent entrepreneur in bankruptcy. Section 1.11 discusses the empirical predictions and the policy conclusion of the paper. Finally, Section 1.12 concludes.

1.2 Chapter 11

In the United States, Chapter 7 and Chapter 11 of the bankruptcy law provide the federal discipline that regulates corporate insolvency procedures. Chapter 7 governs the phase of liquidation, while Chapter 11 governs the process of financial restructuring. They are both carried out under the oversight of specialized bankruptcy courts.

Chapter 11 ultimate target is to protect a bankrupt firm from outsiders' pressure while it is coping with a process of rehabilitation. Chapter 11 prescribes a system of countervailing

[7]See Section 1.11 for a more detailed discussion on model's testable predictions and policy conclusion.

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rights aimed at protecting both creditors' and debtors' interests. On the debtors' side is the provision that allows the entrepreneur to file unilaterally for Chapter 11, at the prospect of potential default. Entry into Chapter 11 opens the Debtor-in-Possession (or DIP) phase, during which the entrepreneur has the right to stop payments to existing investors (automatic stay) and devise a restructuring plan to be submitted to creditors by a given period of time.[8] During the Debtor-In-Possession phase, the entrepreneur can also search for new funds and in order to facilitate this, Chapter 11 prescribes that the investors willing to finance bankrupt firms are privileged in the reimbursement of their claims at the end of the restructuring process - i.e., they can be repaid before (even senior) existing investors.

Creditors have two important rights in Chapter 11: first, they can propose an alternative plan to the entrepreneur's and second, they vote on the restructuring project in a ballot disciplined by a system of qualified majorities.[9] In fact, by rejecting the plan, creditors can reverse the restructuring procedure into a Chapter 7 liquidation process.

In the model, I compare the impact of several renegotiation environments in bankruptcy over ex ante investment choices. More specifically, the *first "soft" bankruptcy game* studies the effects on investments of a *financial renegotiation* game designed following the rights that Chapter 11 grants to contracting parties. Particular emphasis is given to two of them: the right that the entrepreneur has to unilaterally file for bankruptcy, search for new funds and devise a restructuring plan, and the right that lenders have to vote on the same plan. In the *second "soft" bankruptcy game*, I look at the interplay between financial renegotiation and *economic restructuring*; there, the bankrupt entrepreneur can both renegotiate with creditors and undertake a process of economic reorganization, two important features of real Chapter 11 cases. In the *third "soft" bankruptcy game*, I analyze the outcome of financial renegotiation under the assumption of *imperfect capital markets*; the objective is to understand the effects of the introduction of a "soft" procedure in economies where banks have strong bargaining power. In the *fourth and fifth "soft" bankruptcy games*, I enlarge financiers' strategy space at the initial funding stage: first, by looking at a game in which *collateral* can be pledged, then by introducing a clause by which *lenders can fire the entrepreneur* and substitute her in bankruptcy.

[8]The deadline is set by law at 120 days, but the bankruptcy judge can concede extensions.

[9]Creditors vote on the plan by classes of seniority. More specifically, an entire class of claims is deemed to accept a plan if the plan is accepted by creditors that hold at least two-thirds in amount and more than one-half in number. A vote of acceptance by a class binds all creditors in the class.

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1.3 Related Literature

Gertner and Scharfstein (1991) has been the first to show how inefficient decisions over bankrupt firms' continuation distort ex ante corporate investments. In this literature, however, the work that is particularly close in spirit to this one is Bebchuk (2002). Bebchuk (2002) analyzes how the Absolute Priority Rule (APR hereafter) deviations that characterize Chapter 11 proceedings influence equity-holders choice between two investment projects, one riskier than the other.[10] Bebchuk (2002) shows that equity-holders may be tempted to choose the risky project because in failure states they are able to secure a positive rent from Chapter 11 negotiations. However, Bebchuk (2002) implicitly assumes that the creditors are unaware of the type of investment projects available to the equity-holders. Instead, in this model I assume that a lender can observe and verify the investment plan that the entrepreneur undertakes, and designs the optimal contract as to induce her to choose the most profitable one. Consequently, I derive the investment strategy choice as a function of the optimal equilibrium contracts and study how the same choice changes with the type of bankruptcy.

An important strand of the literature designs "soft" bankruptcy as an information revelation process in which the economic viability of the firm is examined. This literature emphasizes the trade-off between the excessive liquidation caused by "tough" procedures and the excessive continuation generated by "soft" procedures.[11] For example, White (1994) investigates the role of bankruptcy as a filtering device in a model with adverse selection and highlights the way bankruptcy can distort liquidation/continuation decisions. I take a different modeling approach by focusing on the agency costs caused by moral hazard and limited commitment in lenient procedures. The costs generated by moral hazard induce the parties to write a contract that prescribes termination in case of project's failure. The problem of limited commitment associated to "soft" codes, though, weakens this threat and forces the lender to grant a higher monetary transfer in order to restore entrepreneur's incentives.

This Chapter is also related to the literature that studies the "soft budget constraint" problem. Dewatripont and Maskin (1995) and von Thadden (1995) investigate the relationship between the "soft budget constraint" problem and investments' time horizon, concluding

[10] The APR determines the order of creditors' claims reimbursement in bankruptcy. It states that creditors who have secured their loans have seniority over other creditors, and, therefore, have the right to be paid back first.

[11] This trade-off has also influenced the debate over the design of the optimal bankruptcy reform. See Hart (1995), chapter 7, for a comprehensive discussion on this topic.

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that *hardening the budget constraint may induce short-termism in investment behavior*.[12] In these papers, it is shown that neglecting the refunding of projects that yield a low outcome in the short-term hinders the implementation of both bad projects, and slow, but good, projects that are able to generate very high gains only in the long-run. Clearly, this is not efficient if the higher profitability of long-term projects offsets the losses caused by bad projects. I contribute to this literature by showing that *hardening the budget constraint induces long-termism* because it allows investors to keep the termination threat credible and limit the costs associated with the problem of repeated moral hazard.

Recent theoretical and empirical contributions show that "soft" bankruptcy procedures foster innovation and entrepreneurship. For example, Acharya and Subramanian (2009) provides empirical evidence on how "soft" codes foster innovation, Biais and Mariotti (2009) develops a model that shows how these procedures produce positive externalities at a general equilibrium level and Landier (2006) proves that "soft" bankruptcy stimulates entrepreneurial initiative. More specifically, Landier (2006) develops a model where the attitude of capital markets towards failure is endogenous: entrepreneurship depends on the cost of funding, which in turn depends on markets' expectations over failed entrepreneurs' ability. Landier (2006) shows that "soft" bankruptcy rules stimulate entrepreneurship because they grant a complete debt relief to the failed entrepreneur and reduce the cost of capital necessary to start new projects. With respect to the analysis in Landier (2006), I let the "cost of funding" depend on the severity of the moral hazard problem, which depends on bankruptcy law.

Finally, the main result of the paper follows from the assumption for which parties can renegotiate the initial contract through bankruptcy: this weakens ex ante incentives but alleviates ex post efficiency loss. Therefore, like in Bolton and Scharfstein (1996), the main focus is on the renegotiation game that is carried out between lender and entrepreneur. However, the aim of Bolton and Scharfstein (1996) is to determine the optimal number of creditors that is able to minimize the trade-off between entrepreneur's ex ante incentives to default strategically and the ex post efficiency costs generated by liquidation. Instead, in this Chapter I am more concerned about the impact of renegotiation on firm's investment plans.

[12]My model differs from von Thadden (1995) insofar as I assume that the lender can observe the project chosen by the firm but cannot observe first period profits. Moreover, I depart from Baliga and Polak (2004), which also builds on Dewatripont and Maskin (1995) by introducing a problem of moral hazard, because there authors employ a one-shot game to study the choice between monitored and non-monitored loans.

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1.4 The Model

The model analyses a financing game in an environment characterized by asymmetric information and entrepreneur's limited liability. There are two classes of risk-neutral agents in the economy: a cash constrained entrepreneur (or borrower, she) and competing lenders.[13] In what follows, I assume that each entrepreneur obtains funding from a single lender (or investor, he) and focus on a representative entrepreneur-lender pair. Moreover, market interest rates are normalized to zero.

The entrepreneur decides the time horizon of the investment and this decision is observed and verified by the lender. More specifically, the entrepreneur can choose between two projects: a short-term project (S) and a long-term project (L). This choice influences firm's expected revenues in the following way. The short-term project is modeled as an outside option that returns a net payoff of $\Pi_S \geq 0$.[14] The long-term project extends over up to two periods, it requires an outlay of $I > 0$ to be started and a further infusion of $\widehat{I} > 0$ to be completed. In the first period, project L delivers a payoff equal to $\Pi > 0$ in the case of success, and zero in the case of failure. Finally, in the second period, the project generates an expected return equal to $\widehat{\Pi} > 0$ independently from first period outcome.

The profitability of the long-term project is subject to two problems of asymmetric information. Firstly, the entrepreneur must decide in each period whether to exert effort or shirk. In the first period, the moral hazard problem is designed as in Holmström-Tirole (1997). More specifically, I assume that if the entrepreneur puts in effort, she would succeed with certainty and if she shirks, she would fail with certainty but gain private benefits $B > 0$.[15] In the second period, the moral hazard problem is designed in a reduced form: the entrepreneur requires the payment of a reward at least equal to $\widehat{B} > 0$ to put in effort.

Secondly, I assume that the entrepreneur privately observes the project's first period outcome. This follows Bolton and Scharfstein (1990) and is equivalent to assuming that the lender needs to bear an infinite cost to observe the true state. The main implication of this hypothesis is that contingent contracts are not feasible in this setting. In other words, the scope of the analysis is limited to contracts in which refunding decisions depend on the

[13] In fact, what follows also applies to managerial firms in which managers' interests are perfectly aligned with equity-holders'.

[14] Π_S corresponds to the net surplus yielded by project S to the agent that holds the bargaining power in the contracting phase. This assumption allows to simplify the analysis. However, what is sufficient for the main result to hold is that project S is not subject to the risk of bankruptcy.

[15] This assumption allows to deliver a sharper result than with intermediate probabilities of success (failure). I would like to remark that the nature of the results would not change assuming that the probability of success (failure) lies into the unit interval.

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results reported at the end of the first period by the entrepreneur.[16]

Time-line and cash flow of the game are given in Figure 1.1.

[FIGURE 1.1 ABOUT HERE]

The entrepreneur holds all the bargaining power at the contracting stage: she makes a take-it-or-leave-it offer to the lender that specifies the project she wants to carry out and the contract that would implement it.[17] If the lender accepts the offer, he provides initial funding and the project is started. The class of contractual mechanisms I focus on are composed by two instruments: a per period repayment from the entrepreneur to the lender and project's continuation decisions. The repayment required in the first period is denoted by R, while the transfer required in the second period is denoted by $\widehat{R}$. Lenders' decisions over project continuation are denoted by $\zeta_j = \{0, 1\}$, with $j = \Pi, 0$, and depend on first period revealed payoff: if the entrepreneur reports Π (zero), the project is refunded when $\zeta_\Pi = 1$ ($\zeta_0 = 1$), terminated otherwise ($\zeta_j = 0$, with $j = \Pi, 0$). Entry into bankruptcy takes place when the entrepreneur reports a nil payoff, because in that case she cannot meet the initial contract's requirements. The implications for the firm of the entrance in bankruptcy depend on bankruptcy code. In Sub-section 1.4.1, I will be more specific on how the game develops in bankruptcy states.

I introduce three parametric assumptions.

Assumption 1

i. $\Pi > B$;

ii. $\Pi > I$;

iii. $\widehat{\Pi} - \widehat{I} - \widehat{B} > 0$.

Assumption 1.*i* implies that, in the first period, entrepreneur's truthful revelation constraint is more binding than the one related to effort provision.[18] Assumption 1.*ii* implies that the long-term project has positive net present value in the first period, Assumption 1.*iii* implies that the long-term project has positive pledgeable income in the second period.[19]

[16] It is important to remark that here project's payoff is function of a decision over effort provision, therefore, it is not randomly determined. This implies that the game is not a signaling game of the Gale and Hellwig (1989) type.

[17] Clearly, the way project S is modeled implies that the relative contract just specifies how Π_S is split.

[18] This assumption greatly simplifies the solution of the maximization problems in the model without loss of generality.

[19] By pledgeable income I mean the surplus delivered by the project net of the cost related to the investment allotment and private benefits.

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The optimal mechanism that implements strategy L is found by solving, by backward induction, for the sequential incentive problems in $t = 2$ and $t = 1$. The equilibrium concept I shall employ is the Subgame Perfect Nash Equilibrium (SPE).

1.4.1 The "Soft" Bankruptcy Game

Renegotiation takes place in bankruptcy and is compliant to bankruptcy code's prescriptions. This implies that bankrupt entrepreneurs are allowed to renegotiate the termination clause only under the mechanisms provided by the law. In particular, in insolvency states, the following *"soft" bankruptcy game* takes place.

1. The entrepreneur searches for new funds on competitive financial markets.

2. If the entrepreneur finds a new lender, this lender makes her an offer.

3. In the case of offer acceptance, the first period lender (or old lender) must decide either to agree on the continuation plan or reject it. More specifically, such a decision is the outcome of an ultimatum game in which the old lender has all the bargaining power and makes a take-it-or-leave-it offer to the agent. This offer specifies the payoff that the lender requires to allow project continuation and is denoted by $\hat{r}$.

4. If the entrepreneur accepts the old lender's offer, the firm continues its activity and the second period time structure is the same as in case of continuation out of bankruptcy. Otherwise, the firm is shut down and the entrepreneur is dismissed.

Notice that the cash flow structure of the game and the assumptions on the moral hazard problems are the same independently from whether the entrepreneur is in bankruptcy.

Two further points must be stressed. Firstly, the lender that provides new liquidity in the second stage of the renegotiation game must not be necessarily different from the first period one. Indeed, in both cases the model would deliver the same type of results.[20]

Secondly, the choice to structure the renegotiation phase as an ultimatum game implies that the allocation of the bargaining power determines the equilibrium outcomes. I assume that the old lender has all the bargaining power in bankruptcy. This hypothesis may seem limiting because it does not capture the interactions that take place among creditors and debtors under the supervision of the bankruptcy judge in a real Chapter 11. However,

[20] It is worth noticing that the empirical evidence provided by Daihya et al. (2003) on Chapter 11 Debtor-In-Possession funding contracts confirms that bankrupt firms do receive money from both investors with whom they already have a lending relationship and new investors.

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weakening old lender's bargaining power would only reinforce my conclusions. In fact, the model shows that even when the initial lender holds the power to decide whether to enforce the contract or not (asking for a huge value of $\hat{r}$, for instance), he may eventually accept renegotiation.[21]

1.4.2 First Best

Analyze first the scenario in which the entrepreneur is not cash constrained and there is no problem of moral hazard. I assume that in these circumstances the long-term project generates a net present value higher than the one attached to the short-term project and therefore determines the value of the firm in the first best scenario.

$$\Pi - I + \widehat{\Pi} - \widehat{I} > \Pi_S. \qquad (FB)$$

In what follows, it is first presented how the contracting game changes when the moral hazard problems are introduced into the analysis and then when the problem of limited commitment is accounted for.

1.5 Optimal Contract with Full Commitment

In this section, it is derived the equilibrium contract that the lender may want to propose to the entrepreneur under the assumption of full commitment. With respect to the first best scenario, I introduce the problem of repeated moral hazard. Therefore, the constraints related to entrepreneur's private decisions on effort provision and payoff revelation must be taken into account. Nevertheless, thanks to full commitment, the bankruptcy code does not affect the investment strategy choice because at the interim stage, no matter what the law prescribes, the lender sticks to the contract signed at the outset and imposes liquidation on the firm.

Lemma 1 presents the equilibrium of the contracting game.

Lemma 1
Under full commitment, two scenarios can arise:

[21] In relation to this feature of the game, it is interesting to remark that during Chapter 11 voting phase the bankruptcy judge can "cram-down" a restructuring plan, even against old lender's will, if she/he believes that the plan preserves firm's value as a going concern. Explicitly introducing this into the renegotiation game would further exacerbate the "soft-budget constraint problem" highlighted in this Chapter, since it would increase entrepreneur's outside option during negotiations.

i. If $\widehat{\Pi} - \widehat{I} < I$*, project* S *is chosen by the entrepreneur, the lender breaks even and the entrepreneur takes* Π_S*. Finally, project* S *is implemented if the lender accepts the offer.*

ii. If $\widehat{\Pi} - \widehat{I} \geq I$*, the entrepreneur offers* $\mathcal{C}^{FC}$ *to the lender.*

$$\mathcal{C}^{FC} \equiv \{R = I, \widehat{R} = \widehat{I}\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 0\}.$$

Consequently, borrower's utility under project L *at equilibrium, denoted* U^{FC}*, is given by*

$$U^{FC} = \Pi - I + \widehat{\Pi} - \widehat{I} > 0 \tag{1.1}$$

and the lender breaks even in expectation. Finally, if the lender accepts the offer, project L *is implemented.*

Proof. See Appendix A.

Contract $\mathcal{C}^{FC}$ induces the first best outcome if the true telling constraint is satisfied; it can be implemented by a sequence of standard short-term debt contracts that require the repayment of a fixed amount at the end of each period and a refunding decision at the interim period.

$\mathcal{C}^{FC}$ prescribes that if the entrepreneur does not report Π the firm is not refunded ($\zeta_0 = 0$) and is put in liquidation (since $0 < R$). In other words, even in a setting with positive second period expected value, it is optimal to terminate the project and push the firm to liquidation. Moreover, the assumption of competitive financial markets implies that the entrepreneur is able to squeeze all the value of project L, hence the first best is attained when L is chosen. Finally, the profitability of the long-term project is not affected by bankruptcy because renegotiation is not allowed under full commitment.

1.6 Optimal Contract with Limited Commitment

In this section, I present how the contracting game changes under the assumption of limited commitment. The departure from full commitment implies that lender's ability to enforce the optimal contract depends on bankruptcy law. If the procedure is "soft", the bankrupt entrepreneur has the right to search for new lenders and the old lender has the power to permit or prevent continuation. I show that the lender allows continuation because this makes recovery rates improve; consequently, a tension arises between ex-post and ex-ante efficiency, which determines the resulting investment strategy.

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Lemma 2

Under limited commitment, two scenarios can arise, depending on the value of project L expected pledgeable income in the second period:

i. *If $\widehat{\Pi} - \widehat{I} - \widehat{B} < I$, project S is chosen by the entrepreneur, the lender breaks even and the entrepreneur takes Π_S. Finally, project S is implemented if the lender accepts the offer.*

ii. *If $\widehat{\Pi} - \widehat{I} - \widehat{B} \geq I$, the entrepreneur offers $\mathcal{C}^{LC}$ to the lender.*

$$\mathcal{C}^{LC} \equiv \{R = I, \widehat{R} = \widehat{I}, \hat{r} = I\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 1\}.$$

Borrower's utility under $\mathcal{C}^{LC}$, denoted U^{LC}, is:

$$U^{LC} = \Pi - I + \widehat{\Pi} - \widehat{I} > 0.$$

The lender breaks even in expectation. Finally, if the lender accepts the offer, project L is implemented.

Proof. See Appendix B.

Proposition 1

Limited commitment reduces the scope for the implementation of the long-term project L.

Proof. The proof follows by comparing the conditions for the implementation of $\mathcal{C}^{FC}$ and $\mathcal{C}^{LC}$ outlined in Lemma 1 and Lemma 2.

Proposition 1 shows that "soft" bankruptcy procedures may cause a bias toward short-termism in firm's investments. The intuition for this result is as follows. On the one hand, a lenient procedure reduces the instruments available to cope with entrepreneur's moral hazard. On the other hand, it allows for an improvement of recovery rates in the case of first period insolvency. Indeed, once the assumption of full commitment is relaxed, it is not rational to the old lender, at the interim stage, to refuse any finite rent from renegotiation, even if this comes at the cost of loosening the refunding decisions. This is a well known principle borrowed from the literature on mutually advantageous renegotiation,[22] and is here employed to study the impact on the investment choice in the presence of renegotiation in bankruptcy.

[22]The general problem is analyzed by Fudenberg and Tirole (1990), instead Gromb (1994) applies it to debt contracts in a setting that draws on Bolton and Scharfstein (1990).

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The bankruptcy game employed reverses the bargaining power allocation with respect to the initial contracting stage, in which it is the entrepreneur to hold all the bargaining power. However, this assumption does not reinforce the result of the paper. If the entrepreneur was to hold all the bargaining power at the renegotiation stage, then the equilibrium of the investment game would never feature the choice of the long-term project because the entrepreneur would squeeze project's net present value in full and the lender would never retrieve I through the recovery rates.

The main finding is that, unless the lender is able to fully recover the initial outlay, the exacerbation of the agency costs caused by the relaxation of the termination threat is not offset by the transfer $\hat{r}$ required by the lender to permit continuation in bankruptcy. In other words, the entrepreneur would always have incentive to divert first period profits and project L would not be profitable from the lender's viewpoint.

The result that tightening the termination threat allows for the implementation of more valuable projects is supported by the empirical analysis in John et al. (2008). Indeed, John et al. (2008) claims that strong creditor protection induces firms' insiders and managers to choose more valuable investment strategies by hampering their rent extraction behavior. This conclusion, and the intuition behind, is consistent with the results of this section.

Further evidence to the short-termism outcome is in the studies that look at financial conditions set by investors at the contracting stage. In particular, Qian and Strahan (2007) shows that stronger creditor protection is correlated with bigger interest rates and longer term financing.

1.7 Bankruptcy and Technological Restructuring

The model in Section 1.4 does not take into account that restructuring in bankruptcy may also give a second chance to ventures in difficulties to restore economic viability. In particular, there I forego the impact that a technological restructuring process would impart on firm's value. This is an important feature of Chapter 11 and it is particularly important if failure is caused by exogenous circumstances, like an adverse shock.

In this extension, I design the investment game to give the bankrupt entrepreneur the power to re-establish the venture's profitability following a first period project failure or after a negative shock that fully depletes first period project value. In this way, I contrast the two conflicting forces triggered by the "soft budget constraint" effect: the one put forward by Dewatripont and Maskin (1995) and von Thadden (1995), where it is shown that *hardening* the budget constraint may bring to an end slow and good projects and the one put forward

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by this Chapter, where I show that *softening* the budget constraint also causes the increase of agency costs.

The goal of this section is to compare the results of a "soft" bankruptcy game with technological restructuring to the case in which bankruptcy is "tough". More specifically, I want to understand to what extent the chances for the long-term strategy to be selected at equilibrium increase with renegotiation and restructuring.

The outcome of this extension is a trade-off in which, on the one hand, restructuring enables the attainment of a higher net value of the long-term project but, on the other hand, the "soft budget constraint" problem intrinsic to renegotiation puts at risk long-term project's implementation.

I modify the structure of both the investment game and the "soft" bankruptcy game with respect to Section 1.4. Firstly, I assume that the long-term project is subject to a shock that may spoil its value and that this shock may happen with probability $1 - \sigma$.[23]

Secondly, I assume that in the second period the expected payoff returned by the long-term project is perfectly correlated with the outcome of the first period, equal to $\widehat{\Pi}$ in the case of success and zero in the case of a nil first period outcome. However, under the "soft" bankruptcy law, the entrepreneur undertakes a restructuring process that increases the payoff of the project to $\widehat{\Pi}$ after a negative shock or a first period project failure. The restructuring process succeeds with certainty and its outcome is publicly observable.[24]

Thirdly, in the framework with "soft" bankruptcy and restructuring, I follow the approach of the *costly state verification* literature by assuming that the lender can perfectly observe the outcome of the project in the first period, by sending the entrepreneur to bankruptcy and paying a fixed cost K.[25] In other words, in the spirit of Gale and Hellwig (1985), I am relaxing the assumption for which the true state is observable at an infinite cost. Therefore, in the case with "soft" bankruptcy and restructuring, the contract specifies a decision rule, denoted by $p_j \in \{0, 1\}$, with $j = \Pi, 0$, according to which the firm can be put in bankruptcy

[23]This hypothesis allows for the enrichment of the analysis in an interesting fashion. Indeed, in absence of such shock, restructuring would be feasible only after first period failure, which, given the moral hazard problem design of Section 1.4, happens only in case of first period shirking. This means that restructuring would just increase the rents attached to continuation in bankruptcy and make the long-term project even less valuable in the case of renegotiation in bankruptcy.

[24]Here I am assuming that the restructuring project does not require any implementation cost and this has two implications: the first is that the entrepreneur is always willing to undertake restructuring and the second is that the payoff of the restructured project is the same as following first period success. I would like to remark that introducing a restructuring cost does not change the nature of the results presented in the following of this section.

[25]Also, the lender can observe whether the entrepreneur has been hit by the shock.

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and the project's payoff verified, depending on the first period revealed outcome. Moreover, the contract defines the payments required in bankruptcy - R_{Π}^{b} and R_{0}^{b}-, and the payments required out of bankruptcy - R_{Π} and R_0.

Finally, consistently with the main model, the legal framework determines to what extent parties can commit to enforce the initial contract and verify the true outcome of the project. More specifically, if bankruptcy is "soft" the opening of the restructuring phase naturally implies that parties can commit to the implementation of the policy of state verification stipulated into the contract and sink the disclosure cost K.[26] At the same time, "soft" bankruptcy implies that the enforcement of the refunding decisions depends on the outcome of the renegotiation phase.

In particular, the new timing of the "soft" bankruptcy game is as follows:

1. *The lender observes the true outcome at cost K.*

2. The entrepreneur searches for new funds on competitive financial markets.

3. If the entrepreneur finds a new lender, this lender makes her an offer.

4. *In case of offer acceptance, the entrepreneur undertakes the technological restructuring process.*

5. The old lender must decide either to agree to the continuation plan or reject it. The old lender and the entrepreneur play an ultimatum game in which the former has all the bargaining power and makes a take-it-or-leave-it offer to the firm. Such an offer specifies the payoff that he requires to allow the project's continuation, indexed $\hat{r}_j$, with $j = \Pi, 0$.

6. If the entrepreneur accepts the old lender's offer, the firm continues its activity and the second period time structure is the same as in the case of continuation out of bankruptcy. Otherwise, the firm is shut down and the entrepreneur is dismissed.

Second period effort decision in bankruptcy is modeled as out of bankruptcy, while the new payoff distribution is in Figure 1.2. Finally, the parametric hypotheses into Assumption 1 hold also in this section. However, Assumption 2 below is introduced.

[26]Note that under the costly state verification approach, parties need to commit to the bankruptcy policy specified in the contract, because otherwise they would never be willing to sink the true state disclosure cost K ex post. Indeed, as remarked by Bolton and Dewatripont (2005), if the entrepreneur expects the policy to be carried out, she always reports the cash flow's exact realization. In turn, the lender, anticipating that the truth is always communicated, would not have incentive to undertake the verification policy.

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Assumption 2
$\widehat{\Pi} - \widehat{I} - \widehat{B} > K$.

[FIGURE 1.2 ABOUT HERE]

Assumption 2 introduces an upper bound to verification costs, K, and it implies that long-run project's second period expected pledgeable income is not depleted after paying K.

1.7.1 Optimal Contract under "Tough" Bankruptcy

In this section, it is derived the contract that lender and entrepreneur sign when bankruptcy (and technological restructuring) is not allowed: this framework corresponds to the one in which parties cannot renegotiate the original deal at the interim stage. Lemma 3 presents the equilibrium of the contracting game.

Lemma 3
Denote by $\mathcal{C}^{NR}$ the equilibrium contract that implements the long-term investment strategy L in absence of "soft" bankruptcy and technological restructuring. $\mathcal{C}^{NR}$ specifies that:

$$\mathcal{C}^{NR} \equiv \{R = R^{NR} \equiv I/\sigma, \widehat{R} = \widehat{I}\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 0\}.$$

$\mathcal{C}^{NR}$ can be implemented if first period limited liability,

$$\Pi \geq I/\sigma,$$

the incentive constraint related to effort provision,

$$\sigma\Pi - I + \sigma(\widehat{\Pi} - \widehat{I}) \geq B, \tag{1.2}$$

and the truth-telling constraint,

$$\widehat{\Pi} - \widehat{I} - I/\sigma \geq 0,$$

are satisfied. Then, borrower's utility, denoted U^{NR}, is equal to:

$$U^{NR} = \sigma\Pi - I + \sigma(\widehat{\Pi} - \widehat{I})$$

and the lender breaks even in expectation. Finally, long-term project L is chosen at equilibrium if:

$$\sigma\Pi - I + \sigma(\widehat{\Pi} - \widehat{I}) \geq \Pi_S. \tag{1.3}$$

Proof. See Appendix C.

The risk of a negative shock increases the repayment required in the first period by the lender, and this has two implications. Firstly, first period limited liability, the incentive constraint and the truth-telling constraint may not hold. Secondly, the value generated by the long-term project is smaller than in the full commitment case of Section 1.5.

1.7.2 Optimal Contract under "Soft" Bankruptcy and Restructuring

If bankruptcy allows the entrepreneur to restructure the firm in case of an adverse shock or a first period failure, there are two conflicting forces that influence the contracting game outcome and project choice. On the one hand, as shown in Section 1.6, renegotiation in bankruptcy increases the agency costs attached to the implementation of project L. On the other hand, technological restructuring can raise the value of the same project and make it more profitable to the entrepreneur. Lemma 4 presents the optimal contract and the conditions that determine project's choice in this framework.

Lemma 4
In a setting with "soft" bankruptcy and technological restructuring, two cases must be distinguished.

(*i*) *If $\widehat{\Pi} - \widehat{I} - \widehat{B} - K < I$, recovery rates are not enough to recoup the initial investment's value. The optimal contract in this case, denoted by $\mathcal{C}^R$, specifies that:*

$$\mathcal{C}^R \equiv \Big\{ R_\Pi = R^R \equiv \frac{I - (\widehat{\Pi} - \widehat{I} - \widehat{B} - K)(1-\sigma)}{\sigma}, R^b_\Pi = R^b_0 = R_0 = 0, \widehat{R} = \widehat{I} \Big\},$$

$$\{p_\Pi = 0, p_0 = 1\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 1\}, \quad \{\hat{r}_\Pi = 0, \hat{r}_0 = \widehat{\Pi} - \widehat{I} - \widehat{B}\}.$$

$\mathcal{C}^R$ can be implemented if first period limited liability

$$\Pi \geq \frac{I - (\widehat{\Pi} - \widehat{I} - \widehat{B} - K)(1-\sigma)}{\sigma}$$

and the incentive constraint related to effort provision,

$$\sigma\Pi - I + (\widehat{\Pi} - \widehat{I} - \widehat{B}) - (1-\sigma)K \geq B, \tag{1.4}$$

are satisfied. Then, borrower's utility, denoted U^R, is equal to:

$$U^R = \sigma\Pi - I + (\widehat{\Pi} - \widehat{I}) - K(1-\sigma),$$

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and the lender breaks even in expectation. Finally, the long-term project L is chosen at equilibrium if:

$$\sigma\Pi - I + (\widehat{\Pi} - \widehat{I}) - K(1-\sigma) \geq \Pi_S. \tag{1.5}$$

(ii) *If $\widehat{\Pi} - \widehat{I} - \widehat{B} - K \geq I$, recovery rates allow for the recoupment of the initial investment's value. In this case, the optimal contract, $\mathcal{C}_s^R$, specifies that:*

$$\mathcal{C}_s^R \equiv \{R_\Pi = I, R_\Pi^b = R_0 = R_0^b = 0, \widehat{R} = \widehat{I}\},$$

$$\{p_\Pi = 0, p_0 = 1\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 1\}, \quad \{\hat{r}_\Pi = 0, \hat{r}_0 = I + K\}.$$

$\mathcal{C}_s^R$ can be implemented if the incentive constraint related to effort provision,

$$\sigma(\Pi + K) \geq B,$$

is satisfied. Then, borrower's utility, denoted U_s^R, is equal to:

$$U_s^R = \sigma\Pi - (1-\sigma)K + (\widehat{\Pi} - \widehat{I} - I),$$

and the lender breaks even in expectation. Finally, long-term project L is chosen at equilibrium if:

$$\sigma\Pi - (1-\sigma)K + (\widehat{\Pi} - \widehat{I} - I) \geq \Pi_S.$$

Proof. See Appendix D.

Focusing on the case in which $\widehat{\Pi} - \widehat{I} - \widehat{B} - K < I$,[27] the optimal contract specifies putting the entrepreneur in bankruptcy and verify the project's outcome only if a nil payoff is reported ($p_0 = 1$, $p_\Pi = 0$). Moreover, the entrepreneur never lies at equilibrium, as she communicates to have zero cash only if she is hit by a negative shock.

1.7.3 Bankruptcy, Technological Restructuring and Short-termism

Proposition 2 compares the main features of $\mathcal{C}^{NR}$ and $\mathcal{C}^R$, the optimal contracts presented in Lemma 3 and Lemma 4, respectively.[28] This allows us to study how the short-termism result presented in Proposition 1 fares when the entrepreneur is entitled to implement a project of technological reorganization in bankruptcy.

[27] I discuss this case in more detail because it is the one in which the short-termism result arises in the main model.

[28] Again, notice that I am focusing on the results under $\widehat{\Pi} - \widehat{I} - \widehat{B} - K < I$.

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Proposition 2
With respect to the case with "tough" bankruptcy, "soft" bankruptcy with technological restructuring has three effects:

(*i*) *The utility of the entrepreneur increases,* $U^R > U^{NR}$.

(*ii*) *The contractual payment required in the first period decreases,* $R^R < R^{NR}$.

(*iii*) *There exists a threshold* $\bar{\sigma} < 1$ *such that:*

$$\forall \quad \sigma > \bar{\sigma} \equiv \frac{\widehat{\Pi} - \widehat{I} - \widehat{B} - K}{\widehat{\Pi} - \widehat{I} - K}$$

The incentive constraint related to effort provision is more binding.

Therefore, if σ *lies below* $\bar{\sigma}$*, the long-term project is chosen by the entrepreneur in a setting with "soft" bankruptcy and restructuring.*

A trade-off emerges at equilibrium. The main benefits of "soft" bankruptcy and restructuring are two. The first is that that the value of the long-term project increases at equilibrium and this raises the chances of it being chosen by the entrepreneur. The second is that the first period transfer required by the lender is smaller, because the lender takes into account that in bankruptcy he will extract a positive rent from the second period (through the recovery rates). Consequently, the first period limited liability condition is more likely to hold under "soft" bankruptcy.[29]

However, comparing the expressions of the incentive conditions related to the effort choice evaluated at the optimal contracts, it emerges that, for high values of σ, such constraint is more binding in the case with "soft" bankruptcy and restructuring. In other words, when a nil outcome is less likely to be caused by unfortunate events, that is, if $(1-\sigma) < (1-\bar{\sigma})$, avoiding a "soft" stance in bankruptcy allows for the improvement of entrepreneur's incentives. Instead, for low values of σ the long-term project can be implemented.

Example. I now construct a simple example putting Proposition 2 to work: more specifically, I provide a framework in which the trade-off between the conflicting forces above can lead to inefficient investment decisions.

First of all, the set of critical values of sigma at which the relevant conditions in Lemma 3 and Lemma 4 hold are pinned down.

[29] A third benefit associated to "soft" bankruptcy is that the entrepreneur never lies along the equilibrium path, while in the case with "tough" bankruptcy this happens only if the truth-telling condition is satisfied.

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The values that satisfy the first period limited liability, incentive constraint and truth-telling constraint in the case without "soft" bankruptcy, denoted respectively by σ_{LL}^{NR}, σ_{IC}^{NR}, σ_{TT}^{NR}, are given in what follows:

$$\sigma_{LL}^{NR} \equiv \frac{I}{\Pi} \qquad \sigma_{TT}^{NR} \equiv \frac{I}{\widehat{\Pi} - \widehat{I}} \qquad \sigma_{IC}^{NR} \equiv \frac{B+I}{\widehat{\Pi} - \widehat{I} + \Pi}$$

In particular, if $\sigma \geq \max\{\sigma_{LL}^{NR}, \sigma_{IC}^{NR}, \sigma_{TT}^{NR}\}$ then the long-term project can be undertaken in the case with "tough" bankruptcy.

Instead, the values that satisfy the first period limited liability and incentive constraint in the case with renegotiation and restructuring, denoted respectively by σ_{LL}^{R} and σ_{IC}^{R}, are given in what follows:

$$\sigma_{LL}^{R} \equiv \frac{I - (\widehat{\Pi} - \widehat{I} - \widehat{B} - K)}{\Pi - (\widehat{\Pi} - \widehat{I} - \widehat{B} - K)} \qquad \sigma_{IC}^{R} \equiv \frac{B + I - (\widehat{\Pi} - \widehat{I} - \widehat{B} - K)}{\Pi + K}$$

In this case, project L can be undertaken if $\sigma \geq \max\{\sigma_{LL}^{R}, \sigma_{IC}^{R}\}$.

Without loss of generality, I introduce the following restrictions on the parameters of the model:

$$(a) \quad \widehat{\Pi} - \widehat{I} = \Pi = 2I \qquad (b) \quad B = \widehat{B} \qquad (c) \quad \sigma > 1/2 \qquad (d) \quad \Pi_S = 0$$

Restriction (a) implies that that the expected payoff of the project in the second period is bigger than that of the first period. This is equivalent to assuming that project L is able to generate very high gains only in the long-term. Restriction (b) implies that the moral hazard problem is equally severe in the first and in the second period. Restriction (c) introduces an upper bound to the probability of being hit by an adverse shock, equal to $1 - \sigma$ and restriction (d) implies that the short-term project leads to a nil payoff to the entrepreneur. Moreover, in this setting, for Assumption 2 to hold it must be that $\Pi - B - K > 0$. The following result holds.

Corollary 1

If $2B > \Pi$, "soft" bankruptcy with technological restructuring reduces the scope for the implementation of the long-term project, L.

Proof. See Appendix E.

Corollary 1 shows that the short-termism result holds in this example provided the moral hazard problem is severe enough and conditions (a)-(d) are satisfied (in particular, if the

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probability of the adverse shock is low enough). Indeed, under these conditions, in a non-empty range of values of σ, project L cannot be implemented in the framework with "soft" bankruptcy and technological restructuring, but it can be undertaken in the framework with "tough" bankruptcy. The entrepreneur chooses the short-term project in a legal framework with renegotiation and restructuring, instead it would choose the long-term project (and earn a positive payoff) in the framework without renegotiation and restructuring. Like in the main model, short-temism is caused by the exacerbation of the repeated agency problem.

1.8 Monopoly Lender

In this section, I solve the model in Section 1.4 in a framework with a monopoly lender. In other words, in the following it is assumed that there is no competition on financial markets in the first period, so that the lender is a monopolist to the borrower. Even though this hypothesis is at odds with a major part of the corporate finance literature, this case has a policy relevance because it is consistent with the financial markets' competitive environments of countries like Germany, Italy and the United Kingdom, where banks hold a strong bargaining power vis-à-vis firms.[30]

The twist introduced with respect to the set-up in Section 1.4 consists of assuming that it is the first period lender who holds all the bargaining power and makes a take-it-or-leave-it offer to the entrepreneur at the contracting game stage. The offer consists of a contract that specifies per period expected repayments, termination decisions and type of investment project. The reversal of the bargaining power also implies that the lender squeezes all of the net value of project S, Π_S. Finally, notice that, in bankruptcy, the entrepreneur has access to competitive financial markets when searching for funding in the second period, as in the game of Sub-section 1.4.1.[31]

The result of this extension is analogous to the one with competitive financial markets,

[30] With particular regard to the United Kingdom, this section is able to study the results of a renegotiation environment analogous to the one that characterizes the London Approach, a widespread practice adopted by British firms' management to implement the process of debt reorganization with creditors (typically big banks) out of the court. The London Approach consists in informal negotiations between a distressed entrepreneur and her lenders and it develops in two distinct phases that closely resemble a Chapter 11: in the first, a consortium of investors agree on a "standstill" that relieves the entrepreneur from the obligation to pay back her debts and in the second parties negotiate on a plan of financial restructuring.

[31] This assumption is consistent with the approach followed in Dewatripont and Maskin (1995), which studies a funding game in which first period lender has full bargaining power at the contracting and renegotiation stage, while creditors intervening at the interim stage are left with zero expected surplus.

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even if at the cost of imposing one further assumption on the parameters of the model.

Assumption 3
$\Pi > \widehat{B} > I$.

Assumption 3 implies that the payment required at the end of the first period by the equilibrium contract does not violate the first period limited liability constraint, but is bigger than the initial investment cost, I, thus making bankruptcy a real concern. In the following, I solve for the optimal contracts under full and limited commitment using Assumption 1 and Assumption 3.

1.8.1 Optimal Contract with Full Commitment

Lemma 5 presents the equilibrium project choice under the hypothesis of *full commitment.*

Lemma 5
Denote by $\mathcal{C}^{FC,m}$ the equilibrium contract that implements the long-term investment strategy L under full commitment and monopolistic lending. $\mathcal{C}^{FC,m}$ specifies that:

$$\mathcal{C}^{FC,m} \equiv \{R = \widehat{B}, \widehat{R} = \widehat{\Pi} - \widehat{B}\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 0\}.$$

At $\mathcal{C}^{FC,m}$, lender's utility, denoted $V^{FC,m}$, is equal to:

$$V^{FC,m} = \widehat{\Pi} - \widehat{I} - I > 0.$$

Entrepreneur's utility, $U^{FC,m}$, is equal to Π. Finally, the lender offers $\mathcal{C}^{FC,m}$ to the entrepreneur if and only if:

$$V^{FC,m} = \widehat{\Pi} - \widehat{I} - I \geq \Pi_S. \tag{1.6}$$

The project is started if the entrepreneur accepts.

Proof. See Appendix F.

The value generated by project L to the lender is smaller than in the first best because of the repeated moral hazard problem. Consequently, while under competitive financial markets and full commitment project L is always chosen by the firm if it is implementable, here it is started only if condition (1.6) holds. In other words, the long-term project may not be undertaken, even when it is implementable, when implementation becomes too costly. The rationale for this result is as follows. In Section 1.4, the entrepreneur holds all the bargaining power and therefore, she is able to fully squeeze the net value of the long-term project. Instead, here the lender holds the bargaining power and must take into account entrepreneur's agency rent when assessing long-term project implementability.

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1.8.2 Optimal Contract with Limited Commitment

Under the hypothesis of *limited commitment*, I study how the possibility to renegotiate the contract in an environment characterized by the bankruptcy game presented in Sub-section 1.4.1 affects project's choice.

Proposition 3
Under limited commitment and monopolistic lending, the long-run project L cannot be implemented without violating entrepreneur's incentives.

Proof. See Appendix G.

The relaxation of the disciplining role imparted by the refunding decisions, and the consequent increase of the reward necessary to induce the right incentives, implies that the entrepreneur would not have incentive to divert first period profits only if R is set to a nil value. Clearly, this is not be feasible from the lender's viewpoint, because it would lead to sure losses.

Overall, the result on short-termism derived under competitive financial markets is even reinforced under monopolistic lending: in the competitive benchmark, the long-run project can be undertaken with limited commitment, provided recovery rates are big enough. In this case, the project cannot be implemented independently from recovery rates' value.

1.9 Collaterized Loan and Automatic Stay

In this section, I present the results of the contracting and bankruptcy games of Section 1.6, that is, under limited commitment, when the entrepreneur can pledge collateral, C.[32] More specifically, I assume that C consists of entrepreneur's existing non-project-related wealth[33] and that it can be seized by the lender in case of first period project's failure.

The existence of C affects the implementation of the long-term project L differently depending on whether the procedure entitles the entrepreneur to invoke the *automatic stay* of creditor's claim. If the automatic stay is not contemplated by the bankruptcy law, then the lender can decide either to seize the collateral or to allow for project's continuation in bankruptcy. Instead, if protected by the automatic stay, the entrepreneur has the right to

[32] I follow Tirole (2006), Chapter 4, in the way collateral is modeled.

[33] More concretely, C may consist of wealth that is too illiquid to be invested directly into the project, but can be used as collateral, like an entrepreneur's house or firm's stock holdings in other companies.

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enter unilaterally in bankruptcy and the collateral is added to project's continuation value, so that lender's recovery rates increase.

It has to be remarked that C cannot violate first period limited liability constraint, therefore one must have that the following feasibility condition holds: $C \leq \Pi - R = \Pi - I$.[34]

To begin with, consider the case in which *the procedure does not prescribe the automatic stay* of lender's claim. Then the lender may decide to seize the collateral instead of continuing with the rescue phase in bankruptcy, provided the value of the collateral is bigger than the project's continuation value. Accordingly, the budget constraint would be naturally tightened. Indeed, the truth-telling constraint could be rewritten as in what follows:

$$\Pi - I + \widehat{\Pi} - \widehat{I} \geq \Pi - C.$$

Hence, if the entrepreneur is able to raise an amount of collateral that satisfies the truth-telling condition and the feasibility condition, project L is chosen at equilibrium. The intuition is that, by seizing C, the lender can implement a particularly harsh punishment in case of failure, even harsher than in the full commitment scenario. Remarkably, this type of lender's conduct in failure states is consistent with the evidence in Franks and Sussman (2005), which finds that in the presence of highly collaterized debt a senior lender is more likely to seize the collateral instead of commencing the rescue process.

If *the procedure prescribes the automatic stay*, then the collateral is used by the entrepreneur in addition to the income generated by project's continuation in bankruptcy. Therefore, in this case, the value of $\hat{r}$ increases to $\min\{\widehat{\Pi} - \widehat{I} - \widehat{B} + C, I\}$, so that if the entrepreneur is able to raise C such that $\widehat{\Pi} - \widehat{I} - \widehat{B} + C \geq I$ and the feasibility condition is satisfied, then the truth-telling constraint holds and project L is chosen at equilibrium.

Concluding, in both scenarios collateral increases the scope for the implementation of the long-term project. However, only in the case without automatic stay the "soft budget constraint" problem is fixed, as in that case the lender is entitled to decide whether to seize the collateral and stop project continuation independently from the procedure.

Proposition 4

Under limited commitment, collateral facilitates the choice of the long-term project L. However, the "soft budget constraint" problem is solved thanks to collateral only if the legal procedure does not prescribe the automatic stay of lender's claim.

[34]This condition is obtained by substituting into the limited liability constraint the optimal value of R, which results from a binding lender's participation constraint using the assumption of competitive financial markets.

The result in Proposition 4 is consistent with the findings in the empirical investigation by Berger et al. (forthcoming); there the authors document that the use of collateral is inherently related with lenders' need to fix the problems caused by asymmetric information in the relationship with entrepreneurs. Moreover, the result in Proposition 4 is delivered by focusing on a lender-borrower couple. The analysis could be enriched by looking at a model with multiple lenders and analyzing whether the same results would carry over (see Bolton and Scharfstein (1996) and Berglöf et al. (forthcoming) for frameworks with multiple lenders), but this out of the scope of this Chapter.

1.10 Management Turnover

In this section, I study the effect of the threat of management replacement on the investment choice. It is presented a game in which the lender can write on the financial contract signed at the outset of the game a clause that allows him to substitute the incumbent entrepreneur in case of bankruptcy. In this framework, the *bankruptcy game* played by parties at the intermediate stage is structured as in what follows.

1. *The lender searches for a new entrepreneur and decides whether to fire the old entrepreneur.*

2. The entrepreneur in charge searches for new funds on competitive financial markets.

3. If a new lender is found, this makes an offer to the entrepreneur.

4. In the case of offer acceptance, the old lender must decide either to agree on the continuation plan or reject it. More specifically, such a decision is the outcome of an ultimatum game in which the old lender has all the bargaining power and makes a take-it-or-leave-it offer to the agent. This offer specifies the payoff that the lender requires to allow project continuation and is denoted by $\hat{r}$.

5. If the entrepreneur accepts the old lender's offer, the firm continues its activity and the second period time structure is the same as in case of continuation out of bankruptcy. Otherwise, the firm is shut down and the entrepreneur is dismissed.

The lender has a clear interest in requiring entrepreneurial turnover in the financing contract and then exert the clause if the first period is claimed to generate a nil payoff; this action is efficient because reintroduces a threat that motivates appropriate behavior from the entrepreneur in the first period.

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However, a necessary condition that has to be satisfied for the turnover clause to restore efficiency is that the new entrepreneur in charge must be able to preserve the value of the firm in the second period. Indeed, if the net pledgeable income generated by the new management in the second period would be negative, then, at the interim stage, the lender would not substitute the old entrepreneur. A condition that may impede a profitable turnover in the case of SMEs is that the old entrepreneur holds a know-how that is crucial for the venture to be viable.[35] Instead, as far as managerial firms are concerned, it is important that the market for managers is lively enough for the lender to find a suitable substitute at the bankruptcy stage.

Proposition 5
Under limited commitment and management turnover, if the pledgeable income generated by the firm under the new management is positive, then the threat of management substitution leads to the choice of the long-term project L.

The conclusion of this section is that management turnover has the potential of restoring an efficient investment choice at the cost of hiring a new entrepreneur/manager that is able to preserve distressed firm's viability in the second period. This prediction is consistent with the results of the empirical analysis in Bharath et al. (2007), in which the authors show that management turnover in Chapter 11 has increased since 1990 and that such an increase has been accompanied by the decrease of APR violations in Chapter 11.

1.11 Testable Predictions and Policy Recommendations

The *first* testable prediction of the paper is that, by worsening the agency problem, "soft" bankruptcy systems would generate bigger indirect costs.[36] In particular, this prediction is consistent with the evidence in Franks and Sussman (2005). Franks and Sussman (2005) shows that in the United Kingdom banks commit to a severe stance towards debt renegotiations and it is argued that this is done to avoid strategic default. Consistently with this evidence, in Section 1.6 I have shown that, unless recovery rates are not big enough to allow for the full recoupment of the outstanding liability, then the entrepreneur would always default strategically by reporting a nil payoff at the end of the first period. In Section 1.8, it

[35] See Baird and Rasmussen (2002) for anecdotal evidence on this point.

[36] In this model, I deal with indirect costs because I show that agency costs paid by investors increase when the entrepreneur anticipates a lenient bankruptcy procedure. Direct costs, instead, would comprise of the expenses necessary to carry out the process of reorganization/liquidation. See Senbet and Seward (1995) for a survey over indirect and direct costs of bankruptcy.

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has been shown that the indirect cost to the lender in terms of strategic default may be even larger when the bargaining power is on his side, like in the case of the United Kingdom.[37]

The *second* and major prediction of the paper regards the effect that the limited commitment problem characterizing "soft" procedures has on ex ante investment choices: more specifically, in my model, agency costs increase to generate a bias for short-termism. Important evidence to this finding is provided by Qian and Strahan (2007) and John et al. (2008). The former shows that stronger creditor protection is associated with lower interest rates and longer term lending, the latter finds that stronger creditor protection triggers more value-enhancing investments. Interestingly, coherently with my theoretical analysis and results, John et al. (2008) claims that stronger creditor protection hampers managers' rent extraction behavior and triggers efficient investment choices.

The main result of the model is also consistent with the evidence provided by several empirical studies on the pressure exerted by stake-holders on American corporate executives for the achievement of short-term objectives. More specifically, the survey by Poterba and Summers (1995) shows that American CEOs are perceived to have a time horizon considerably shorter than their competitors in Europe. Also, Poterba and Summers (1995), as well as Blume et al. (1980), provides an estimate of firms' cut-off rates that substantially exceeds the real market discount rate. Finally, Corbett (1987) points to the difference in funded projects' length to show that Anglo-Saxon corporations are subject to a stronger bias towards short-termism than their German and Japanese counterparts.

The message conveyed by this Chapter is that it is the joint rights on the entrepreneur's side (to file unilaterally for bankruptcy, to decide on the firm's restructuring and search for new funds) that exacerbate agency costs. Consequently, those bankruptcy reforms that implement a system which limits the capability of the bankrupt entrepreneur to extract rents from the distressed company during the reorganization phase, like the German one, should be less afflicted by the inefficiencies I highlight. This conclusion is also corroborated by the evidence reported in Bharath et al. (2007), where authors show that management turnover in Chapter 11 has risen by 65% since 1990 and is observed in 37.7% of reorganization cases in 2000. Remarkably, such an increase has been accompanied by the reduction of APR violations in Chapter 11. This piece of evidence bears witnesses to a growing influence exerted by creditors in Chapter 11, at the expenses of the bankrupt management. The section in which the impact of management substitution on investments is analyzed rationalizes these

[37] Franks and Sussman (2005) also shows that in the presence of highly collaterized debt a senior lender is more likely to seize the collateral instead of commencing the rescue process, which is a conduct in line with the outcome of Section 1.9, the extension of the model with collateral.

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results, showing that tightening the termination threat can reduce the indirect costs of "soft" bankruptcy.

A further important policy suggestion I put forward is that the phase of firm's restructuring under court's supervision should be designed to make the entrepreneur work to restore firm's economic viability, because this would alleviate the problem of investments' inefficiency. Indeed, I prove that if financial renegotiation is accompanied by venture's technological restructuring, then the entrepreneur is more likely to choose the long-term project.

1.12 Conclusion

I employ a model with repeated moral hazard in which an entrepreneur can choose between a long-term and a short-term project: the former is more valuable than the latter but is subject to the risk of bankruptcy. Crucially, at the core of the "soft" bankruptcy game I propose is a renegotiation game that gives to the entrepreneur the right to start a process of financial restructuring.

The main insight of the paper is that, under a "soft" procedure, the implementation of the optimal financing contract is subject to a problem of "soft budget constraint" for which the lender is tempted to renegotiate the termination clause and let the entrepreneur continue if recovery rates increase. In a nutshell, the basic mechanism put forward in the benchmark bankruptcy game goes as follows. The "soft" bankruptcy procedure is modeled by requiring the liquidation plan in the financial contract to be sub-game perfect. Thus, the lender cannot commit to liquidating the firm after the non-payment of the initial claim if there is a positive benefit to be captured from second period production. This weakens or eliminates the ability of the contract to solve the moral hazard and truthful revelation problems embedded in the first period production and implies that if there is not sufficient rents in the second period it may be optimal for the entrepreneur to select the short-term project.

I analyze the robustness of the short-termism result, show that it holds in an environment with monopolistic lending and if the law allows the bankrupt entrepreneur to devise a plan of technological restructuring (on top of the one of financial restructuring). In particular, in the extension with bankruptcy and technological restructuring, bankruptcy allows the entrepreneur to undertake a process of economic reorganization after a first period low outcome. Such low outcome can be caused either by opportunistic behavior or by an adverse, exogenous shock. The resulting equilibrium features short-termism when the moral hazard problem is particularly harsh. However, it also features the choice of the efficient investment project if the likelihood of the exogenous shock is high enough. I look at a variant of the main model with collaterized loan, where it is shown that the soft-budget constraint problem may be alleviated when the entrepreneur can pledge collateral, and at one with management turnover, where it emerges that by threatening to substitute the incumbent management the lender can induce the efficient investment choice. The rationale behind both results is that a new punishment device is introduced into the model that compensates the lender for the inefficacy of the refunding decision.

Although not directly related, this model can be employed to understand the possible consequences of the rescue plan decided by main western countries to counteract the financial crisis that affected the international banking system in the fall of 2008. In an effort to inject trust in the financial markets, governments have guaranteed to intervene and protect major banks against the risk of failure. In this Chapter, I highlight that the likely effect of such a lenient policy is to increase the pressure exerted by investors for short-run corporate results, unless it is not accompanied by the turnover of the incumbent management found liable.[38]

[38] Particularly suggestive is the following quotation by the United Kingdom Prime Minister Gordon Brown, commenting on the necessity to introduce stronger regulation concerning banks' management rewarding schemes: "We are leading the world in sweeping away the old short-term bonus culture of the past and replacing it with determination that there are no rewards for failure and rewards only for long-term success". *The Guardian*, 10^{th} February 2009.

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1.13 Appendix A

In this section, I derive the optimal contract that implements the long-term investment project L under the assumption of *full commitment*.

$$\max_{\{R,\widehat{R}\}\{\zeta_\Pi,\zeta_0\}} \Pi - R + \zeta_\Pi(\widehat{\Pi} - \widehat{R})$$

$$\Pi - R + \zeta_\Pi(\widehat{\Pi} - \widehat{R}) \geq \begin{cases} \Pi + \zeta_0(\widehat{\Pi} - \widehat{R}) & (TT) \\ B + \zeta_0(\widehat{\Pi} - \widehat{R}) & (IC) \\ 0 & (ePC) \end{cases}$$

$$R - I + \zeta_\Pi(\widehat{R} - \widehat{I}) \geq 0 \qquad (lPC)$$

$$\Pi - R \geq 0 \qquad (LL_1)$$

$$\widehat{\Pi} - \widehat{R} \geq 0 \qquad (LL_2)$$

$$(\zeta_\Pi, \zeta_0) \in \{0, 1\} \qquad (FC)$$

The entrepreneur maximizes her utility subject to three incentive constraints: the truth-telling constraint (TT), the incentive constraint related to effort provision (IC), and her participation constraint (ePC). Also, the entrepreneur takes into account the lender's participation constraint (lPC), first and second period limited liability constraints, (LL_1) and (LL_2), and the feasibility conditions (FC).

Conditional on project continuation, in the second period, perfect competition drives the repayment required by the lender to $\widehat{I}$, so that $\widehat{R} = \widehat{I}$. This implies that the entrepreneur is the residual claimant and gets the all net present value generated by the project, which is equal to $\widehat{\Pi} - \widehat{I}$.

The optimal contract is completed by first period repayment and lender's refunding decisions. First of all, notice that due to Assumption $1.i$, the only relevant incentive constraint is (TT). Then, financial markets' perfect competition implies that first period repayment, R, is equal to I. Finally, the problem can be simplified by setting $\zeta_0 = 0$ and $\zeta_\Pi = 1$, the entrepreneur is not rewarded if she reveals 0, while she is refunded if she reveals Π: both simplifications improve entrepreneur's incentives, the latter also increases entrepreneur's expected utility. Therefore, at the equilibrium, constraint (TT) can be rewritten as

$$\Pi - I + \widehat{\Pi} - \widehat{I} \geq \Pi \iff \widehat{\Pi} - \widehat{I} - I \geq 0,$$

while the lender earns zero profits. Denote by $\mathcal{C}^{FC}$ the optimal contract that implements strategy L. $\mathcal{C}^{FC}$ is given by:

$$\mathcal{C}^{FC} \equiv \{R = I, \widehat{R} = \widehat{I}\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 0\},$$

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at which entrepreneur's utility is equal to:

$$U^{FC} = \Pi - I + \widehat{\Pi} - \widehat{I} > 0.$$

In order to implement L, the entrepreneur offers $\mathcal{C}^{FC}$ to the lender, and, if $\widehat{\Pi} - \widehat{I} - I \geq 0$ and the latter accepts the deal, the project is started. ■

1.14 Appendix B

The optimization problem is as in what follows.

$$\max_{\{R,\widehat{R}\}\{\zeta_\Pi,\zeta_0\}} \quad \Pi - R + \zeta_\Pi(\widehat{\Pi} - \widehat{R})$$

$$\Pi - R + \zeta_\Pi(\widehat{\Pi} - \widehat{R}) \geq \begin{cases} \Pi + \zeta_0(\widehat{\Pi} - \widehat{R}) - \hat{r} & (TT) \\ B + \zeta_0(\widehat{\Pi} - \widehat{R}) - \hat{r} & (IC) \\ 0 & (ePC) \end{cases}$$

$$R - I + \zeta_\Pi(\widehat{R} - \widehat{I}) \geq 0 \qquad (lPC)$$

$$\Pi - R \geq 0 \qquad (LL_1)$$

$$\widehat{\Pi} - \widehat{R} \geq 0 \qquad (LL_2)$$

$$(\zeta_\Pi, \zeta_0) \in \{0, 1\} \qquad (FC)$$

To begin with, $\hat{r}$ reduces the rent that the entrepreneur obtains when she reveals a nil payoff and the firm is in bankruptcy. Then, two scenarios must be distinguished. If the entrepreneur reveals Π, she is not in bankruptcy and, by perfect competition, the required payment in the second period, $\widehat{R}$, is equal to $\widehat{I}$.

If the firm is in bankruptcy, the game presented in Sub-section 1.4.1 takes place. More specifically, if the entrepreneur finds a new lender, this makes her an offer at which the entrepreneur is residual claimant and the new lender breaks even in expectation. Consequently, conditional on offer acceptance, second period expected pledgeable income is equal to $\widehat{\Pi} - \widehat{I} - \widehat{B} > 0$. However, before the project is implemented, the old lender must agree on continuation.

The old lender has monopoly power in the ultimatum game with the entrepreneur: he makes her an offer consisting in the value of $\hat{r}$ required to allow continuation. In particular, the initial lender asks at least the minimum value between the pledgeable income of the project and the value of the outstanding liability, that is, the old lender offers either $\hat{r} >$

$\min\{\widehat{\Pi}-\widehat{I}-\widehat{B},I\}$ or $\hat{r}=\min\{\widehat{\Pi}-\widehat{I}-\widehat{B},I\}$. In the former case, the lender would implicitly enforce the ex ante optimal contract, because the entrepreneur would not be able to repay and parties' payoffs would be zero at the end of bargaining. In the latter case, the offer is feasible and would permit the old lender to improve recovery rates.

At the SPE of the bargaining game, the old lender asks for $\hat{r}=\min\{\widehat{\Pi}-\widehat{I}-\widehat{B},I\}$ and the entrepreneur accepts. Consequently, recovery rates increase and the refunding decisions, $\{\zeta_\Pi,\zeta_0\}$, become ineffective (that is, $\zeta_\Pi=\zeta_0=1$). Using the results derived so far, the truth-telling constraint can be rewritten as:

$$\Pi-I+(\widehat{\Pi}-\widehat{I})\geq\Pi+(\widehat{\Pi}-\widehat{I})-\min\{\widehat{\Pi}-\widehat{I}-\widehat{B},I\},$$

Hence, one has that:

i. If $\widehat{\Pi}-\widehat{I}-\widehat{B}<I$, project S is chosen by the entrepreneur, because the truth-telling constraint is not satisfied.

ii. If $\widehat{\Pi}-\widehat{I}-\widehat{B}\geq I$, the entrepreneur offers $\mathcal{C}^{LC}$ to the lender.

$$\mathcal{C}^{LC}\equiv\{R=I,\widehat{R}=\widehat{I},\hat{r}=I\},\quad\{\zeta_\Pi=1,\zeta_0=1\}.$$

Borrower's utility under $\mathcal{C}^{LC}$, denoted U^{LC}, is:

$$U^{LC}=\Pi-I+\widehat{\Pi}-\widehat{I}>0$$

and the lender breaks even in expectation. Finally, if the lender accepts the offer, project L is started. ■

1.15 Appendix C

The optimization problem follows.

$$\max_{\{R,\widehat{R}\}\{\zeta_\Pi,\zeta_0\}}\quad\sigma[\Pi-R+\zeta_\Pi(\widehat{\Pi}-\widehat{R})]$$

$$\sigma[\Pi-R+\zeta_\Pi(\widehat{\Pi}-\widehat{R})]\geq\begin{cases}\sigma[\Pi+\zeta_0(\widehat{\Pi}-\widehat{R})] & (TT)\\ B & (IC)\\ 0 & (ePC)\end{cases}$$

$$\sigma R-I+\sigma\zeta_\Pi(\widehat{R}-\widehat{I})\geq 0\qquad(lPC)$$

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$$\Pi - R \geq 0 \qquad (LL_1)$$

$$\widehat{\Pi} - \widehat{R} \geq 0 \qquad (LL_2)$$

$$(\zeta_\Pi, \zeta_0) \in \{0, 1\} \qquad (FC)$$

First of all, perfect competition on financial markets implies that the payment required in the second period is equal to $\widehat{I}$. Moreover, as for Lemma 1, the refunding decision in case of success and no adverse shock is equal to one, while the refunding decision associated to a nil outcome is equal to zero. Then, lender's zero profit condition implies that first period transfer is equal to I/σ. Consequently, (TT), (IC) and (LL_1) can be rewritten, as:

$$\begin{aligned} \sigma(\widehat{\Pi} - \widehat{I}) - I &\geq 0 \qquad (TT) \\ \sigma\Pi - I + \sigma(\widehat{\Pi} - \widehat{I}) &\geq B \qquad (IC) \\ \sigma\Pi - I &\geq 0 \qquad (LL_1) \end{aligned}$$

Denote by $\mathcal{C}^{NR}$ the optimal contract that implements strategy L in the case without bankruptcy and technological restructuring. $\mathcal{C}^{NR}$ is given by:

$$\mathcal{C}^{NR} \equiv \{R = R^{NR} \equiv I/\sigma, \widehat{R} = \widehat{I}\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 0\},$$

at which entrepreneur's utility is equal to:

$$U^{NR} = \sigma\Pi - I + \sigma(\widehat{\Pi} - \widehat{I}).$$

Provided the limited liability condition, the incentive constraint and the truth-telling constraint are satisfied, the entrepreneur offers $\mathcal{C}^{NR}$ to the lender, and project L is started if

$$\sigma\Pi - I + \sigma(\widehat{\Pi} - \widehat{I}) \geq \Pi_S.$$

■

1.16 Appendix D

In this section, I derive the optimal contract that implements the long-run investment project L in the case with bankruptcy and technological restructuring. The optimization program is given by

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$$\max_{\{R^b_\Pi, R^b_0\},\{R_\Pi,R_0\},\{p_\Pi,p_0\},\{\zeta_\Pi,\zeta_0\},\widehat{R}} \sigma[\Pi - p_\Pi(R^b_\Pi + \zeta_\Pi \hat{r}_\Pi) - (1-p_\Pi)R_\Pi]+$$
$$+ (1-\sigma)[-p_0(R^b_0 + \zeta_0 \hat{r}_0) - (1-p_0)R_0] + [\sigma\zeta_\Pi + (1-\sigma)\zeta_0](\widehat{\Pi} - \widehat{R}).$$

$$\sigma[\Pi - p_\Pi(R^b_\Pi + \zeta_\Pi \hat{r}_\Pi) - (1-p_\Pi)R_\Pi] + (1-\sigma)[-p_0(R^b_0 + \zeta_0 \hat{r}_0) - (1-p_0)R_0] +$$
$$+[\sigma\zeta_\Pi + (1-\sigma)\zeta_0](\widehat{\Pi} - \widehat{R}) \geq \begin{cases} B - p_0(R^b_0 + \zeta_0 \hat{r}_0) - (1-p_0)R_0 + \zeta_0(\widehat{\Pi} - \widehat{R}) & (IC_1) \\ 0 & (ePC) \end{cases}$$

$$\sigma[p_\Pi(R^b_\Pi + \zeta_\Pi \hat{r}_\Pi - K) + (1-p_\Pi)R_\Pi] + (1-\sigma)[p_0(R^b_0 + \zeta_0 \hat{r}_0 - K) + (1-p_0)R_0] + [\sigma\zeta_\Pi + (1-\sigma)\zeta_0](\widehat{R} - \widehat{I}) \geq I \qquad (lPC)$$

$$\begin{cases} R^b_\Pi \leq R_0 \quad \forall (p_\Pi = 1, p_0 = 0), \quad R^b_0 \leq R_\Pi \quad \forall (p_0 = 1, p_\Pi = 0) \\ R_\Pi = R_0 = R \quad \text{if} \quad p_\Pi = p_0 = 0 \end{cases} \qquad (IC_2)$$

$$\begin{cases} \Pi - R_\Pi \geq 0 & R_0 \leq 0 \\ \Pi - R^b_\Pi \geq 0 & R^b_0 \leq 0 \end{cases} \qquad (LL_1)$$

$$\widehat{\Pi} - \widehat{R} \geq 0 \qquad (LL_2)$$

$$(\zeta_\Pi, \zeta_0) \in \{0, 1\}$$

$$(p_\Pi, p_0) \in \{0, 1\}$$

K is the cost that must be sunk to retrieve the true outcome in bankruptcy and the couple (p_Π, p_0) determines the bankruptcy policy: if $p_j = 1$, with $j = \Pi, 0$, then the contract requires that the firm is put in bankruptcy and the true outcome is monitored at the cost K. R^b_Π, $\hat{r}_\Pi$, R^b_0 and $\hat{r}_0$ characterize the payments and recovery rates required in bankruptcy as function of the first period outcome, while R_Π and R_0 denote the payments required out of bankruptcy.

First of all, I can rewrite the problem setting $\zeta_\Pi = \zeta_0 = 1$, as in Section 1.6.[39]

Moreover, all transfers must satisfy first and second period limited liability conditions. However, with respect to the problem in Section 1.6, I also need to take into account the set of incentive compatibility constraints (IC_2). These make sure that the transfers required out of bankruptcy do not depend on the revealed outcome, otherwise the entrepreneur would lie as to avoid the bigger repayment. Similarly, the payments required in bankruptcy must be smaller than those out of bankruptcy, otherwise the entrepreneur would report the outcome that entails a lower repayment.

[39] In Section 1.6, I prove that, in absence of commitment, the assumption of second period positive pledgeable income implies that the refunding decisions play no role whatsoever.

In case a nil outcome is reported, the firm is always put in bankruptcy ($p_0 = 1$), and verification costs K paid by the lender, because otherwise the entrepreneur would claim to have zero cash and repay nothing. Conversely, the optimal contract must feature $p_\Pi = 0$: if the outcome is high, the entrepreneur can repay the amount specified in the contract (provided limited liability is satisfied).

Then, before solving for the optimal contractual payments, together with the bankruptcy policy that makes sure that the true outcome is revealed by the entrepreneur, I can make a number of simplifications. By invoking the assumption of perfectly competitive financial markets, I can set $\widehat{R} = \widehat{I}$ and (lPC) binding, moreover, (LL_1) implies that $R_0 = R_0^b = 0$.

As for $\hat{r}_0$, in analogy to Section 1.6, this is given by $\min\{\widehat{\Pi} - \widehat{I} - \widehat{B}, I + K\}$: at the bargaining game with the entrepreneur, the old lender formulates an offer at which he gets the minimum between the full value of the project in the second period and the allotment invested to start the project and verify the true state. Finally, denote by $R^R = R_\Pi$ the value that solves a binding (lPC).

In what follows, I first present the case in which recovery rates (net of K) are smaller than first period investment's value I, then the one in which recovery rates in bankruptcy allow to fully recoup I.

Case $\hat{r}_0 < I + K$

If $\hat{r}_0 = \widehat{\Pi} - \widehat{I} - \widehat{B} < I + K$, the lender breaks even in expectation if:

$$R^R = \frac{I - (\widehat{\Pi} - \widehat{I} - \widehat{B} - K)(1-\sigma)}{\sigma} > I.$$

Using the results I have derived so far, condition (IC_1) can be written as:

$$\sigma\Pi - I + (\widehat{\Pi} - \widehat{I} - \widehat{B}) - (1-\sigma)K \geq B$$

Denote by $\mathcal{C}^R$ the optimal contract that implements strategy L in the case with bankruptcy and technological restructuring. $\mathcal{C}^R$ is given by:

$$\mathcal{C}^R \equiv \Big\{R_\Pi = R^R \equiv \frac{I - (\widehat{\Pi} - \widehat{I} - \widehat{B} - K)(1-\sigma)}{\sigma}, R_\Pi^b = R_0^b = R_0 = 0, \widehat{R} = \widehat{I}\Big\},$$

$$\{p_\Pi = 0, p_0 = 1\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 1\}, \quad \{\hat{r}_\Pi = 0, \hat{r}_0 = \widehat{\Pi} - \widehat{I} - \widehat{B}\}.$$

$\mathcal{C}^R$ can be implemented if first period limited liability,

$$\Pi \geq \frac{I - (\widehat{\Pi} - \widehat{I} - \widehat{B} - K)(1-\sigma)}{\sigma},$$

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and the incentive constraint related to effort provision,

$$\sigma\Pi - I + (\widehat{\Pi} - \widehat{I} - \widehat{B}) - (1-\sigma)K \geq B,$$

are satisfied. Then, borrower's utility, denoted U^R, is equal to:

$$U^R = \sigma\Pi - I + (\widehat{\Pi} - \widehat{I}) - K(1-\sigma).$$

The lender breaks even in expectation. Finally, the entrepreneur offers $\mathcal{C}^R$ to the lender and the long-run project L is started if:

$$\sigma\Pi - I + (\widehat{\Pi} - \widehat{I}) - K(1-\sigma) \geq \Pi_S.$$

Case $\hat{r}_0 = I + K$

If $\hat{r}_0 = I + K \geq \widehat{\Pi} - \widehat{I} - \widehat{B}$, the optimal contract is given by

$$\mathcal{C}_s^R \equiv \{R_\Pi = I, R_\Pi^b = R_0 = R_0^b = 0, \widehat{R} = \widehat{I}\},$$

$$\{p_\Pi = 0, p_0 = 1\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 1\}, \quad \{\hat{r}_\Pi = 0, \hat{r}_0 = I + K\}.$$

$\mathcal{C}_s^R$ can be implemented if the incentive constraint related to effort provision,

$$\sigma(\Pi + K) \geq B,$$

is satisfied. Then, borrower's utility, denoted U_s^R, is equal to:

$$U_s^R = \sigma\Pi - I + (\widehat{\Pi} - \widehat{I}) - (1-\sigma)K.$$

and the lender breaks even in expectation. Finally, the entrepreneur offers $\mathcal{C}_s^R$ to the lender, and the long-run project L is started if:

$$\sigma\Pi - (1-\sigma)K + (\widehat{\Pi} - \widehat{I} - I) \geq \Pi_S.$$

■

1.17 Appendix E

In this section, I want to show that in a non-empty range of values of σ, the implementation of the long-run project is put at risk by renegotiation in bankruptcy.

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First of all, by using restrictions $(a)-(c)$, one can easily show that $\sigma_{LL}^{NR}=\sigma_{TT}^{NR}=1/2>\sigma_{LL}^{R}$. In other words, the truth-telling constraint and the limited liability condition hold in the case with "tough" bankruptcy, as well as the limited liability condition in the case with "soft" bankruptcy and restructuring. Then, the only relevant conditions are the incentive constraints.

The value of σ_{IC}^{NR} and σ_{IC}^{R} lies above 1/2 under the conditions set up in Corollary 1. Indeed, if $\Pi<2B$, then $\sigma_{IC}^{NR}>1/2$ and $\sigma_{IC}^{R}>1/2$. Finally, I need to show under which condition $\sigma_{IC}^{R}\geq\sigma_{IC}^{NR}$:[40]

$$\sigma_{IC}^{R}=\frac{2B+K-\frac{\Pi}{2}}{\Pi+K}>\frac{B+\frac{\Pi}{2}}{2\Pi}=\sigma_{IC}^{NR}.$$

Solving for such inequality, one has that:

$$\begin{aligned}
2\Pi(B+\Pi/2)+2\Pi(K-\Pi+B) &> (\Pi+K)(B+\Pi/2)\Rightarrow\\
2\Pi(K-\Pi+B) &> (K-\Pi)(B+\Pi/2)\Rightarrow\\
(\Pi-K)(B+\Pi/2) &> 2\Pi(\Pi-K)-2\Pi B\Rightarrow\\
(\Pi-K)(3\Pi/2-B) &< 2\Pi B\Rightarrow\\
\Pi(3\Pi/2-3B) &< K(3\Pi/2-B)
\end{aligned}$$

The left-hand side of the last inequality is negative if $\Pi<2B$, which completes the proof of Corollary 1. ■

1.18 Appendix F

In this section, I derive the optimal contract that implements the long-run investment project L under the assumption of *full commitment* and monopolistic lending.

$$\max_{\{R,\widehat{R}\}\{\zeta_\Pi,\zeta_0\}} R-I+\zeta_\Pi(\widehat{R}-\widehat{I})$$

$$\Pi-R+\zeta_\Pi(\widehat{\Pi}-\widehat{R})\geq\begin{cases}\Pi+\zeta_0(\widehat{\Pi}-\widehat{R}) & (TT)\\ B+\zeta_0(\widehat{\Pi}-\widehat{R}) & (IC)\\ 0 & (ePC)\end{cases}$$

$$R-I+\zeta_\Pi(\widehat{R}-\widehat{I})\geq 0 \qquad (lPC)$$

$$\Pi-R\geq 0 \qquad (LL_1)$$

[40] Also, $\sigma_{IC}^{NR}<1$ (given that $\Pi>B$ by Assumption 1), while σ_{IC}^{R} may be bigger than 1 if $\Pi<4B/3$.

$$\widehat{\Pi} - \widehat{R} \geq 0 \qquad (LL_2)$$

$$(\zeta_\Pi, \zeta_0) \in \{0, 1\} \qquad (FC)$$

If the entrepreneur is solvent in the first period, in the second period the lender rewards her with $\widehat{B}$, as to induce effort and extract $\widehat{R} - \widehat{I} = \widehat{\Pi} - \widehat{I} - \widehat{B}$. Conversely, if insolvent in the first period, the entrepreneur is put in liquidation.

By Assumption 1.i, the only relevant incentive constraint is (TT), moreover, this constraint is binding at equilibrium, otherwise the lender could always profitably increase R without violating (TT). As in Appendix A, then, one can set $\zeta_0 = 0$ and $\zeta_\Pi = 1$ and consequently have that $R = \widehat{B} > I$. The optimal contract, denoted $\mathcal{C}^{FC,m}$, follows:

$$\mathcal{C}^{FC,m} \equiv \{R = \widehat{B}, \widehat{R} = \widehat{\Pi} - \widehat{B}\}, \quad \{\zeta_\Pi = 1, \zeta_0 = 0\}.$$

Lender's utility, given by project L pledgeable income, and denoted by $V^{FC,m}$, is equal to:

$$V^{FC,m} = \widehat{\Pi} - \widehat{I} - I > 0.$$

Entrepreneur's utility, $U^{FC,m}$, amounts to Π. Therefore, at equilibrium, if $V^{FC,m} > \Pi_S$ the lender offers $\mathcal{C}^{FC,m}$ to the entrepreneur and the long-term project is started if the entrepreneur accepts. ■

1.19 Appendix G

The optimization problem is the same as in Lemma 5. If the entrepreneur is solvent at the end of the first period, the reward that the old lender promises to the entrepreneur in the second period is equal to $\widehat{B}$. In this way, he induces effort and generates $\widehat{\Pi} - \widehat{I} - \widehat{B}$. In case of bankruptcy, instead, the renegotiation game presented in Sub-section 1.4.1 takes place. If the entrepreneur finds a new lender, the assumption of competitive financial markets in the renegotiation phase drives new lenders' expected surplus to zero, while makes the entrepreneur the residual claimant. Therefore, second period expected pledgeable income in bankruptcy is the same as out of bankruptcy and equal to $\widehat{\Pi} - \widehat{B} - \widehat{I} > 0$.

Before the project is implemented, the old investor must agree on continuation. The old lender has monopoly power in the ultimatum game with the agent and makes an offer to the firm consisting in the value of $\hat{r}$ required to allow continuation. More specifically, the old lender can offer either $\hat{r} > \widehat{\Pi} - \widehat{I} - \widehat{B}$ or $\hat{r} = \widehat{\Pi} - \widehat{I} - \widehat{B}$. In the former case, the lender would implicitly enforce the ex ante optimal contract, because the entrepreneur would not be able to repay. In the latter case, the offer is feasible and would permit the old lender to improve recovery rates. At the SPE of this game, the old lender asks for $\hat{r} = \widehat{\Pi} - \widehat{B} - \widehat{I}$, which is what he would have been able to extract from the project in case of refunding, and the entrepreneur accepts. Consequently, the refunding decisions, $\{\zeta_\Pi, \zeta_0\}$, become ineffective and the problem solved at the contracting stage by the entrepreneur can be written as in the following.

$$\max_R R - I + \widehat{\Pi} - \widehat{I} - \widehat{B}$$

$$\Pi - R + \widehat{B} = \Pi + \widehat{B} \qquad (TT)$$

$$R - I + \widehat{\Pi} - \widehat{I} - \widehat{B} \geq 0 \qquad (lPC)$$

$$\Pi - R \geq 0 \qquad (LL_1)$$

Clearly, a binding (TT) is violated at any strictly positive value of the first period repayment, R. ■

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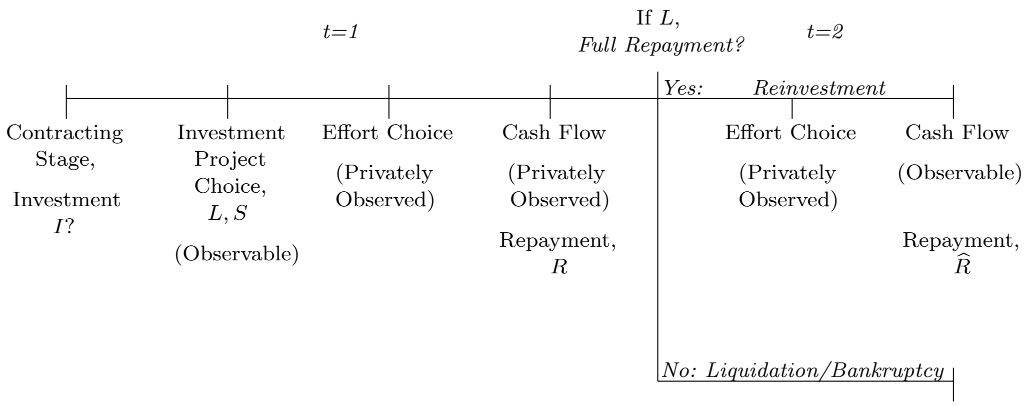
1.20 Figures

Figure 1.1: Timeline and Cash Flow



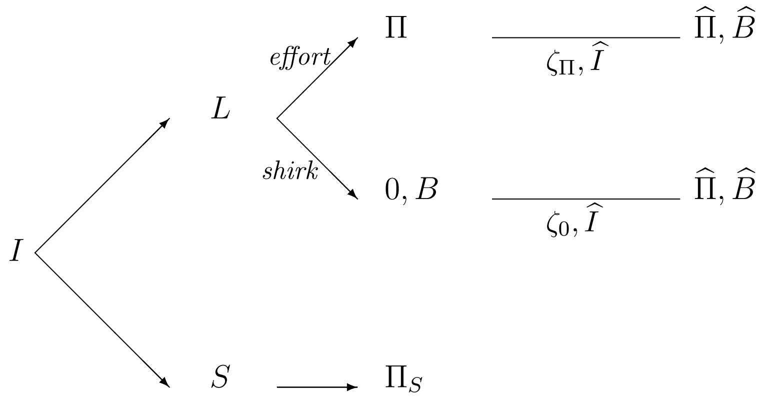


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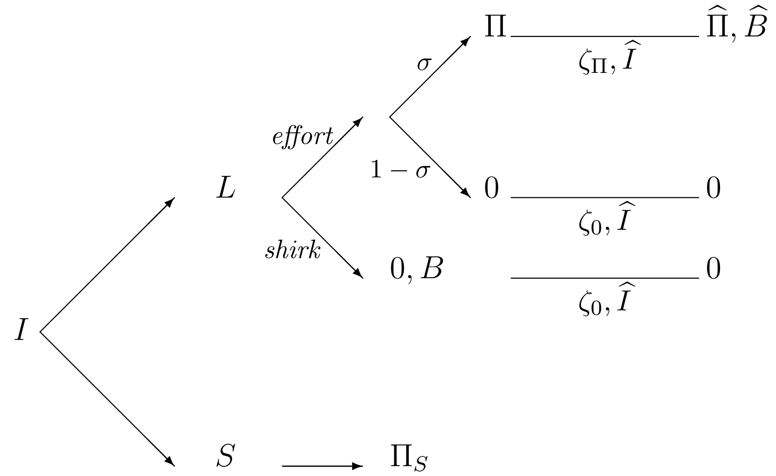
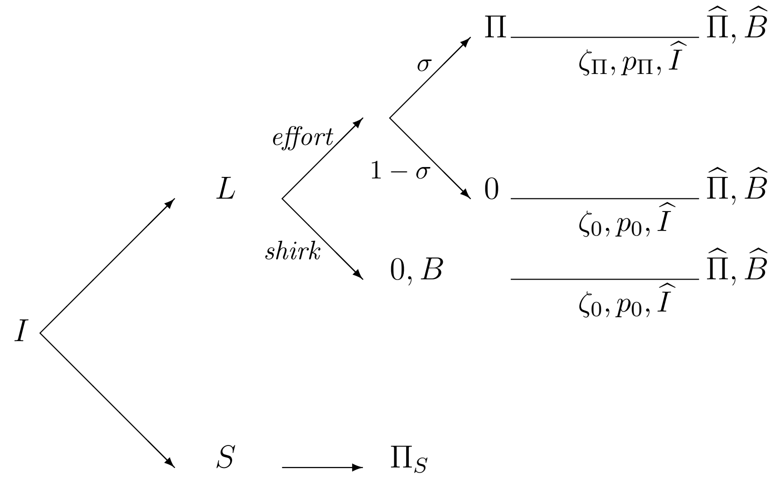
Figure 1.2: Model with “Soft” Bankruptcy and Restructuring, Cash Flows

Cahs Flow Without Bankruptcy and Restructuring



Cahs Flow With Bankruptcy and Restructuring



Tarantino, Emanuele (2010), Three Essays in Industrial Organization and Corporate Finance
European University Institute DOI: 10.2870/23062

Bibliography

[1] Acharya, Viral V., and Krishnamurthy Subramanian, 2009, Bankruptcy Codes and Innovation, *Review of Financial Studies*, 22(12), 4949-4988.

[2] Baird, Douglas G. and Robert K. Rasmussen, 2002, The End of Bankruptcy, *Stanford Law Review*, Vol. 55.

[3] Baliga, Sandeep, and Ben Polak, 2004, The Emergence and Persistence of the Anglo-Saxon and German Financial Systems, *Review of Financial Studies*, 17(1), 129-163.

[4] Bebchuk, Lucian A., 2002, Ex Ante Costs of Violating Absolute Priority in Bankruptcy, *Journal of Finance*, 57(1), 445-460.

[5] Berger, Allen N., Marco A. Espinosa-Vega, W. Scott Frame, and Nathan H. Miller, forthcoming, Why Do Borrowers Pledge Collateral? New Empirical Evidence on the Role of Asymmetric Information, *Journal of Financial Intermediation.*

[6] Berglöf, Erik, Gerard Roland, and Ernst Ludwig von Thadden, forthcoming, The Design of Corporate Debt Structure and Bankruptcy, *Review of Financial Studies.*

[7] Bharath, Sreedhar T., Venky Panchapegesan, and Ingrid Werner, 2007, The Changing Nature of Chapter 11, *Fisher College Business Working Paper*, No. 2008-03-003.

[8] Biais, Bruno, and Thomas Mariotti, 2009, Credit, Wages and Bankruptcy Laws, *Journal of European Economic Association*, 7(5), 939-973.

[9] Blume, Marshall E., Irwin Friend, and Randolph Westerfield, 1980, "Impediments to Capital Formation", *Rodney L. White Center for Financial Research Working Paper*, University of Pennsylvania, Dec. 1982 and Dec. 1984.

[10] Bolton, Patrick, and Mathias Dewatripont, 2005, *Contract Theory* (The MIT Press, Cambridge, MA).

Tarantino, Emanuele (2010), Three Essays in Industrial Organization and Corporate Finance
European University Institute DOI: 10.2870/23062

[11] Bolton, Patrick, and David S. Scharfstein, 1990, A Theory of Predation Based on Agency Problems in Financial Contracting, *American Economic Review*, 80(1), 93-106.

[12] Bolton, Patrick, and David S. Scharfstein, 1996, Optimal Debt Structure and the Number of Creditors, *Journal of Political Economy*, 104(1), 1-25.

[13] Brouwer, Maria, 2006, Reorganization in US and European Bankruptcy Law, *European Journal of Law and Economics*, 22, 5-20.

[14] Corbett, Jenny, 1987, International Perspectives on Financing: Evidence from Japan, *Oxford review of Econornic Policy*, 3, 30-55.

[15] Daihya, Sandeep, Kose John, Manju Puri, and Gabriel G. Ramirez, 2003, Debtor-in-possession Financing and Bankruptcy Resolution: Empirical Evidence, *Journal of Financial Economics*, 69(1), 259-280.

[16] Davydenko, Sergei A., and Julian R. Franks, 2008, Do Bankruptcy Codes Matter? A Study of Defaults in France, Germany and the UK, *Journal of Finance*, 63(2), 565-608.

[17] Dewatripont, Mathias, and Eric Maskin, 1995, Credit and Efficiency in Centralized and Decentralized Economies, *Review of Economic Studies*, 62(4), 541-555.

[18] Diamond, Douglas W., 2004, Committing to Commit: Short-term Debt when Enforcement is Costly, *Journal of Finance*, 59(4), 1447-1480.

[19] Franks, Julian R., and Oren Sussman, 2005, Financial Distress and Bank Restructuring of Small to Medium Size UK Companies, *Review of Finance*, 9, 65-96.

[20] Fudenberg, Drew, and Jean Tirole, 1990, Moral Hazard and Renegotiation in Agency Contracts, *Econometrica*, 58, 1279-1320.

[21] Gale, Douglas, and Martin F. Hellwig, 1985, Incentive-Compatible Debt Contracts: The One Period Problem, *Review of Economic Studies*, 52, 647-663.

[22] Gale, Douglas, and Martin F. Hellwig, 1989, Repudiation and Renegotiation: the Case of Sovereign Debt, *International Economic Review*, 30(1), 3-31.

[23] Gertner, Robert, and David S. Scharfstein, 1991, A Theory of Workouts and the Effects of Reorganizational Law, *Journal of Finance*, 46(4), 1189-1222.

[24] Gromb, Dennis, 1994, Renegotiation in Debt Contracts, mimeo.

[25] Hart, Oliver, 1995, *Firms, Contracts, and Financial Structure* (Oxford University Press, Oxford, UK).

[26] Holmström, Bengt, and Jean Tirole, 1997, Financial Intermediation, Loanable Funds, and the Real Sector, *Quarterly Journal of Economics*, 112(3), 663-691.

[27] John, Kose, Lubomir Litov, and Bernard Yeung, 2008, Corporate Governance and Risk-Taking, *Journal of Finance*, 63(4), 1679-1728.

[28] Kornai, Janos, Eric Maskin, and Gerard Roland, 2003, Understanding the Soft Budget Constraint, *Journal of Economic Literature*, 41(4), 1095-1136.

[29] Landier, Augustin, 2006, Entrepreneurship and the Stigma of Failure, *Stern School of Business Working Paper*, New York University.

[30] Poterba, James M., Lawrence H. Summers, 1995, A CEO Survey of U.S. Companies, Time Horizons, and Hurdle Rates, *Sloan Management Review*, 37, 43-53.

[31] Qian, Jun, Philip E. Strahan, 2007, How law and institutions shape financial contracts: The case of bank loans, *Journal of Finance*, 62(6), 2803-2834.

[32] Senbet, Lemma W., and James Seward, 1995, Financial Distress, Bankruptcy and Reorganizatio, in Robert Jarrow, Vojislav Maksimovic, and William T. Ziemba, ed.: *Finance* (Elsevier Science, New York).

[33] Stanghellini, Lorenzo, 2008, *Le Crisi di Impresa tra Diritto ed Economia*, (Il Mulino, Bologna).

[34] von Thadden, Ernst Ludwig, 1995, Long-term Contracts, Short-term Investment and Monitoring, *Review of Economic Studies*, 62(4), 557-575.

[35] Tirole, Jean, 2006, *The Theory of Corporate Finance* (Princeton University Press, Princeton and Oxford).

[36] White, Michelle J., 1994, Corporate Bankruptcy as a Filtering Device: Chapter 11 Reorganizations and Out-of-Court Debt Restructuring, *Journal of Law, Economics, and Organization*, 10(2), 268-295.

[37] White, Michelle J., 2005, Bankruptcy Law, in Mitchell A. Polinski and Steven Shavell, ed.: *Handbook of Law and Economics* (Elsevier).

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Chapter 2

Technology Adoption in Standard Setting Organizations: A Model of Exclusion with Complementary Inputs and Hold-up

2.1 Introduction

Voluntary Standard Setting Organizations (SSOs) are consortia of industry operators devoted to the achievement of an agreement on the rules that define the design of a final product or process. The theoretical literature has recently increased its attention towards the functioning of standard setting bodies (see Lerner and Tirole (2006), Choi et al. (2007), and Farrell and Simcoe (2009)), and the empirical work by Rysman and Simcoe (2008) confirms their relevance by showing that they play a crucial role in leading to a bandwagon process among adopters.[1]

The SSOs tend to emphasize the consensus that would characterize their decisions. However, strategic considerations among their participants can be intense and several pieces of evidence show that strong competitive tensions influence the procedure of standard choice, eventually leading to judicial disputes. These disputes mainly arise from the conflicting interests that operators with different business structures try to put forward in the process of standard certification (see Sherry and Teece (2003), DeLacey et al. (2006), Feldman et al.

[1] Rysman and Simcoe (2008) documents that patents disclosed in SSOs receive up to twice as many citations as other patents in the same sector.

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(2009) and Schmalensee (2009)).

This Chapter focuses on the conflict between two categories of firms: vertically integrated operators (like IBM and Nokia), which dominate many standard setting consortia, and pure developers of new technologies (like Rambus and Qualcomm). These firms participate to SSOs with strikingly different objectives. Integrated organizations mostly aim at the important economic benefits that derive from coordination among industry participants. Consequently, they have a clear interest in paying low rates for standard's technologies while competing on the product market. Instead, IPR developers raise most of their revenue from the technology licensing market. They are primarily interested in having a patented technology into a new standard, because this can help them raise a long stream of licensing revenue.

I propose a framework to analyze the incentives that firms in SSOs have to employ patented technologies into their production process. The issue is addressed by studying how market competition and licensing decisions interact with technology adoption. Consequently, the model encompasses two markets: the technology licensing market (or upstream market) and the product market (or downstream market). Moreover, I conduct a welfare analysis to assess the adoption choices that would maximize total welfare.

The game involves two vertically integrated firms and a pure upstream firm. Each firm holds a patented technology; the first vertically integrated firm holds an "essential" technology, whilst the second integrated firm holds a technology that competes with the one of the upstream firm for the employment in the production of a final good. To make the conflict between these two firms more interesting, it is assumed that the technology of the pure innovator is more efficient.

I do not impose that the use of the same bundle of inputs, or technology platform, is mandatory to industry's participants. Thus, two types of scenario can arise from the adoption decision: either operators agree on the employment of the same platform ("technology standard" case), or they decide to use different platforms ("competing platforms" case). The latter outcome captures a situation in which the standardization effort fails and is far from being purely theoretical, because multiple technologies can coexist, for instance, when users' network externalities are not particularly strong.[2]

Like in most SSOs, in the model licensing takes place after the adoption of a certain technology by industry's operators in their production process; thus a standard hold-up problem arises. To fix the contractual inefficiency caused by the hold-up problem, vertically

[2] An important example is the wireless telephony, where handsets based on different chips' technologies are marketed (Gandal et al. (2003)).

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integrated firms can exchange respective technologies by signing cross-licensing agreements. However, these deals are not possible with the pure upstream firm, because it is not active on the product market. Accordingly, the results of the welfare analysis are affected by the balance between the efficiency of the upstream firm's technology and the inefficiency that characterizes its licensing contracts.

The trade-off that determines manufacturers' choice to use the technology of the stand-alone firm and the outcome of the welfare analysis is as in what follows. *On the one hand, the employment of the independent upstream firm's input allows integrated companies to use a more efficient technology for the production of the final good. On the other hand, it allows the stand-alone firm to exploit monopoly bargaining power over its patented technology (because of the hold-up problem).*

The model delivers the pattern of integrated firms' *technology adoption* as function of two parameters: the one that measures the efficiency of the independent licensor's technology and the one that captures the cost-savings generated by SSO's support of a unique standard. More specifically, if the benefits generated by standardization are large, then vertically integrated firms cross-license their own patents, adopt a common technology standard and forgo the independent firm's input efficiency. Instead, the smaller are the standardization benefits (and the more is the specialized firm efficient), the more likely is that an equilibrium with competing platforms emerges on the product market.[3]

The intuition is simple and has to do with the balancing of the two forces in the trade-off above: as the advantages from having a standard increase, the integrated companies have a growing interest in signing an agreement that allows them to share respective rents. Instead, as the advantages from having a standard decrease, the benefits of using the specialized firm's technology become relatively more important, up to overcome the hold-up problem.

Under the *welfare* point of view, I show that the trade-off between the productive efficiency of the upstream firm technology and the contractual efficiency of cross-licensing may give rise to an *inefficient market outcome*: this happens when integrated operators choose a standard with their own techs although a social planner would adopt a standard with the vertically-specialized firm technology.

Three main assumptions are made concerning the composition and the functioning of the ideal certification body. The *first assumption* is that two vertically integrated firms and one

[3]Also Cabral and Salant (2009) and Farrell and Simcoe (2009) show that a scenario with *competing platforms* can arise at equilibrium, although their analysis is based on different underpinnings. More specifically, Cabral and Salant (2009) argues that a unique standard causes a problem of free-riding that reduces the incentives to invest on R&D with respect to a market structure with competing technologies, whereas in Farrell and Simcoe (2009) competing standards are the outcome of a war of attrition.

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upstream firm populate the representative organization. A framework with a majority of vertically integrated entities is able to capture the conflict between integrated firms and pure innovators. Moreover, it is able to replicate SSOs' environment in several situations and in particular in two antitrust cases that have been for a long time under the scrutiny of antitrust authorities in the US and Europe: the FTC v. Rambus case and the EC v. Qualcomm case. In both cases major vertically integrated firms were among the plaintiffs and accused upstream developers of keeping a misleading conduct during the phase of standard definition.

The *second assumption* is that it is vertically integrated firms that decide which technologies are included into the standard. This modeling choice is based on the evidence arising from the SSOs operating in the information and communications technology sector, where vertical integration is a pervasive phenomenon. Standardization bodies in this industry are commonly founded by manufacturers with the intent of controlling the development of a particular technology and avoid mis-coordination among vendors.[4] Clearly, being in the pool of founding members allows these firms to play a crucial role in the phase of standard definition.

Further evidence regarding manufacturers' decision power arises from the two organizations involved in the Qualcomm and Rambus cases mentioned above. Gandal et al. (2003) remarks that in ETSI, the SSO of the Qualcomm case, the voting rule allowed even a small minority of operators to impose the adoption of their favorite standard configuration.[5] JEDEC, the SSO of the Rambus case, was mostly composed by vertically integrated manufacturers that, consequently, could strongly influence the composition of a standard.[6]

The *third assumption* is that licensing negotiations take place after downstream manufacturers choice and adoption of a specific technology, in compliance with most of the standard definition processes undertaken in technology certification consortia.[7] The main implication

[4]Updegrove (1993) provides a detailed analysis of the strategic motivations that lead manufacturers to push for the formation of standardization consortia. Blind and Thumm (2004) documents that technology-users, rather than technology-developers, are in the majority in formal standardization processes. Also, Blind and Thumm (2004) provides an empirical analysis of the incentives behind patenting and participation to standardization decisions that confirms the conflict between the business models of large companies and small technology-developers.

[5]Indeed, ETSI rules required a majority of 71 percent for standard approval but with a voting weighting system based on European turnover; this favored European producers, and many of these were vertically integrated (for example, Nokia and Sony-Ericsson were in ETSI).

[6]The evidence gathered by the FTC in the Rambus case bears witness to the vast presence of integrated firms in JEDEC (In the Matter of Rambus Inc., Docket No. 9302).

[7]A remarkable exception is VITA, which switched in 2006 to a policy that requires the owners of patented technologies to disclose the maximum royalty rates and provide binding written license declarations at several

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of this assumption is that licensing firms whose technology has been employed have full monopoly power on the determination of the royalty rate (which gives rise to the hold-up problem).

An important impediment to the implementation of an ex-ante licensing policy is the risk that SSOs' participants undertake anticompetitive coordinated practices, which would be punished by antitrust authorities. In an extension to the basic model, I analyze the optimal technology choice by using a negotiation environment that fulfills with the implementation of FRAND agreements' reasonableness requirement.[8] In other words, there I assume that the holders of substitute patents compete for the employment by producers and set royalty rates before manufacturers commit to the adoption of a specific technology. The result is that early licensing decisions induce integrated companies to design the standard more efficiently.

The game is solved by assuming that active licensors sell technologies by means of royalty rates. Indeed, Layne-Farrar and Lerner (2008) documents that linear royalties are used by a vast majority of patent pools' members to license-out their technology. Under linear pricing, licensing decisions are influenced by two strategic effects, the *Cournot effect* and the *raising rival's costs effect*,[9] whose impact is discussed in the analysis of the adoption cases.

To assess the robustness of the main results to the assumption on the contractual form, I solve the model under two-part tariffs, in which case manufacturers' technology adoption choices only depend on the hold-up problem. Indeed, two-part tariffs contracts are not affected by the Cournot effect and the double marginalization problem (implying that they are more efficient than royalty rates).[10] In analogy to the setting with linear pricing, the result of the game with two-part tariffs is that if the standardization advantages are large,

specified points during the standard development process.

[8]The licensors that participate to SSOs are often required to commit to license their technologies on Fair Reasonable And Non-Discriminatory (FRAND) terms in case of adoption by manufacturers. A patent holder commitment to license to any interested party on FRAND terms implies that each licensee can obtain a license at the royalty rate established by the patent holder and is not put in comparative disadvantage with respect to other licensees. Choi et al. (2007) provides a survey of the SSOs that require firms to comply with FRAND agreements.

[9]The former effect is caused by the complementarity between the technologies required to produce the final good. Indeed, when pricing their technology independently licensors do not take into account the negative externality they exert on downstream firms (Cournot (1838)). The latter effect is related to the incentive that the downstream competing vertically integrated firms have to increase their rivals' costs as to push them out of the market (Salop and Scheffman (1983, 1987)).

[10]Wang (1998) compares the profitability of licensing contracts with linear royalties and fixed fees for a monopolist licensor that also competes in a downstream duopoly. Although my work shares some analogies with Wang (1998), I am not interested in the optimality of the type of licensing contracts but rather in whether producers' optimal technology choice changes with the type of licensing contract.

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then integrated firms adopt their technologies into the standard and cross-license respective patents. Otherwise, competing platforms are employed. Finally, the inefficient exclusion of the pure innovator arises also in the framework with two-part tariffs.

2.2 Policy Implications and Discussion of the Results

The main *policy implication* of the model is that cross-licensing agreements may be inefficient. Scholars in the law and economics literature have often stressed the beneficial role of cross-licensing on the level of royalty rates (e.g., Shapiro (2001)). However, it has been overlooked that cross-licensing may also lead to the exclusion of the enterprises that are not in the position to participate to cooperative licensing agreements (like pure innovators), and such exclusionary practice would be welfare-detrimental if pure innovators are more efficient. The implication is that, if the technology of an excluded upstream firm is ascertained to be superior,[11] then antitrust authorities should cautiously assess a defense argument based on the pro-efficient effects of cross-licensing by integrated organizations.

Under the *normative* point of view, the model suggests that standard setting consortia should adopt a policy of early-licensing commitments to kill the hold-up problem and allow integrated companies to design the standard efficiently. This result provides an argument in support of the idea that SSOs' participants should be left free to discuss the royalties on patented technologies before a specific standard configuration has been decided. So far, this kind of policy has received a timid support by SSOs (as well as little attention by the theoretical literature), especially because of members' fear of antitrust authorities' intervention. My model shows that competition agencies should also be concerned by the possibility that late licensing decisions would lead to inefficient market outcomes.

The model also delivers two clear and intuitive *testable predictions* regarding the pattern of SSOs' technology adoption choices. *An SSO dominated by integrated firms is expected to sponsor a technology standard if standardization's benefits are strong.* For example, this result is consistent with the employment of the IEEE 802.11n Wi-Fi protocol as industry standard. The IEEE 802.11n protocol is the standard for wireless communications among electronic devices (like laptops, smart-phones and PDAs); clearly, had conflicting protocols emerged on the marketplace, the important network externalities generated by a standardized technology for wireless communications would have not been exploited and the diffusion of the same technology would have been seriously inhibited. This clearly provided manufacturers with

[11] The technical studies carried out by the FTC in the Rambus case provide a clear example of the techniques that can be used to establish technological efficiency.

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the right incentives to achieve coordination.

If standardization is less effective in terms of scale economies, either in production or in demand, then the model predicts that manufacturers' standardization effort is more likely to fail, leading to competing technology platforms. This result is consistent with the evidence in the telecommunications industry, where, as documented by Gandal et al. (2003), the CDMA2000 and the WCDMA (or UMTS) technologies, two incompatible platforms, do coexist on the market.

The CDMA2000 is employed on the US market and is an upgrade of the CDMA technology; moreover, both the CDMA and the CDMA2000 have been developed by Qualcomm (a pure innovator). The WCDMA was adopted by ETSI, an SSO dominated by integrated companies that decides on technology standardization in the European telecommunications industry. The WCDMA is a *variation* of the CDMA2000 platform that is largely incompatible with it. As clarified by Cabral and Salant (2009), the incompatibility between CDMA2000 and WCDMA implies that chipsets meant to work on one platform would not easily work on the other one. However, from the point of view of a user in this industry the costs of multiple incompatible standards are insignificant, because universal access to each other handset is not threatened by incompatibility; this implies that network effects (if any) are not hindered by manufacturers' mis-coordination.

The Chapter proceeds as follows. Section 2.3 compares my findings with those established in related works. Section 2.4 presents the model, Section 2.5 solves the game under contracts with linear royalties and Section 2.6 studies the impact of a policy of early-licensing commitments on adoption choices. In Section 2.7, I analyze technology adoption under different specifications of model's framework and in Section 2.8, I test the robustness of the results by employing two-part tariffs contracts. Finally, Section 2.9 concludes.

2.3 Related Literature

This Chapter analyzes the scope for "exclusionary effects" in the choice of a technology platform by looking at how *technology adoption interacts with licensing decisions and product market competition.* In Schmidt (2008) and Schmalensee (2009) it is investigated the interdependence of pricing decisions between upstream innovators, downstream producers and integrated entities, however they do not analyze technology adoption and do not study the extent to which cross-licensing can lead to upstream (inefficient) exclusion.[12]

[12]Schmalensee (2009) focuses on the analysis of the strategic pricing decisions taken by integrated firms and vertically-specialized operators, and then on the pricing schemes that may solve the hold-up problem.

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The mechanism for which the stand-alone firm is excluded from the standard shares some analogies with the one in Bernheim and Whinston (1998) and Segal and Whinston (2000), where contracting externalities may give rise to anticompetitive outcomes. Indeed, in my model, *the independent firm's tech is not employed because of the externality exerted on the holder of the essential technology (firm 1 in the model) by the bias in favor of cross-licensing of the other integrated firm (firm 2)*, and by the fact that the upstream firm does not participate to the adoption decision.[13]

Bloch (1995) studies a problem of coalition formation by using a model in which the initiator of an association proposes a cooperative agreement to his product-market competitors. The equilibrium of the model is one where coordination efforts fail, because competing associations always form. My model differs from Bloch (1995) insofar as I provide an analysis of the technology choice adopted by a given organization and the welfare consequences associated with it.

The article is also related to the literature on *patent pools' formation*. Lerner and Tirole (2004) studies an all-or-nothing patent pool formation problem. In that paper, it is developed a framework in which the degree of patents' complementarity is the equilibrium outcome of a game in which licensing decisions are constrained either by demand forces or strategic forces. Instead, I am interested in the analysis of the conflicts between holders of competing technologies for a given degree of complementarity, to understand whether *inefficient holdouts* may arise at equilibrium.

Finally, the contribution of the Chapter to the literature on *vertical integration* is twofold: the first consists in analyzing the incentive that vertically integrated firms have to exclude an independent firm that operates on the upstream market if inputs are complementary and because of the danger of hold-up, instead the received literature has typically focused on settings with substitute intermediate goods (see Rey and Tirole (2007)). The second consists in investigating whether *cross-licensing can cause inefficient exclusion on the upstream market.*[14]

Schmidt (2008) proves that, compared to a situation in which only vertically integrated firms are active, the presence of pure upstream innovators triggers royalty rates' and final output's decrease: this result is driven by the incentive that vertically integrated firms have to raise the cost of the inputs sold to downstream rivals (the "raising rival's cots" problem). Schmidt (2008) concludes that cross-licensing agreements between vertically integrated firms can alleviate this problem.

[13]Indeed, could the upstream firm compensate firm 2 for the profit loss suffered when the latter does not cross-license with firm 1, then the adoption of the stand-alone firm's technology would emerge as technology standard.

[14]Most of the economic literature on licensing has studied the anticompetitive effects imparted by upstream pricing decisions on the downstream market. More specifically, Rey and Salant (2009) analyzes the impact

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2.4 The Model

There are 3 firms: firm 1 and firm 2 are vertically integrated, firm 3 is a stand-alone upstream firm. Each firm owns a patented technology, indexed by τ: two of them are substitute, namely technologies τ_2 and τ_3, the third, τ_1, is perfect complement to the other two.

Upstream firms bear a nil marginal cost and can choose among two pricing schemes to license out their technology: independent licensing or cross-licensing. Cross-licensing is modeled by assuming that active licensors maximize joint profits, moreover cross-licensing can only take place between vertically integrated firms because firm 3 does not operate downstream.

To produce the final good each manufacturer needs τ_1 and only one between τ_2 and τ_3. This assumption limits the scope of the analysis to two alternative platforms, $\mathcal{P}(\tau_1, \tau_2)$ and $\mathcal{P}(\tau_1, \tau_3)$, and makes the conflict between τ_2 and τ_3 more compelling. The framework of the model is given in Figure 3.1.

[FIGURE 3.1 ABOUT HERE]

Downstream, vertically integrated firms compete in quantities and produce an homogeneous good. The choice between $\mathcal{P}(\tau_1, \tau_2)$ and $\mathcal{P}(\tau_1, \tau_3)$ is taken by manufacturers in a non-cooperative manner, by comparing own profits under different platform specifications. More specifically, four cases are possible: two in which both integrated firms employ the same inputs, so that a technology *standard (S)* arises, and two in which they employ different inputs, so that two *competing platforms (CP)* coexist on the marketplace.

The technology adoption choice affects the value of the marginal cost of production. Indeed, final good's production process requires the payment of a marginal cost $c \in (0, 1)$ on top of the fees paid to acquire upstream inputs. However, if manufacturers adopt the same platform, or standard, then they pay a marginal cost equal to σc, with $\sigma \in (0, 1)$.[15] Furthermore, technology 3 is superior to technology 2; indeed, if a firm uses τ_3 instead of τ_2, then its marginal cost is discounted by $\epsilon \in (0, 1)$.

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of alternative licensing policies by owners of essential IPRs on downstream competition. Lin (1996) shows that firms can use fixed fee licensing agreements to collude on the product market. Analogously, Eswaran (1994) proves that cross-licensing constitutes a device that facilitates collusion among downstream horizontal competitors.

[15]This formalization can be interpreted as a reduced form of a richer model where joint adoption leads to scale economies, either in production or in demand.

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Summarizing, the value of firm i's marginal cost of production is equal to:

$$c_i = \begin{cases} \mathbf{1}\sigma c + (1-\mathbf{1})c & \textit{if firm } i \textit{ adopts } \mathcal{P}(\tau_1, \tau_2) \\ \\ \mathbf{1}\sigma\epsilon c + (1-\mathbf{1})\epsilon c & \textit{if firm } i \textit{ adopts } \mathcal{P}(\tau_1, \tau_3) \end{cases}$$

With $i = 1, 2$ and $\mathbf{1}$ being an indicator function given by:

$$\mathbf{1} = \begin{cases} 1 & \textit{if a standard (S) is chosen} \\ 0 & \textit{if two competing platforms (CP) are chosen} \end{cases}$$

[TABLE 2.1 ABOUT HERE]

Consumers have inverse demand $P(Q)$, where Q is the total industry output. Assume for simplicity that $P(Q)$ is linear and given by $\max\{0, 1-Q\}$. Demand linearity makes sure that the Cournot-Nash equilibrium of the game exists and is unique.

Finally, side payments are not allowed in this model. Side payments would take the form of conditional contracts in which parties specify before the adoption of a technology what type of transfers they would carry out depending on the same choice. Agreements of this sort can be ruled out invoking the following sorts of argument. First of all, having a contingent nature the parties may be tempted to renegotiate them ex post. Secondly, rational agents may design them to collude on the product market, so that, like other forms of horizontal agreements, they are typically treated as per se unlawful by antitrust authorities.

2.5 Linear Pricing: Equilibrium analysis

In this section, the results of the analysis carried out assuming that firms set licensing agreements by means of linear pricing and public contracts are presented.

In what follows, w_{jk} indicates the royalty rate set by firm j to firm k, with $j, k = 1, 2$ and $j \neq k$. Instead, $w_{31} = w_{32} = w_3$ is the fee set by firm 3 to both 1 and 2; in other words, firm 3 cannot discriminate among downstream firms.[16] Finally, firm 1 (firm 2) internalizes the cost of using τ_1 (τ_2) in the production process.

The timing of the game follows.

1. *Technology Choice Stage*: downstream firms choose a production technology and sink a fixed investment cost equal to I.

[16] This hypothesis is consistent with the non-discriminatory requirement that firms in SSOs must comply with when agreeing on FRAND commitments. In Section 2.7, I show that if one would relax this assumption the main results of the model still go through.

2. *Pricing Scheme and Royalty Setting Stage*: upstream firms whose technology is adopted downstream choose the pricing scheme (independent licensing/cross-licensing) and the royalty rate. Consequently, each downstream firm decides whether to pay the royalty rate (and produce) or give up production.

3. *Product Market Competition Stage*: active firms set quantities.

By sinking I, the downstream units commit to firm-specific investments and set up the equipment necessary to carry out final good's production. In what follows, it is assumed that the fixed cost I is big enough to make the technology choice irreversible once the licensing stage is reached and let the hold-up problem arise.

The model is solved by backward induction and the equilibrium concept employed is the Sub-game Perfect Nash Equilibrium (SPE). I first present the two frameworks in which vertically integrated firms jointly employ $\mathcal{P}(\tau_1, \tau_2)$ or $\mathcal{P}(\tau_1, \tau_3)$, i.e. the cases in which a standard arises as outcome of the technology adoption phase. I denote these two cases as $S2$ and $S3$, respectively. Then, I discuss the scenarios that feature the adoption of two competing platforms: the one in which firm 1 adopts $\mathcal{P}(\tau_1, \tau_3)$ and firm 2 adopts $\mathcal{P}(\tau_1, \tau_2)$, which is denoted by $CP32$, and the one in which firm 1 adopts $\mathcal{P}(\tau_1, \tau_2)$ and firm 2 adopts $\mathcal{P}(\tau_1, \tau_3)$, denoted by $CP23$.

The analysis will be conducted under the following parametric assumption:

Assumption 4
$\epsilon > \bar{\epsilon}(c) \equiv \max\{0, (7c - 3)/4c\}$.

Assumption 4 implies that in the cases with competing platforms the difference between the marginal costs borne by producers is small enough. Consequently, if market monopolization arises at equilibrium it is not due to the cost savings generated by the employment of τ_3, the pure upstream firm's technology.

2.5.1 Adoption of $\mathcal{P}(\tau_1, \tau_2)$ as Technology Standard- "$S2$"

To begin with, I derive the optimal quantities set by firm 1 and firm 2 for given royalties, then I compute the equilibrium royalty rates.

At the competition stage, each downstream firm maximizes:

$$\max_{q_j \geq 0} \Pi_j = [1 - q_j - q_k - w_{kj} - \sigma c]q_j + q_k w_{jk}$$

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With j, k=1,2, $j \neq k$. The equilibrium is characterized by:

$$\begin{cases} q_j^{S2}(w_{12}, w_{21}) = \frac{1-\sigma c-2w_{kj}+w_{jk}}{3} \\ Q^{S2}(w_{12}, w_{21}) = \frac{2(1-\sigma c)-(w_{jk}+w_{kj})}{3} \\ P(Q^{S2}(w_{12}, w_{21})) = \frac{1+2\sigma c+w_{jk}+w_{kj}}{3} \end{cases} \tag{2.1}$$

At this stage, two sub-cases must be distinguished: the one in which firm 1 and firm 2 license their technologies independently (independent licensing) and the one in which licensing decisions are taken cooperatively (cross-licensing).

Independent Licensing

At the royalty setting stage of the game with independent licensing vertically integrated firms maximize:

$$\max_{w_{jk} \geq 0} \Pi_j^{S2} = [P(Q^{S2}(w_{12}, w_{21})) - w_{kj} - \sigma c] q_j^{S2}(w_{12}, w_{21}) + q_k^{S2}(w_{12}, w_{21}) w_{jk}.$$

With j, k=1,2 and $j \neq k$. The first-order condition is:

$$\frac{\partial \Pi_j^{S2}}{\partial w_{jk}} = \underbrace{[P(Q^{S2}) - w_{kj} - \sigma c] \frac{\partial q_j^{S2}}{\partial w_{jk}}}_{>0, \text{ raising rival's costs}} + \frac{\partial P(Q^{S2})}{\partial Q} \frac{\partial Q^{S2}}{\partial w_{jk}} q_j^{S2} + q_k^{S2} + \frac{\partial q_k^{S2}}{\partial w_{jk}} w_{jk} = 0. \tag{2.2}$$

If firm j raises w_{jk} it trades off the higher revenue generated downstream (partly due to the raising rival's costs effect) with the lower upstream revenue caused by firm k's output contraction downstream. Linearity leads to:

$$w_{jk}(w_{kj}) = \frac{5(1 - \sigma c) - w_{kj}}{10}$$

With $j, k = 1, 2$ and $j \neq k$. By symmetry, equilibrium wholesale prices are:

$$w_{12}^{S2} = w_{21}^{S2} = 5(1 - \sigma c)/11.$$

Plugging this value in (2.1), under the joint employment of $\mathcal{P}(\tau_1, \tau_2)$ and independent licensing one has the results in Table 2.2. In particular, active firms' profits are equal to $\Pi_1^{S2} = \Pi_2^{S2} = 14(1 - \sigma c)^2/121$ and the consumer surplus is given by $CS = Q^2/2 = 8(1 - \sigma c)^2/121$.

[TABLE 2.2 ABOUT HERE]

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At the licensing equilibrium of the game in which vertically integrated firms price their technologies non cooperatively, royalties are determined by two effects: the *Cournot effect* and the *raising rival's costs effect*. The former is caused by the complementarity between the technologies in the standard and the latter is due to the fact that both vertically integrated firms act as monopoly inputs' providers to their product market's rival.

Cross-licensing

Cross-licensing is modeled in the following way. Vertically integrated firms maximize joint profits by setting a royalty rate $W_{CL} = w_{12} + w_{21}$ that implements the monopoly outcome on the product market.

Using Q^{S2} from (2.1), upstream firms solve:[17]

$$Q^{S2}(W_{CL}) = \frac{2(1-\sigma c) - W_{CL}^{S2}}{3} = \frac{1-\sigma c}{2} \iff W_{CL}^{S2} = \frac{1-\sigma c}{2}$$

Then, symmetry leads to $w_{12}^{S2} = w_{21}^{S2} = W_{CL}^{S2}/2 = (1-\sigma c)/4$.

Cross-licensing allows firms to fix the raising rival's costs and double marginalization effects bringing royalties down to the monopoly level ($W_{CL}^{S2}/2 = (1-c_J)/4 < w_{jk}^{S2} = 5(1-c_J)/11$). Downstream firms split the monopoly's profit and raise $\Pi^{S2} = (1-c_J)^2/8$ each. Moreover, the consumer surplus is equal to $CS = Q^2/2 = (1-\sigma c)^2/8 > 8(1-\sigma c)^2/121$, so that cross-licensing is beneficial to consumers as well.

Comparing the results in Table 2.2, it is clear that the equilibrium licensing scheme when vertically integrated firms jointly adopt a standard with technology 1 and technology 2 is cross-licensing. Indeed, each firm strictly prefers the cooperative agreement to the non-cooperative one, as $\Pi_j^{S2} = 14(1-c_J)^2/121 < (1-c_J)^2/8 = \Pi^{S2}$.

2.5.2 Adoption of $\mathcal{P}(\tau_1, \tau_3)$ as Technology Standard - "$S3$"

If vertically integrated firms adopt a standard that displays technology 1 and technology 3, then both benefit from the greater efficiency of τ_3. Moreover, firms are asymmetric at the upstream level, because firm 2 does not license its technology downstream and needs

[17] Analogously, one can show that the same result holds by explicitly solving for the maximization problem of vertically integrated firms' joint profits. Indeed,

$$W_{CL}^{S2} = \arg\max_{W_{CL}} \Pi_1^{S2} + \Pi_2^{S2} = [1 - Q^{S2}(W_{CL}) - \sigma c]Q^{S2}.$$

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to acquire externally τ_1 and τ_3. Finally, licensing firms 1 and 3 cannot cross-license their technologies, because firm 3 does not operate downstream.

At the product market competition stage, firm 1 solves:

$$\max_{q_1 \geq 0} \Pi_1 = [1 - q_1 - q_2 - w_3 - \epsilon\sigma c]q_1 + q_2 w_{12}.$$

Firm 2 solves

$$\max_{q_2 \geq 0} \Pi_2 = [1 - q_1 - q_2 - w_3 - w_{12} - \epsilon\sigma c]q_2.$$

The results at equilibrium are:

$$\begin{cases} q_1^{S3}(w_{12}, w_3) = \frac{1-\epsilon\sigma c - w_3 + w_{12}}{3} \\ q_2^{S3}(w_{12}, w_3) = \frac{1-\epsilon\sigma c - w_3 - 2w_{12}}{3} \\ Q^{S3}(w_{12}, w_3) = \frac{2(1-\epsilon\sigma c)-(2w_3+w_{12})}{3} \\ P(Q^{S3}(w_{12}, w_3)) = \frac{1+2\epsilon\sigma c+2w_3+w_{12}}{3} \end{cases} \tag{2.3}$$

At the royalty setting stage, firm 1 solves the following problem:

$$\max_{w_{12} \geq 0} \Pi_1^{S3} = [P(Q^{S3}(w_{12}, w_3)) - w_3 - \epsilon\sigma c]q_1^{S3}(w_{12}, w_3) + q_2^{S3}(w_{12}, w_3)w_{12}.$$

The first-order condition is:

$$\frac{\partial \Pi_1^{S3}}{\partial w_{12}} = [P(Q^{S3}) - w_3 - \epsilon\sigma c]\frac{\partial q_1^{S3}}{\partial w_{12}} + \frac{\partial P(Q^{S3})}{\partial Q}\frac{\partial Q^{S3}}{\partial w_{12}} q_1^{S3} + q_2^{S3} + \frac{\partial q_2^{S3}}{\partial w_{12}} w_{12} = 0.$$

The optimal value of w_{12} is determined by the tradeoff triggered by an higher royalty rate on downstream and upstream revenues. More specifically, the first term is related to the raising rival's costs effect, it is positive and acts only at the expenses of firm 2.

Invoking linearity, firm 1 upstream reaction function is equal to:

$$w_{12}(w_3) = \frac{1 - w_3 - \epsilon\sigma c}{2}. \tag{2.4}$$

Firm 3 solves the following problem:

$$\max_{w_3 \geq 0} \Pi_3^{S3} = Q^{S3}(w_{12}, w_3)w_3.$$

The resulting first-order condition is:

$$\frac{\partial \Pi^{S3}}{\partial w_3} = \frac{\partial Q^{S3}}{\partial w_3} w_3 + Q^{S3} = 0.$$

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Clearly, the raising rival's costs effect does not play any role for firm 3, because it does not operate on the product market. Using linearity, one finds that the reaction function of firm 3 is given by:

$$w_3(w_{12}) = \frac{2(1-\epsilon\sigma c) - w_{12}}{4}. \tag{2.5}$$

Solving for w_{12} and w_3 from (2.4) and (2.5), one can derive the following equilibrium expressions:

$$\begin{cases} w_{12}^{S3} = \frac{2(1-\epsilon\sigma c)}{7} \\ w_3^{S3} = \frac{3(1-\epsilon\sigma c)}{7} \end{cases} \tag{2.6}$$

Table 2.3 summarizes the results of this section. In particular, $\Pi_3^{S3} = 6(1-\epsilon\sigma c)^2/49 > \Pi_1^{S3} = 4(1-\epsilon\sigma c)^2/49 > \Pi_2^{S3} = 0$ and the consumer surplus is equal to $CS = Q^2/2 = 2(1-\epsilon\sigma c)^2/49$.

[TABLE 2.3 ABOUT HERE]

The equilibrium of the game in which firm 1 and firm 3 price their technologies non cooperatively features a monopoly of firm 1 downstream. This is because, with respect to the case of joint adoption of $\mathcal{P}(\tau_1, \tau_2)$, firm 2 loses a device to face firm 1 competition on the product market (namely, the possibility to price an input of firm 1).

2.5.3 Competing Platforms: firm 1 uses $\mathcal{P}(\tau_1, \tau_3)$ and firm 2 uses $\mathcal{P}(\tau_1, \tau_2)$ - "$CP32$"

At the product market competition stage, firm 1 solves:

$$\max_{q_1 \geq 0} \Pi_1 = [1 - q_1 - q_2 - w_3 - \epsilon c]q_1 + q_2 w_{12},$$

Firm 2 solves:

$$\max_{q_2 \geq 0} \Pi_2 = [1 - q_1 - q_2 - w_{12} - c]q_2.$$

Firm 2 employs its own technology, then the marginal cost it pays is equal to c. Instead, Firm 1 employes τ_3, thus the marginal cost c is discounted by the parameter ϵ. The reduced form equilibrium results associated with the maximization problems above are given in the following.

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$$\begin{cases} q_1^{CP32}(w_{12}, w_3) = \frac{1-c(2\epsilon-1)-2w_3+w_{12}}{3} \\ q_2^{CP32}(w_{12}, w_3) = \frac{1-c(2-\epsilon)+w_3-2w_{12}}{3} \\ Q^{CP32}(w_{12}, w_3) = \frac{2-c(1+\epsilon)-(w_3+w_{12})]}{3} \\ P(Q^{CP32}(w_{12}, w_3)) = \frac{1+c(1+\epsilon)+(w_3+w_{12})}{3} \end{cases} \tag{2.7}$$

At the royalty setting stage, firm 1 solves:

$$\max_{w_{12}\geq 0} \Pi_1^{CP32} = [1 - Q^{CP32}(w_{12}, w_3) - w_3 - \epsilon c]q_1^{CP32}(w_{12}, w_3) + q_2^{CP32}(w_{12}, w_3)w_{12}$$

The first-order condition follows:

$$\frac{\partial \Pi_1^{CP32}}{\partial w_{12}} = [1 - Q^{CP32} - w_3 - \epsilon c]\frac{\partial q_1^{CP32}}{\partial w_{12}} - \frac{\partial Q^{CP32}}{\partial w_{12}} q_1^{CP32} + q_2^{CP32} + \frac{\partial q_2^{CP32}}{\partial w_{12}} w_{12} = 0$$

Firm 1 takes into account the fact that by raising the value of w_{12} it can exert a negative externality on firm 2 and reduce its product market share. By linearity, firm 1 upstream reaction function is equal to:

$$w_{12}(w_3) = \frac{5 - c(4+\epsilon) - w_3}{10}. \tag{2.8}$$

Firm 3 solves the following problem:

$$\max_{w_3\geq 0} \Pi_3^{CP32} = q_1^{CP32}(w_{12}, w_3)w_3.$$

The first-order condition is:

$$\frac{\partial \Pi^{CP32}}{\partial w_3} = \frac{\partial q_1^{CP32}}{\partial w_3} w_3 + q_1^{CP32} = 0.$$

In this case, firm 3 can exert its monopoly power only at expenses of firm 1 because firm 2 employs its own technology. Using linearity, one finds that the reaction function of firm 3 is equal to:

$$w_3(w_{12}) = \frac{1 - c(2\epsilon - 1) + w_{12}}{4}. \tag{2.9}$$

By solving for w_{12} and w_3 from (2.8) and (2.9), one can derive the following equilibrium expressions:

$$\begin{cases} w_{12}^{CP32} = \frac{19-c(2\epsilon+17)}{41} \\ w_3^{CP32} = \frac{3[5-c(7\epsilon-2)]}{41} \end{cases} \tag{2.10}$$

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The expressions in (2.10) must be employed in (2.7) to compute firms' payoffs. The results of this section are in Table 2.4 .

[TABLE 2.4 ABOUT HERE]

Remarkably, under Assumption 4 firm 2 produces a positive amount on the market for the final good; this is because, by using τ_2 instead of τ_3, firm 2 is not stifled by the raising rival's costs effect and it is only firm 1 to be held-up by firm 3. More specifically, if $\epsilon \in [\bar{\epsilon}(c), (9c+2)/11c)$, then $q_1^{CP32} > q_2^{CP32} > 0$, and if $\epsilon \in [(9c+2)/11c, 1)$, then $q_2^{CP32} \geq q_1^{CP32} > 0$.

2.5.4 Competing Platforms: firm 1 uses $\mathcal{P}(\tau_1, \tau_2)$ and firm 2 uses $\mathcal{P}(\tau_1, \tau_3)$ - "$CP23$"

To start with, it is important to stress that this scenario does not emerge as Nash equilibrium of the adoption game in the linear pricing case and is here presented for the sake of completeness.

At the product market competition stage, firm 1 solves:

$$\max_{q_1 \geq 0} \Pi_1 = [1 - q_1 - q_2 - w_{21} - c]q_1 + q_2 w_{12},$$

Firm 2 solves:

$$\max_{q_2 \geq 0} \Pi_2 = [1 - q_1 - q_2 - w_3 - w_{12} - \epsilon c]q_2 + q_1 w_{21}.$$

The reduced form equilibrium results of the maximization problems above are as in what follows:

$$\begin{cases} q_1^{CP23}(w_{12}, w_{21}, w_3) = \frac{1 - c(2-\epsilon) + w_3 - 2w_{21} + w_{12}}{3} \\ q_2^{CP23}(w_{12}, w_{21}, w_3) = \frac{1 - c(2\epsilon - 1) - 2(w_3 + w_{12}) + w_{21}}{3} \\ Q^{CP23}(w_{12}, w_{21}, w_3) = \frac{2 - c(1+\epsilon) - (w_3 + w_{12} + w_{21})}{3} \\ P(Q^{CP23}(w_{12}, w_{21}, w_3)) = \frac{1 + c(1+\epsilon) + (w_3 + w_{12} + w_{21})}{3} \end{cases} \tag{2.11}$$

At the royalty setting stage, firm 1 solves:

$$\max_{w_{12} \geq 0} \Pi_1^{CP23} = [1 - Q^{CP23}(w_{12}, w_{21}, w_3) - w_{21} - c]q_1^{CP23}(w_{12}, w_{21}, w_3) + q_2^{CP23}(w_{12}, w_{21}, w_3)w_{12}.$$

The resulting first-order condition is:

$$\frac{\partial \Pi_1^{CP23}}{\partial w_{12}} = [1 - Q^{CP23} - w_{21} - c]\frac{\partial q_1^{CP23}}{\partial w_{12}} - \frac{\partial Q^{CP23}}{\partial w_{12}} q_1^{CP23} + q_2^{CP23} + \frac{\partial q_2^{CP23}}{\partial w_{12}} w_{12} = 0.$$

Using linearity, firm 1 upstream reaction function is equal to:

$$w_{12}(w_{21}, w_3) = \frac{5 - c(1+4\epsilon) - 4w_3 - w_{21}}{10}. \tag{2.12}$$

Differently from case $CP32$, in case $CP23$ firm 2 licenses τ_2 to firm 1. In particular, firm 2 solves the following problem:

$$\max_{w_{21}\geq 0} \Pi_2^{CP23} = [1 - Q^{CP23}(w_{12}, w_{21}, w_3) - w_{12} - w_3 - \epsilon c] q_2^{CP23}(w_{12}, w_{21}, w_3) + q_1^{CP23}(w_{12}, w_{21}, w_3) w_{21}.$$

The first-order condition follows:

$$\frac{\partial \Pi_2^{CP23}}{\partial w_{21}} = [1 - Q^{CP23} - w_{12} - w_3 - \epsilon c]\frac{\partial q_2^{CP23}}{\partial w_{21}} - \frac{\partial Q^{CP23}}{\partial w_{21}} q_2^{CP23} + q_1^{CP23} + \frac{\partial q_1^{CP23}}{\partial w_{21}} w_{21} = 0.$$

Thus, in this case the royalty rates of both firm 1 and firm 2 are influenced by the raising rival's costs effect. The reaction function of firm 2 is given by:

$$w_{21}(w_{12}, w_{21}, w_3) = \frac{5 - c(\epsilon+4) - w_3 - w_{12}}{10}. \tag{2.13}$$

Finally, firm 3 solves:

$$\max_{w_3\geq 0} \Pi_3^{CP23} = q_2^{CP23}(w_{12}, w_{21}, w_3) w_3.$$

The first-order condition is:

$$\frac{\partial \Pi^{CP23}}{\partial w_3} = \frac{\partial q_2^{CP23}}{\partial w_3} w_3 + q_2^{CP23} = 0.$$

Firm 3 exerts its monopoly power at expenses of firm 2, because firm 1 employs the technology licensed by 2. The reaction function of firm 3 is equal to:

$$w_3(w_{12}, w_{21}, w_3) = \frac{1 - c(2\epsilon - 1) - 2w_{12} + w_{21}}{4}. \tag{2.14}$$

Solving for $\{w_{12}, w_{21}, w_3\}$ from (2.12), (2.13) and (2.14), one can derive the following equilibrium expressions:

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$$\begin{cases} w_{12}^{CP23} = \frac{21-c(8+13\epsilon)}{54} \\ w_{21}^{CP23} = \frac{12-c(\epsilon+11)}{27} \\ w_{3}^{CP23} = \frac{3-c(7\epsilon-4)}{18} \end{cases} \tag{2.15}$$

The equilibrium expressions in (2.15) must be employed in (2.11) to compute firms' payoffs. Table 2.5 summarizes the results of this section.[18]

[TABLE 2.5 ABOUT HERE]

Under Assumption 4, firm 1 and firm 2 produce a positive amount on the market for the final good (that is, $q_1^{CP23} > 0$ and $q_2^{CP23} > 0$).

2.5.5 Technology Choice

In the first stage of the game, vertically integrated firms choose the technology platform they employ for the production of the final good.

Proposition 6
Assume that side payments are not allowed and that the choice of the technology is taken by vertically integrated firms, then the unique Nash equilibrium of the adoption game features:

i. The employment of $\mathcal{P}(\tau_1, \tau_2)$ as technology standard ($S2$) if $\sigma \leq \tilde{\sigma}(c, \epsilon)$;

ii. The employment of competing platforms ($CP32$) if $\sigma > \tilde{\sigma}(c, \epsilon)$.

[18] In case $CP23$, firm 1 and firm 2 may cross-license respective technologies, however it turns out that a cooperative agreement cannot be reached if one rules out side payments. First of all, the sum of integrated firms' profits can be rewritten as in the following:

$$\Pi_1^{CP23} + \Pi_2^{CP23} = [1 - Q^{CP23}]Q^{CP23} - cq_1^{CP23} - (w_3 + \epsilon c)q_2^{CP23}$$

Hence, one could rewrite above expression as function of W_{CL} and see that the ideal monopolist would set W_{CL} (and share it between firm 1 and firm 2) as to let the firm with the cheaper technology be active on the product market. In other words, one integrated firm would raise positive profits and the other would be made worse off with respect to independent licensing. Consequently, without side payments, a cooperative agreement cannot be found in case $CP23$.

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Proof. See Appendix A.

The main result of Proposition 6 is that the case with technology τ_3 into the standard ($S3$) is not an equilibrium of the technology adoption game. This outcome is determined by the basic trade-off outlined in the Introduction: from the point of view of firms 1 and 2, cross-licensing preserves rents, instead contracting with pure developers is efficient but leads to rent dissipation (because of hold-up). The result in Proposition 6 shows that if σ is small the former effect prevails and if σ is large the latter effect prevails.

More specifically, on the one hand, if the cost-savings generated by having a technology standard are sufficiently important, then the employment of τ_2 is a dominant strategy to firm 2 and the Nash equilibrium is determined by the choice of firm 1. Firm 1 employs technology τ_2 (and cross licenses with 2) if the value of σ is small, instead, as σ increases, the adoption of competing platforms becomes more profitable for firm 1.

On the other hand, if the cost-savings generated by having a technology standard become less important, then the use of $\mathcal{P}(\tau_1, \tau_3)$ is more attractive to firm 2 and the employment of $\mathcal{P}(\tau_1, \tau_2)$ is not a dominant strategy anymore. However, firm 2 still anticipates that in the case of a joint adoption of $\mathcal{P}(\tau_1, \tau_3)$ it would be stifled by the raising rival's costs and hold-up effects. Consequently, if firm 1 would choose $\mathcal{P}(\tau_1, \tau_3)$ then firm 2 would reply by employing its own technology.

Therefore, at equilibrium, either a standard with $\mathcal{P}(\tau_1, \tau_2)$ is chosen or there are competing platforms, with firm 1 employing $\mathcal{P}(\tau_1, \tau_3)$ and firm 2 employing $\mathcal{P}(\tau_1, \tau_2)$.

2.5.6 Welfare Analysis

The welfare analysis is conducted by assuming that a benevolent planner decides the technology to be employed by comparing the value of social surplus associated with the four cases of adoption ($S2$,$S3$,$CP32$,$CP23$). Hence, the following game is solved:

1. *Technology Choice Stage*: the benevolent planner chooses a production technology.

2. *Pricing Scheme and Royalty Setting Stage*: upstream firms whose technology is adopted downstream choose the pricing scheme (independent licensing/cross-licensing) and the royalty rate. Consequently, each downstream firm decides whether to pay the royalty rate (and produce) or give up production.

3. *Product Market Competition Stage*: active firms set quantities.

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In other words, this analysis provides the outcome of a game in which the technology choice is taken by disregarding the strategic interactions that determine the equilibrium of the adoption game in Proposition 6. However, the planner still takes into account both the impact that the employment of a particular technology has on firms' choices at the licensing and product market stages, and the hold-up problem. The result of the game above is in what follows.

Lemma 6
Assume that the choice of the technology is taken by a benevolent planner, then at the equilibrium she would employ:

i. $\mathcal{P}(\tau_1, \tau_2)$ *as technology standard (S2) in:*
$\{(\epsilon, \sigma)| \quad \sigma \in (0, \bar{\sigma}(c, \epsilon))\} \quad \setminus \quad \{(\epsilon, \sigma)| \quad \sigma \in (\bar{\bar{\sigma}}(c, \epsilon), \min\{\bar{\sigma}(c, \epsilon), 1\})\}$;

ii. $\mathcal{P}(\tau_1, \tau_3)$ *as technology standard (S3) in:*
$\{(\epsilon, \sigma)| \quad \sigma \in (\bar{\sigma}(c, \epsilon), 1)\} \quad \setminus \quad \{(\epsilon, \sigma)| \quad \sigma \in (\max\{\bar{\sigma}(c, \epsilon), \bar{\bar{\bar{\sigma}}}(c, \epsilon)\}, 1)\}$;

iii. Competing platforms (CP32) in:
$\{(\epsilon, \sigma)| \quad \sigma \in (\bar{\bar{\sigma}}(c, \epsilon), \min\{\bar{\sigma}(c, \epsilon), 1\})\} \quad \cup \quad \{(\epsilon, \sigma)| \quad \sigma \in (\max\{\bar{\sigma}(c, \epsilon), \bar{\bar{\bar{\sigma}}}(c, \epsilon)\}, 1)\}$.

Proof. See Appendix B.

There are three relevant areas: the joint adoption of $\mathcal{P}(\tau_1, \tau_2)$ maximizes total welfare for low values of σ and the joint employment of $\mathcal{P}(\tau_1, \tau_3)$ maximizes total welfare for high values of σ. However, if σ is big enough the employment of $\mathcal{P}(\tau_1, \tau_3)$ by firm 1 and $\mathcal{P}(\tau_1, \tau_2)$ by firm 2 ($CP32$) can generate a value of surplus bigger than the cases of standard adoption ($S2$ and $S3$).

Using the results of Proposition 6 and Lemma 6, one can derive the following proposition.

Proposition 7
There is a wedge between the adoption choice taken by integrated entities and the one of the social planner; in this wedge, the exclusion of firm 3 from the standard employed by vertically integrated organizations is inefficient.

Proof. See Appendix C.

Proposition 7 shows that the trade-off between the technological efficiency of the upstream firm input and the contractual efficiency of cross-licensing can lead to a technology choice that is sub-optimal from the total welfare point of view. This is because, when the advantages

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from adopting a standard and the cost savings due to the employment of the specialized firm are sufficiently large, vertically integrated firms may prefer to cross-license their technologies while a benevolent planner would adopt a standard with τ_3.

2.5.7 A Numerical Example

Here it is presented a numerical example that illustrates the results above. More specifically, it is assumed that the marginal cost of production c is equal to $1/2$.

[FIGURE 2.2 ABOUT HERE]

For $c = 1/2$ the value of $\bar{\epsilon}(c)$ in Assumption 4 is equal to $1/4$, hence, in the figure, the relevant range of values of ϵ is given by $(1/4, 1)$.

The panel (a) of Figure 2.2 presents the outcome of the adoption game and the panel (b) presents the results of the welfare analysis. Panel (c) shows the area of total exclusion of $\mathcal{P}(\tau_1, \tau_3)$ (marked by T) and two areas of partial exclusion, P_3 and P_2. In P_3 the adoption of $\mathcal{P}(\tau_1, \tau_3)$ as technology standard is efficient but an equilibrium with competing platforms arises. Instead, in P_2 the adoption of $\mathcal{P}(\tau_1, \tau_2)$ as technology standard is more efficient than the equilibrium with competing platforms.

2.6 Ex-ante Licensing Policy

In the time-line of the game with linear pricing, active licensors set royalty rates after being employed by manufacturers; this choice grants monopoly power in the negotiations' phase to the licensors whose technology is adopted. In this section, I study the SPE of a game in which the royalty rate stage precedes technology choice and adoption, and let firm 2 and firm 3 compete for the employment of their technologies.

The timing of the new set-up follows.

1. *Licensing Scheme and Royalty Setting Stage*: upstream firms set the royalty rate and the licensing scheme (independent licensing/cross-licensing).

2. *Technology Choice Stage*: downstream firms choose the technology.

3. *Product Market Competition Stage*: active firms set quantities.

This time-line reproduces the results of an auction carried out between the technologies of firm 2 and firm 3 at the competitive conditions prevailing before the adoption phase. In other

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words, in this framework it is analyzed what consequences would have the implementation of a policy of early licensing commitments on the choice of the technology, so to replicate the effects of FRAND agreements' reasonableness requirement implementation.[19]

Proposition 8
Assume that active licensors set royalty rates before their technologies have been employed by manufacturers, then the equilibrium of the adoption game features the employment of $\mathcal{P}(\tau_1, \tau_3)$ *as technology standard (*$S3$*) and is efficient.*

Proof. See Appendix D.

Proposition 8 shows that the hold-up problem crucially tilts the licensing negotiations between firm 1 and firm 3 (the pure innovator). Indeed, the twist in the timing changes the incentives of firm 3 when pricing its technology, instead, the best agreement that firm 2 can aim at reaching with firm 1 does not depend on the timing of the negotiations and consists in cross-licensing respective patents. However, in the set-up of this extension, firm 3, being more efficient, can match the offer of firm 2 and convince firm 1 to employ τ_3.

The resulting normative policy implication is that SSOs members should be allowed to talk about royalties when they choose among the technologies to include in a standard, because this would solve the hold-up problem and lead to a more efficient decision.

2.7 Technology Adoption in Alternative Frameworks

The model shows that the adoption of $\mathcal{P}(\tau_1, \tau_2)$ as technology standard depends on the profitability of cross-licensing and the severity of the hold-up problem. Based on this, one can analyze SSO adoption choices in different frameworks.

2.7.1 N vertically integrated firms

If the set-up would include N vertically integrated firms, then the per-firm profits generated by cross-licensing would decrease as N increases. Therefore, it would be more difficult to sustain an equilibrium featuring the joint employment of $\mathcal{P}(\tau_1, \tau_2)$.

[19] Reasonableness requires that licensing decisions taken before technology adoption must be consistent with those decided after technology's employment by manufacturers, so to avoid excessive royalties due to the lack of competitive alternatives.

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2.7.2 N stand-alone upstream firms

If it were the number of upstream firms endowed with the efficient technology to increase, then the scope for the exclusion of firm 3 would remain because the hold-up problem does not depend on the number of upstream firms but rather on the timing of technology adoption.

2.7.3 Price competition with differentiated products

In a framework with price competition the main results of the model would stay the same. Indeed, the upstream operations of the integrated firms could keep up the profitability of an agreement featuring the joint adoption of $\mathcal{P}(\tau_1, \tau_2)$ and cross-licensing by setting royalty rates equal to the monopoly price and so implementing the monopoly outcome on the downstream market.

2.7.4 Set-up with one vertically integrated firm

Assume that the framework would embed integrated firm 2 facing the competition of a stand-alone downstream firm, D_1, and that τ_1 and τ_3 are provided by two upstream stand-alone firms, indexed by U_1 and U_3. In this modified setting, the profitability for D_1 of using the technologies of firm 2 and firm U_1 would greatly reduce.[20] Indeed, now D_1 cannot cross-license with firm 2, moreover it would be subject to the raising-rival's costs incentive of integrated firm 2 and the hold-up of firm U_1. Therefore, it is expectable that the payoff of U_1 when it employs $\mathcal{P}(\tau_1, \tau_2)$ with firm 2 is squeezed by firm 2 and U_1, so to make the employment of τ_2 less profitable to D_1 than in the main model.

2.7.5 Stand-alone firm 3 can discriminate

In case $S3$, firm 3 cannot discriminate between firm 1 and firm 2, but this assumption is not crucial for the exclusion of firm 3 from the technology standard. Indeed, given that at the licensing stage its technology has already been adopted, were firm 3 free to discriminate it would let firm 1 be monopolist and squeeze as much as possible its downstream rent through the royalty rate. Therefore, the scope for the employment of τ_3 would further shrink.

[20] Notice that firm 1 would be in a strategic position analogous to the one of firm 2 in case $S3$ of the main model. There, the profit of firm 2 is nil.

2.7.6 Acquisition of firm 3 by integrated operators

Assume a merger stage is introduced into the game at which integrated firms can take over firm 3. There are two cases to be distinguished, depending on whether the merger stage precedes or follows the technology adoption stage.

If firm 3 merges with vertically integrated firms before the production technology is chosen, then firm 3 would join the deciding coalition and, clearly, the adoption of platform $\mathcal{P}(\tau_1, \tau_3)$ would emerge at equilibrium. However, if the merger stage would be the first stage, followed by the technology choice, the licensing game and the product market stage, then the hold-up problem would still affect the results of the technology adoption stage leading to the same qualitative results as in the main model.

2.8 Two-part Tariffs

In this extension, upstream firms use two-part tariffs to license-out their technology to downstream firms. It is important to remark that contracts by means of two-part tariffs are more efficient than those with linear pricing because they are not affected by the double marginalization problem. Therefore, if the exclusionary result arises in this setting it is entirely caused by the hold-up effect.

The timing of the game follows:

1. *Technology Choice Stage*: downstream firms choose the technology.

2. *Licensing Scheme and Royalty Setting Stage*: upstream firms whose technology is adopted downstream make a public take-it-or-leave-it offer to downstream firms, consisting of a tariff, indexed by $T_{ij} = w_{ij}q_j + F_{ij}$, and a scheme (independent licensing/cross-licensing) at which they license-out their technologies. Consequently, each downstream firm decides whether to pay the fee (and produce) or give up production.

3. *Product Market Competition Stage*: active firms set quantities.

Firms pay the due tariff after the product market competition stage and under the protection of a limited liability constraint for which they cannot pay more than the profits they raise on the market. Therefore, first firms negotiate over the licensing contracts, then they decide to produce and carry out the payment of the tariffs they agreed upon initially.

Without loss of generality, I assume that upstream firms make sequential offers, so to solve the problems of coordination intrinsic to the settings with complementary inputs; more specifically, this assumption rules out those cases in which the sum of the offers exceeds the profit of a downstream firm.

In what follows, I use π to indicate the rent generated by the product market, as opposed to Π, which indicates total profits.

Like in the model with linear prices, I assume that downstream production requires the payment of a marginal cost $c \in (0,1)$ and that the employment of a standard generates a cost-saving measured by $\sigma \in (0,1)$. The adoption of τ_3 reduces the cost borne by downstream manufacturers by $\epsilon \in (0,1)$. Finally, Assumption 4 holds in this setting as in the model with royalty rates.

2.8.1 Adoption of $\mathcal{P}(\tau_1, \tau_2)$ as Technology Standard

If integrated firms choose $\mathcal{P}(\tau_1, \tau_2)$ as technology standard, at the product market competition stage the equilibrium values are the same as in equations (2.1) in the model with linear prices.

In particular, $\pi^c = (1-\sigma c)^2/9$ denotes the value of the per-firm Cournot profit and $\pi^m = (1-\sigma c)^2/4$ the one of the monopoly profit at $w_{12} = w_{21} = 0$.

Lemma 7 presents the equilibria of the licensing game when firm 1 and firm 2 set T_{12} and T_{21} *non-cooperatively.*

Lemma 7
Under independent licensing and technologies τ_1 and τ_2 in the standard, the Nash equilibria of the licensing game are as in what follows:

i. Firm j offers $w_{jk} = (1-\sigma c)/2$ and $F_{jk} = 0$, firm k offers $w_{kj} = 0$ and $F_{kj} = \pi^m$. Alternatively, firm j and k offer $w_{jk} = w_{kj} = 0$, $F_{jk} = F_{kj} = \pi^m$: in both cases firm j is in, firm k is out, but extracts all downstream profits from firm j. Moreover, $\Pi_j = 0$, $\Pi_k = \pi^m$.

ii. Firm j and k offer $w_{jk} = w_{kj} = 0$, $F_{jk} = \pi^m$ and $F_{kj} \in [\pi^c, \pi^m)$, at which firm j is out and firm k is in. In this case, $\Pi_j = \pi^m$, $\Pi_k = 0$.

Proof. See Appendix E.

At a Nash equilibrium of the non-cooperative licensing game, one of the two firms is out of the market but takes rival's downstream profit through the fixed fee. Unfortunately, though, multiple equilibria imply that it is not possible to determine whether it is firm 1

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or firm 2 to get the full monopoly profit. In order to get rid of this limitation, I assume that each upstream firm in the SSO has an equal probability of being first in approaching downstream firms. This implies that, in expected terms, vertically integrated firms share the monopoly profit and get $\Pi_j^{S2} = \Pi_k^{S2} = \pi^m/2$.

Cross-licensing

Under cross-licensing, firms set their fees cooperatively, but behave non-cooperatively at the production stage. The best deal that vertically integrated firms can negotiate upon is one at which they equally share the monopoly rent.

Lemma 8
Under cross-licensing and technologies τ_1 and τ_2 in the standard, at equilibrium firms write the following agreement: firm j offers $w_{jk} = 0$ and $F_{jk} = \pi^m/2$, whilst firm k offers $w_{kj} = (1-\sigma c)/2$ and $F_{kj} = 0$. At this agreement, firm k is the monopolist and transfers half of the monopoly rent to firm j.

At the cooperative equilibrium, firm j stays out of the market, firm k is monopolist and transfers half of the downstream rent to firm k at the payment stage. Cross-licensing and independent licensing deliver the same total profit to vertically integrated firms under two-part tariffs. Thus, in this framework, the decision over the standard is not affected by cross-licensing.[21]

2.8.2 Adoption of $\mathcal{P}(\tau_1, \tau_3)$ as Technology Standard

In case of joint adoption of platform $\mathcal{P}(\tau_1, \tau_3)$, the product market competition stage equilibrium values are the same as in (2.3).

Here, $\pi^c = (1-\epsilon\sigma c)^2/9$ is the per-firm profit under Cournot competition and $\pi^m = (1-\epsilon\sigma c)^2/4$ is the profit under monopoly at $w_{12} = w_3 = 0$.

Lemma 9 presents the equilibrium tariffs in case $S3$.[22]

Lemma 9
At a Nash equilibrium, firm 3 offers $w_3 = 0$ and $F_3 = \pi^m$. Firm 1 sets either $w_{12} = 0$ and

[21] Clearly, this holds if in the independent licensing case analyzed above firms have an equal probability of being first in making the offer. Otherwise, in the extreme case in which one firm is always the first, independent licensing and cross-licensing would imply a rather different profits' allocation.

[22] In analogy to the model with linear pricing, I am also assuming that firm 3 cannot discriminate between firm 1 and firm 2.

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$F_{12} \geq \pi^m - F_3$ or $w_{12} = (1 - \sigma\epsilon c)/2$ and $F_{12} = 0$. In both cases, $\Pi_j^{S3} = 0$, with $j = 1, 2$, $\Pi_3^{S3} = \pi^m$ and either firm 1 or firm 2 would be the downstream monopolist.

Proof. See appendix F.

Lemma 9 shows that under the adoption of standard $\mathcal{P}(\tau_1, \tau_3)$, if firms license their technologies by means of two-part tariffs then the hold-up problem is so severe that the stand-alone upstream firm is able to fully squeeze integrated firms' profits.

2.8.3 Competing Platforms: firm 1 uses $\mathcal{P}(\tau_1, \tau_3)$ and firm 2 uses $\mathcal{P}(\tau_1, \tau_2)$

The equilibrium values at the product market competition stage when firm 1 uses $\mathcal{P}(\tau_1, \tau_3)$ and firm 2 uses $\mathcal{P}(\tau_1, \tau_2)$ are the same as in (2.7).

Therefore, at $w_{12} = w_3 = 0$, if firm 1 would be the monopolist its profit would be equal to $\pi_1^m = (1 - \epsilon c)^2/4$. If firm 2 would be the monopolist, then $\pi_2^m = (1 - c)^2/4$. In the case of duopoly, an asymmetric Cournot would arise on the market, with associated payoffs given by $\pi_1^c = (1 - 2\epsilon c + c)^2/9$ and $\pi_2^c = (1 - 2c + \epsilon c)^2/9$.

Lemma 10 presents the equilibrium license fees in scenario $CP32$.

Lemma 10
At equilibrium, firm 1 sets $w_{12} = 0$ and firm 3 sets $w_3 = 0$. Moreover, the fee of firm 3 is given by $F_3 = \pi_1^c$ and firm 1 replies by setting F_{12} as to push firm 2 out of the downstream market. Consequently, $\Pi_1^{CP32} = \pi_1^m - \pi_1^c$, $\Pi_2^{CP32} = 0$ and $\Pi_3^{CP32} = \pi_1^c$.

Proof. See appendix G.

Firm 3 anticipates that if the fee it sets is too high then firm 1 would stay inactive. Firm 1 replies foreclosing the downstream market, which yields the surplus between the monopoly rent and the Cournot profit.

2.8.4 Competing Platforms: firm 1 uses $\mathcal{P}(\tau_1, \tau_2)$ and firm 2 uses $\mathcal{P}(\tau_1, \tau_3)$

The equilibrium values at the product market competition stage in case $CP23$ are given in (2.11).

If $w_{12} = w_3 = 0$, were firm 1 to be the monopolist then its profit would be equal to $\pi_1^m = (1 - c)^2/4$, instead, if firm 2 would be the monopolist then $\pi_2^m = (1 - \epsilon c)^2/4$. The per-firm Cournot profits are given by $\pi_1^c = (1 - 2c + \epsilon c)^2/9$ and $\pi_2^c = (1 - 2\epsilon c + c)^2/9$.

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Independent Licensing

Lemma 11 presents the Nash equilibrium of the licensing game in which all three firms set their tariffs non-cooperatively.

Lemma 11
At an equilibrium of the licensing game, firms set $w_{21} = w_l = w_n = 0$, $F_{21} > \pi_1^m$, $F_l + F_n \in [0, \pi_c]$, with $l, n = 3, 12$ and $l \neq n$. Therefore, firm 2 gains $\Pi_2^{CP23} = \pi_2^m - \pi_2^c$, instead firm 1 and firm 3 get $\pi_2^c/2$ each.

Proof. See Appendix H.

In this case, like in case $CP32$, firm 1 and firm 3 anticipate that by setting an aggregate fee above the Cournot profit of firm 2, this would have incentive to stay inactive. Therefore, they let 2 operate as monopolist and get its Cournot rent. As in Lemma 7, the problem of coordination between firm 1 and firm 3 is solved by assuming that thay have an equal probability to be the first in contracting with firm 2, so that each gets $\pi_2^c/2$ in expectation.

Cross-licensing

Under cross-licensing, firm 1 and firm 2 set their fees cooperatively but behave non-cooperatively at the production stage. The cooperative agreement is accepted by firms 1 and 2 if both are not made worse-off than in the non-cooperative equilibrium.

The vertically integrated firms could agree on a deal that lets firm 2 be active as monopolist and transfer part of the rents to 1 through the fee. In this case, cross-licensing would generate the same amount of total profit as in the independent licensing equilibrium, the integrated organizations would still be held-up by firm 3 and firms 1 and 2 would not improve with respect to the independent licensing case. Indeed, for the integrated firms to improve with respect to the independent licensing equilibrium it must be that the share of the rent left to firm 3 reduces. However, a profitable reply by firm 3 would be to ask a huge fee and break down the cooperative agreement.

2.8.5 Technology Choice and Welfare Analysis with Two-part tariffs

Proposition 9 presents the results of the adoption game's equilibrium analysis under public licensing contracts and two-part tariffs.

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Proposition 9

Assume that side payments are not allowed and that the choice of the technology is taken by vertically integrated firms, then the unique Nash equilibrium of the adoption game features:

i. The employment of $\mathcal{P}(\tau_1, \tau_2)$ *as technology standard if:*

$$\sigma \leq \tilde{\sigma}_{TT}(c, \epsilon).$$

ii. The adoption of competing platforms ($CP23$*) if:*

$$\sigma > \tilde{\sigma}_{TT}(c, \epsilon).$$

Proof. See Appendix I.

With two-part tariffs, vertically integrated firms employ respective technologies if σ is low, otherwise a scenario with competing platforms arises.

Two remarks must be done. The first is that *the adoption of* $\mathcal{P}(\tau_1, \tau_3)$ *is constrained efficient, so that the inefficient and total exclusion of firm 3 emerges also with two-part tariffs.* The second is that, differently from the game with linear pricing, as σ rises above $\tilde{\sigma}_{TT}(c, \epsilon)$ here the Nash equilibrium of the adoption game features case $CP23$, in which firm 1 uses τ_2 and firm 2 uses τ_3. This happens because for a given adoption of τ_3 by firm 2, firm 1's best reply is to avoid the hold-up effect and squeeze part of firm 2's downstream rent through the fee.

Figure 2.3 illustrates the results of a numerical example in which it is assumed that the marginal cost of production c is equal to $1/5$.

[FIGURE 2.3 ABOUT HERE]

For $c = 1/5$ the value of $\bar{\epsilon}(c)$ is zero, so that the relevant range of values of ϵ is given by the all unit interval. In Figure 2.3, the area marked by T is the one in which firms 1 and 2 adopt standard $\mathcal{P}(\tau_1, \tau_2)$ and exclude firm 3's technology. Instead, area CP is the one in which integrated firms adopt competing technology platforms.

2.9 Conclusion

In this Chapter, I studied the incentives that SSOs' vertically integrated firms have to employ patented technologies into their production process. The model develops on the idea that a

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pure innovator endowed with market power can hold up vertically integrated firms through the sale of an intermediate good. Integrated organizations can choose between two inputs, among which the one provided by the vertically-specialized firm is superior.

The contracting environment employed resembles the one of SSOs in several aspects and in particular in the assumption for which parties negotiate over the royalty fees after downstream manufacturers' choice and adoption of a certain technology. This timing gives a strong bargaining power to upstream suppliers whose technology is employed for the production of the final good and generates the hold-up problem.

The outcome of the welfare analysis shows that by cross-licensing their patents, integrated organizations may inefficiently exclude the pure innovator's superior technology. Moreover, the model rationalizes the pattern of SSOs' technology adoption in major sectors of the information and communications technology industry.

In the extension with two-part tariffs the outcome of the technology adoption game is affected by the incentive that a pure upstream firm with market power has to expropriate the downstream rent of an integrated organization via the provision of a complementary input. In Chapter 3, the analysis of this effect (and the profitability of vertical integration) is analyzed in greater detail.

Finally, an important policy conclusion of the Chapter is that, to kill the hold-up problem, firms in SSOs should be allowed to talk about royalties when they choose among competing technologies. Indeed, as shown in the section where a framework with ex-ante licensing is studied, the resulting choice by manufacturers features standard's efficient design. This supports the initiatives by SSOs like VITA, which recently moved towards a policy that requires the owners of patented technologies to disclose the maximum royalty rates and provide binding written license declarations at several specified points during the standard development process.

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2.10 Appendix A

The analysis can be greatly simplified by searching for the dominant strategy of firm 2. More specifically, if one compares Π_2^{S2} with Π_2^{CP23} then it turns out that the adoption of $\mathcal{P}(\tau_1, \tau_2)$ is a dominant strategy for firm 2 if σ is low enough:

$$\Pi_2^{S2} = \frac{(1-\sigma c)^2}{8} \geq \Pi_2^{CP23} = \frac{c^2(5\epsilon^2 - 10\epsilon + 14) + 9(1-2c)}{81} \iff$$

$$\sigma \leq \tilde{\tilde{\sigma}}(c,\epsilon) \equiv \frac{9 - 2\sqrt{2}\sqrt{c^2(5\epsilon^2 - 10\epsilon + 14) + 9(1-2c)}}{9c}.$$

$\tilde{\tilde{\sigma}}(c,\epsilon)$ is decreasing in c and increasing in ϵ, moreover if $c \leq .32$ then $\tilde{\tilde{\sigma}}(c,\epsilon) \geq 1$ independently from the value of ϵ.[23]

If the employment of $\mathcal{P}(\tau_1, \tau_2)$ is a dominant strategy for firm 2, then the Nash equilibirum is found by studying the choice of firm 1. In particular, firm 1 compares Π_1^{S2} with Π_1^{CP32} and it chooses $\mathcal{P}(\tau_1, \tau_2)$ if the following holds:

$$\Pi_1^{S2} = \frac{(1-\sigma c)^2}{8} \geq \Pi_1^{CP32} = 2\frac{c^2(90\epsilon^2 - 110\epsilon + 127) - 2c(35\epsilon + 72) + 107}{1681} \iff$$

$$\sigma \leq \tilde{\sigma}(c,\epsilon) \equiv \frac{41 - 4\sqrt{c^2(90\epsilon^2 - 110\epsilon + 127) - 2c(35\epsilon + 72) + 107}}{41c}.$$

With $\tilde{\sigma}(c,\epsilon) < \tilde{\tilde{\sigma}}(c,\epsilon)$, indeed

$$\tilde{\sigma}(c,\epsilon) - \tilde{\tilde{\sigma}}(c,\epsilon) < 0 \iff \Big[c(8 + 13\epsilon) - 21\Big]\Big[c(95\epsilon - 74) - 21\Big] > 0$$

holds true for all c and ϵ into the unit interval. Summarizing, if $\sigma \in (\tilde{\sigma}(c,\epsilon), \tilde{\tilde{\sigma}}(c,\epsilon)]$ the Nash equilibrium features the adoption of $\mathcal{P}(\tau_1, \tau_3)$ by firm 1 and $\mathcal{P}(\tau_1, \tau_2)$ by firm 2 ($CP32$). Instead, if $\sigma \in (0, \tilde{\sigma}(c,\epsilon)]$ the Nash equilibrium features the adoption of $\mathcal{P}(\tau_1, \tau_2)$ by firm 1 and firm 2 ($S2$).

[TABLE 2.6 ABOUT HERE]

For σ above $\tilde{\tilde{\sigma}}(c,\epsilon)$ the adoption of platform $\mathcal{P}(\tau_1, \tau_2)$ is not a dominant strategy to firm 2. More specifically, if $\sigma > \tilde{\tilde{\sigma}}(c,\epsilon)$ then $\Pi_2^{CP23} > \Pi_2^{S2}$ and $\Pi_2^{CP32} > \Pi_2^{S3} = 0$; furthermore, given that $\tilde{\tilde{\sigma}}(c,\epsilon) > \tilde{\sigma}(c,\epsilon)$, one has that $\Pi_1^{CP32} > \Pi_1^{S2}$. Hence, firm 2 employs $\mathcal{P}(\tau_1, \tau_3)$ if

[23] The fact that $\tilde{\tilde{\sigma}}(c,\epsilon) \geq 1$ for $c \leq .32$ implies that the analysis of the Nash equilibrium for σ above $\tilde{\tilde{\sigma}}(c,\epsilon)$ is relevant only if $c > .32$.

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firm 1 chooses $\mathcal{P}(\tau_1, \tau_2)$, instead, firm 2 adopts $\mathcal{P}(\tau_1, \tau_2)$ if firm 1 uses $\mathcal{P}(\tau_1, \tau_3)$. At the same time, if firm 2 chooses $\mathcal{P}(\tau_1, \tau_2)$, then firm 1 chooses $\mathcal{P}(\tau_1, \tau_3)$ and if firm 2 chooses $\mathcal{P}(\tau_1, \tau_3)$, then firm 1 decides by comparing Π_1^{S3} and Π_1^{CP23}. In this latter case, it turns out that Π_1^{S3} is bigger than Π_1^{CP23} for $\sigma > \tilde{\tilde{\sigma}}(c, \epsilon)$.[24]

Summarizing, if $\sigma > \tilde{\tilde{\sigma}}(c, \epsilon)$ the Nash equilibrium of the technology adoption game is at $CP32$, instead case $S3$ does not arise at equilibrium. ■

2.11 Appendix B

In the following, it is analyzed the choice of the benevolent planner for given results of the second and third stage of the game. In particular, the planner decides by comparing the social surplus generated by the four cases of technology adoption.

First of all, it is useful to establish a result that simplifies the analysis below: the total welfare generated by case $CP23$ is smaller than the one associated with case $CP32$. Indeed, the difference between TS^{CP32} and TS^{CP23} can be rewritten as:

$$TS^{CP32} - TS^{CP23} = \frac{[c(8 + 13\epsilon) - 21][c(1,627\epsilon - 1,156) - 471]}{272,322} > 0 \quad \forall c, \epsilon \in (0, 1).$$

Consequently, in the following I can focus on cases $S2$, $S3$ and $CP32$. $S2$ is more efficient than $S3$ if the following holds:

$$TS^{S2} = \frac{3(1 - \sigma c)^2}{8} \geq TS^{S3} = \frac{12(1 - \epsilon\sigma c)^2}{49} \iff \sigma \leq \bar{\sigma}(c, \epsilon) \equiv \frac{7 - 4\sqrt{2}}{c(7 - 4\sqrt{2}\epsilon)},$$

$\bar{\sigma}(c, \epsilon)$ is decreasing in c and increasing in ϵ, moreover $\bar{\sigma}(c, \epsilon) \geq 1$ for all $c \in (0, .19]$ and $\epsilon \in (0, 1)$.

Now I check whether case $CP32$ delivers a bigger total surplus than $S3$ and $S2$ above and below $\bar{\sigma}(c, \epsilon)$, respectively. In particular, by using the standard quadratic formula for σ and taking the root whose value lies into the unit interval, it turns out that $S2$ is more efficient than $CP32$ if the following holds:

$$TS^{S2} = \frac{3(1 - \sigma c)^2}{8} \geq TS^{CP32} = 4\frac{c^2(139\epsilon^2 - 138\epsilon + 131) - 4c(31 + 35\epsilon) + 132}{1681} \iff$$

$$\sigma \leq \bar{\bar{\sigma}}(c, \epsilon) \equiv \frac{123 - 4\sqrt{6}\sqrt{c^2(139\epsilon^2 - 138\epsilon + 131) - 4c(31 + 35\epsilon) + 132}}{123c}.$$

[24]The proof of this last step is not presented here because not essential to the result that $S3$ does not emerge as Nash equilibrium of the adoption game, but can be provided by the author if requested.

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$\bar{\bar{\sigma}}(c,\epsilon)$ is decreasing in c and increasing in ϵ.

$S3$ is more efficient than $CP32$ if the following holds:

$$TS^{S3} = \frac{12(1-\epsilon\sigma c)^2}{49} \geq TS^{CP32} = 4\frac{c^2(139\epsilon^2 - 138\epsilon + 131) - 4c(31+35\epsilon) + 132}{1681} \iff$$

$$\sigma \leq \bar{\bar{\bar{\sigma}}}(c,\epsilon) \equiv \frac{123 - 7\sqrt{3}\sqrt{c^2(139\epsilon^2 - 138\epsilon + 131) - 4c(31+35\epsilon) + 132}}{123\epsilon c}.$$

$\bar{\bar{\bar{\sigma}}}(c,\epsilon)$ is increasing in c for all $c \in (.43, 1)$ and decreasing in ϵ if $1 > \epsilon > \bar{\epsilon}(c) > 0$.

The function that generates the locus of points in which $\bar{\bar{\sigma}}(c,\epsilon)$ and $\bar{\bar{\bar{\sigma}}}$ cross $\bar{\sigma}(c,\epsilon)$ is the same. Indeed, after simple algebra manipulations one finds that:

$$\bar{\bar{\sigma}}(c,\epsilon) = \bar{\sigma}(c,\epsilon) = \bar{\bar{\bar{\sigma}}}(c,\epsilon) \iff$$

$$c^2(139\epsilon^2 - 138\epsilon + 131) - 4c(31+35\epsilon) + 132 = \Big[\frac{123(1-\epsilon)}{\sqrt{3}(7-4\sqrt{2}\epsilon)}\Big]^2 \tag{2.16}$$

The function $c(\epsilon)$ along which $\bar{\bar{\sigma}}(c,\epsilon)$ and $\bar{\bar{\bar{\sigma}}}(c,\epsilon)$ cross $\bar{\sigma}(c,\epsilon)$ is obtained by solving (2.16), which is a quadratic equation in c whose coefficients are functions of ϵ. Applying the quadratic formula and taking the root that lies below $\bar{c}(\epsilon) = 3/(7-4\epsilon)$,[25] one has that the relevant solution to (2.16) is given by $c_W(\epsilon)$:

$$c_W(\epsilon) = \frac{0.552 + 0.177\epsilon - 0.504\epsilon^2 - 0.662(1-\epsilon)\sqrt{(0.005+\epsilon)(1.359+\epsilon)}}{(1.237-\epsilon)[0.942-(0.993-\epsilon)\epsilon]}.$$

The function $c_W(\epsilon)$ is convex in ϵ; in particular, it is decreasing in ϵ for all $\epsilon \in (0, .22)$ and increasing for all $\epsilon \in (.22, 1)$. Furthermore, $c_W(0) = \bar{c}(0) = .43$, $c_W(.22) = .33$ and $c_W(1) = \bar{c}(1) = 1$. Hence, $\bar{\bar{\sigma}}(c,\epsilon)$ and $\bar{\bar{\bar{\sigma}}}(c,\epsilon)$ do not cross $\bar{\sigma}(c,\epsilon)$ if $c \leq .33$, they cross $\bar{\sigma}(c,\epsilon)$ twice if $c \in (.33, .43]$ and once if $c \in (.43, 1)$. The graph of $c_W(\epsilon)$ is in Figure 2.4.

[FIGURE 2.4 ABOUT HERE]

$\bar{\sigma}(c,\epsilon) \geq \bar{\bar{\sigma}}(c,\epsilon)$ and $\bar{\sigma}(c,\epsilon) \geq \bar{\bar{\bar{\sigma}}}(c,\epsilon)$ if the following holds:

$$c^2(139\epsilon^2 - 138\epsilon + 131) - 4c(31+35\epsilon) + 132 \geq \Big[\frac{123(1-\epsilon)}{\sqrt{3}(7-4\sqrt{2}\epsilon)}\Big]^2$$

[25] $\bar{c}(\epsilon)$ is the inverse of $\bar{\epsilon}(c)$ and $\bar{\epsilon}(c)$ is the lower bound of ϵ specified in Assumption 4.

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and above inequality is satisfied for all $c \leq c_W(\epsilon)$.[26] The characterization of the areas of constrained maximum welfare follows. To start with, one has that:

$$\forall c \in (0, .33),\ \epsilon \in (0,1), \quad \bar{\sigma}(c,\epsilon) > \bar{\bar{\sigma}}(c,\epsilon) > \bar{\bar{\bar{\sigma}}}(c,\epsilon)$$

Above $\bar{\sigma}(c,\epsilon)$, $CP32$ is more efficient than $S3$ because $\bar{\sigma}(c,\epsilon)$ lies above $\bar{\bar{\bar{\sigma}}}(c,\epsilon)$.[27] Below $\bar{\sigma}(c,\epsilon)$, $S2$ is more efficient than $S3$, however $CP32$ is more efficient than $S2$ into the interval $(\bar{\bar{\sigma}}(c,\epsilon), \bar{\sigma}(c,\epsilon))$. Thus, the planner would decide as in what follows:

i. If $\sigma \in (0, \bar{\bar{\sigma}}(c,\epsilon)]$, then TS^{S2} is bigger than TS^{S3} and TS^{CP32} and the planner would adopt $\mathcal{P}(\tau_1, \tau_2)$ as technology standard;

ii. If $\sigma \in [\bar{\bar{\sigma}}(c,\epsilon), 1)$, then TS^{CP32} is bigger than TS^{S2} and TS^{S3} and the planner would adopt competing platforms.

Instead, for $c \in [.33, 1)$ the three functions of interest $(\bar{\sigma}(c,\epsilon), \bar{\bar{\sigma}}(c,\epsilon), \bar{\bar{\bar{\sigma}}}(c,\epsilon))$ cross each other at least once. In particular, one has that,

$$\begin{gathered}
\forall c \in [.33, .43) \qquad \exists \qquad (\hat{\epsilon}_1, \hat{\epsilon}_2) \in (0,1) \quad s.t. \\
\bar{\bar{\sigma}}(c,\epsilon) < \bar{\sigma}(c,\epsilon) \quad \forall \epsilon \in (0, \hat{\epsilon}_1) \cup (\hat{\epsilon}_2, 1) \quad and \quad \bar{\bar{\bar{\sigma}}}(c,\epsilon) > \bar{\sigma}(c,\epsilon) \quad \forall \epsilon \in (\hat{\epsilon}_1, \hat{\epsilon}_2), \\
\forall c \in (.43, 1) \quad \exists \quad \hat{\epsilon} \in (0,1) \quad s.t. \\
\bar{\bar{\sigma}}(c,\epsilon) < \bar{\sigma}(c,\epsilon) \quad \forall \epsilon \in (\hat{\epsilon}, 1) \quad and \quad \bar{\bar{\bar{\sigma}}}(c,\epsilon) > \bar{\sigma}(c,\epsilon) \quad \forall \epsilon \in (\bar{\epsilon}, \hat{\epsilon}).
\end{gathered}$$

Hence, for $c \in [.33, 1)$ the areas of (constrained) maximum welfare are as in what follows:

i. TS^{S2} is bigger than TS^{S3} and TS^{CP32} in:
$\{(\epsilon,\sigma)| \quad \sigma \in (0, \bar{\sigma}(c,\epsilon)]\} \quad \setminus \quad \{(\epsilon,\sigma)| \quad \sigma \in (\bar{\bar{\sigma}}(c,\epsilon), \min\{\bar{\sigma}(c,\epsilon), 1\})\}$;

ii. TS^{S3} is bigger than TS^{S2} and TS^{CP32} in:
$\{(\epsilon,\sigma)| \quad \sigma \in [\bar{\sigma}(c,\epsilon), 1)\} \quad \setminus \quad \{(\epsilon,\sigma)| \quad \sigma \in (\max\{\bar{\sigma}(c,\epsilon), \bar{\bar{\bar{\sigma}}}(c,\epsilon)\}, 1)\}$;

iii. TS^{CP32} is bigger than TS^{S2} and TS^{S3} in:
$\{(\epsilon,\sigma)| \quad \sigma \in (\bar{\bar{\sigma}}(c,\epsilon), \min\{\bar{\sigma}(c,\epsilon), 1\})\} \quad \cup \quad \{(\epsilon,\sigma)| \quad \sigma \in (\max\{\bar{\sigma}(c,\epsilon), \bar{\bar{\bar{\sigma}}}(c,\epsilon)\}, 1)\}$.

The characterization of the efficient cases above determines the choice of the benevolent planner, moreover it embeds the case with c smaller than .33 as a special case, in which $\bar{\sigma}(c,\epsilon)$ is bigger than $\bar{\bar{\bar{\sigma}}}(c,\epsilon)$ and $\bar{\bar{\sigma}}(c,\epsilon)$, and the set in which $S3$ is more efficient than $CP32$ is empty.■

[26] Notice that the coefficient attached to the squared term, equal to $(139\epsilon^2 - 138\epsilon + 131)$, is positive for $\epsilon \in (0,1)$.

[27] Remind that case $S3$ is more efficient than $CP32$ only if σ lies below $\bar{\bar{\bar{\sigma}}}(c,\epsilon)$.

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2.12 Appendix C

To prove that the total exclusion of τ_3 from the standard can be inefficient, it has to be shown that the area in which $\bar{\sigma}(c,\epsilon)$ lies below $\tilde{\sigma}(c,\epsilon)$ is not empty for some values of c and ϵ. If this is the case, the adoption of $\mathcal{P}(\tau_1,\tau_3)$ as technology standard ($S3$) is more efficient than the Nash equilibrium featuring the joint employment of $\mathcal{P}(\tau_1,\tau_2)$ ($S2$). More specifically,

$$\tilde{\sigma}(c,\epsilon) \leq \bar{\sigma}(c,\epsilon) \iff$$

$$c^2(90\epsilon^2 - 110\epsilon + 127) - 2c(72+35\epsilon) + 107 \geq \left[\frac{41\sqrt{2}(1-\epsilon)}{(7-4\sqrt{2}\epsilon)}\right]^2 \tag{2.17}$$

Like in the proof of Lemma 1, the function $c(\epsilon)$ along which $\bar{\sigma}(c,\epsilon)$ crosses $\tilde{\sigma}(c,\epsilon)$ is obtained by solving a quadratic equation in c whose coefficients are functions of ϵ. Applying the quadratic formula and taking the root that lies below $\bar{c}(\epsilon) = 3/(7-4\epsilon)$ one has that the function that solves (2.17) with an equality is given by $c_N(\epsilon)$:

$$c_N(\epsilon) = \frac{0.9899 - (0.3188 + 0.3889\epsilon)\epsilon - 0.3602(1-\epsilon)\sqrt{(0.0514+\epsilon)(8.7475+\epsilon)}}{(1.2374-\epsilon)[1.4111-(1.2222-\epsilon)\epsilon]}.$$

Moreover, (2.17) is satisfied for all $c \leq c_N(\epsilon)$.[28] The function $c_N(\epsilon)$ is convex in ϵ; in particular, it is decreasing in ϵ for all $\epsilon \in (0,.22)$ and increasing for all $\epsilon \in (.22,1)$. Also, $c_N(0) = \bar{c}(0) = c_W(0) = .43$, $c_N(.22) = .38 > c_W(.22) = .33$ and $c_N(1) = \bar{c}(1) = c_W(1) = 1$. Hence, $c_N(\epsilon)$ lies above $c_W(\epsilon)$. The graphs of $c_N(\epsilon)$ and $c_W(\epsilon)$ are in Figure 2.5.

[FIGURE 2.5 ABOUT HERE]

Summarizing, there is a wedge between the area in which $S3$ is more efficient than $S2$ and the one in which $S2$ is employed by vertically integrated firms; more specifically, such wedge arises for $c > .38$. Also, the fact that $c_N(\epsilon)$ lies above $c_W(\epsilon)$ implies that this wedge lies (at least partly) in the area in which $S3$ is more efficient than $CP32$. Indeed, for any $c > .38$, the value of ϵ in which $\bar{\sigma}(c,\epsilon)$ crosses $\bar{\bar{\bar{\sigma}}}(c,\epsilon)$ and $\bar{\bar{\sigma}}(c,\epsilon)$ is different than the one in which $\bar{\sigma}(c,\epsilon)$ crosses $\tilde{\sigma}(c,\epsilon)$ (in particular, it is strictly bigger if $c > .43$). All this implies that the area of inefficient total exclusion of $\mathcal{P}(\tau_1,\tau_3)$ is not empty. ■

[28]Indeed, the coefficient attached to the squared term, given by $(90\epsilon^2 - 110\epsilon + 127)$, is positive for $\epsilon \in (0,1)$.

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2.13 Appendix D

Solving the game backwards, the equilibrium values at the product market competition stage when integrated firms choose $\mathcal{P}(\tau_1, \tau_2)$ are the same as in (2.1), those in case of joint adoption of $\mathcal{P}(\tau_1, \tau_3)$ are given in (2.3) and those related to the cases with competing platforms are in (2.7) and (2.11).

At the royalty setting stage, firm 1 sets a monopoly royalty rate, to push firm 2 out of the market. Instead, firms 2 and 3 compete for the adoption by manufacturers. Firm 2 can offer to firm 1 to cross-license their technologies, however, in this case firms 1 and 2 are not symmetric; firm 2 is constrained by the offer that firm 3 can make to 1 for the employment of τ_3. Consequently, the agreement in this case cannot consist of equally sharing the monopoly profit, instead firm 2 accepts to let firm 1 squeeze all the rents from using technology standard $\mathcal{P}(\tau_1, \tau_2)$, so to increase the chances for the adoption of its technology. Analogously, in all other cases perfect competition between 2 and 3 leads to an equilibrium in which firm 3 leaves manufacturers just indifferent between using τ_2 and τ_3.

[TABLE 2.7 ABOUT HERE]

In all cases, firm 1 would be the monopolist and firm 2 would be left with a nil payoff. In particular, if $\mathcal{P}(\tau_1, \tau_3)$ would be the technology standard then firm 1 would raise $(1-\epsilon\sigma c)^2/4$ and if $\mathcal{P}(\tau_1, \tau_2)$ would be the technology standard then firm 1 would raise $(1-\sigma c)^2/4$. In the case with competing platforms $CP32$ firm 1 would obtain a payoff equal to $(1-\epsilon c)^2/4$, and in the case with competing platforms $CP23$ firm 1 would gain $(1-c)^2/4$.

Finally, by assuming that indifference is broken in favor of the more efficient technology one has the result in the proposition, i.e., $\mathcal{P}(\tau_1, \tau_3)$ is adopted as technology standard at equilibrium. ■

2.14 Appendix E

To start with, notice that were firm j to set $w_{jk} > 0$ it would raise the royalty rate to kick k out of the market and be monopolist. Then, the best reply by k would be to set $F_{kj} = \pi^m$ and get firm j's downstream rent.

Instead, were $w_{jk} = w_{kj} = 0$, in order to determine the equilibria of the licensing game, I analyze firm k's best response to the fixed fee F_{jk} set by firm j.[29] There are two relevant

[29] Due to symmetry, the firm j's best response will be analogous.

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thresholds: the Cournot profit, indexed by π^c, and the monopoly profit, indexed by π^m. Consequently, three cases must be considered.

1. If $0 < F_{jk} < \pi^c$ firm k would always be active. More specifically, were it to set $F_{kj} > \pi^c$, it would be a monopolist and attain profit equal to $\pi^m - F_{jk} > 0$. Instead, were k to set $F_{kj} = \pi^c$, it would be duopolist and obtain profit equal to $2\pi^c - F_{jk} > 0$. Therefore, the best response by k to $F_{jk} < \pi^c$ is to set $F_{kj} > \pi^c$, at which k would earn $\Pi_k = \pi^m - F_{jk}$. This is optimal because $\pi^m > 2\pi^c$. If $F_{kj} > \pi^c$, firm j would stay out of the market and earn $\Pi_j = F_{jk}$.

2. If $\pi^c \leq F_{jk} < \pi^m$ firm k would be active only if monopolist, instead it would not find it profitable to produce if duopolist. In particular, were firm k to set $F_{kj} > \pi^m$, it would be a monopolist and gain $\pi^m - F_{jk}$. If k would set $F_{kj} = \pi^m$, it would stay out of the market, but it would fully extract j's monopoly profit. Finally, k may set $F_{kj} < \pi^m$, at which it would be out and have incentive to raise its fee further. Therefore, the best response by k to $\pi^c \leq F_{jk} < \pi^m$ is to set $F_{kj} = \pi^m$, at which j would be the monopolist and k would squeeze all its profit, gaining $\Pi_k = F_{kj}$.

3. If $F_{jk} \geq \pi^m$, firm k is out of the market, independently from the fee it sets. Therefore, k's optimal response is to set $F_{kj} = \pi^m$, stay out, but extract all downstream revenue from the rival.

Equilibrium. Under independent licensing and technologies τ_1 and τ_2 in the standard the Nash equilibria of the licensing game are given by:

i. $w_{jk} = (1 - \sigma c)/2, w_{kj} = 0,\ F_{jk} = 0, F_{kj} = \pi^m$ and $w_{jk} = w_{kj} = 0,\ F_{jk} = F_{kj} = \pi^m$: at these equilibria firm j is in, firm k is out, but extracts all downstream profits from firm j. Moreover, $\Pi_j = 0, \Pi_k = \pi^m$.

ii. $w_{jk} = w_{kj} = 0$ and $F_{jk} = \pi^m, F_{kj} \in [\pi^c, \pi^m)$, at which firm j is out and firm k is in. At this equilibrium, $\Pi_j = \pi^m$, $\Pi_k = 0$. However, k does not have any incentive to deviate if and only if when it sets $F_{kj} = \pi^m$ it anticipates that the continuation equilibrium is such that $\Pi_k^{S2} = 0$.

Finally, notice that there does not exist any equilibrium where $w_{kj} = w_{jk} = 0$ and $F_{jk} < \pi^c$, $F_{kj} > \pi^c$, as the best reply to $F_{kj} > \pi^c$ would be to set $F_{jk} = \pi^m$. ■

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2.15 Appendix F

First of all, notice that by a standard argument, firm 3 sets $w_3 = 0$ not to distort firm 1's production decisions and tamper downstream rent. Now, if firm 1 sets w_{12} as to monopolize the downstream market it would have all its downstream rent extracted by 3 through the fixed fee.

Instead, if $w_{12} = w_3 = 0$, firm 1 and firm 3 would compete over the fixed fee. In the following, I present the best responses of firm 1 to the fee set by firm 3.

1. If $0 < F_3 < \pi^c$, firm 1 would always be active. The royalty setting game sees firm 1 competing with firm 3. Two responses are possible by 1: the first would be to set $F_{12} > \pi^c - F_3$, at which firm 2 would not operate, the second would be to set $F_{12} \leq \pi^c - F_3$, at which both firms would be active. In the former case firm 1 would gain $\pi^m - F_3$, firm 2's payoff would be nil and firm 3 would extract F_3 from 1. In the latter case, the profit of firm 1 would be equal to $\pi^c - F_3 + F_{12} = 2\pi^c - 2F_3 = 0$, those of firm 2 would be given by $\pi^c - F_3 - F_{12} = 0$, instead firm 3 would extract $2\pi^c$. Clearly, 1's best response is to set $F_{12} > \pi^c - F_3$, operate as monopolist and gain profit $\Pi_1 = \pi^m - F_3 > 0$.

2. If $\pi^c \leq F_3 < \pi^m$, firm 1 would be active only if monopolist. Setting $F_{12} > \pi^m - F_3$, firm 1 would force firm 2 to stay out of the market and gain $\pi^m - F_3$, instead firm 3 would extract F_3 from 1. Otherwise, setting $F_{12} = \pi^m - F_3$, firm 1 would stay out and extract 2's profit, firm 2, although monopolist, would be left with zero profits, firm 3 would gain F_3 from 2. Therefore, firm 1 optimal response is to fix $F_{12} \geq \pi^m - F_3$, at which either 1 or 2 would be monopolist, but firm 2 would make zero profit in any case, firm 3 would get $\Pi_3 = F_3$ and firm 1's payoff would be equal to $\Pi_1 = \pi^m - F_3$.

3. If $F_3 \geq \pi^m$, firm 1 and firm 2 stay out of the market. Therefore, all firms would earn zero profit.

Equilibrium. First notice that it is a dominant strategy for firm 3 to set $F_3 = \pi^m - \eta$, with $\eta > 0$, small. Consequently, it is an equilibrium for firm 1 to set either $w_{12} = 0$ and $F_{12} = \pi^m - F_3$ or $w_{12} = 0$ and $F_{12} > \pi^m - F_3$ or $w_{12} = (1 - \sigma\epsilon c)/2$ and $F_{12} = 0$: in the first case, 1 would let 2 be a monopolist, but extract all 2's profit (net of F_3, of course), in the second and third cases, 1 would be a monopolist. However, in all three cases the payoff of 1 would be given by $\Pi_1^{S3} = \eta$, instead $\Pi_2^{S3} = 0$ and $\Pi_3^{S3} = F_3 = \pi^m - \eta$. Finally, by focusing on η equal to zero one has the results in the Lemma.

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Remark. One may find counterintuitive that firm 3 takes all the industry profit and firm 1, which has a complementary technology, takes none, and also wonder whether there exist other equilibria where firm 1 is able to extract a part of the industry surplus. In fact, this never occurs. Suppose there is a candidate equilibrium where firm 1 sets $F_{12} = k\pi^m$ and firm 3 sets $F_3 = (1-k)\pi^m$, with $k \in (0, 1]$.[30] At this equilibrium, firm 3 would obtain a payoff equal to $F_3 = (1-k)\pi^m$, but it would have an incentive to deviate and set $F_3^{'} = \pi^m$. If $F_{12} = k\pi^m, F_3^{'} = \pi^m$, firm 2 would never produce because it would not be able to recover the cost of the fees, even if firm 1 does not produce. Instead, if firm 1 produces it will not have to pay the fee for the use of technology 1, so there is a continuation equilibrium where firm 1 sells and firm 2 does not and firm 1 transfers all the monopoly profit to firm 3 through the fee. This shows that the unique equilibrium consists in the one identified above where firm 3 extracts all the monopolistic rents from the industry. ■

2.16 Appendix G

Like in case $S3$ (see Lemma 9), the royalty setting game sees firm 1 competing with firm 3. However, firm 2 now does not employ technology 3.

Firm 3 sets $w_3 = 0$ at equilibrium, not to distort firm 1's operations downstream. If firm 1 replies by setting w_{12} as to monopolize the downstream market it would have all its rent extracted by 3 through the fixed fee.

Instead, if $w_{12} = w_3 = 0$, then firm 1 and firm 3 would compete over the fixed fee. In the following, I present the best responses of firm 1 to the fee set by firm 3 at $w_{12} = w_3 = 0$.

1. If $0 < F_3 \leq \pi_1^c$, firm 1 would always be active. The possible responses by 1 follow. The first would be to set $F_{12} > \pi_2^c$, at which firm 2 would not operate. The second would be to shed π_2^c by η, positive and negligible, be active with 2 on the product market and squeeze its Cournot profit.[31] In the former case firm 1 would gain $\pi_1^m - F_3 = \pi_1^m - \pi_1^c$, firm 2's payoff would be nil and firm 3 would extract F_3 from 1. In the latter case, the profit of firm 1 would be equal to $\pi_1^c - F_3 + F_{12} = \pi_1^c + \pi_2^c - \pi_1^c$, the one of firm 2 would be given by $\pi_2^c - F_{12} = 0$, instead firm 3 would get F_3. The best response of 1 is to set $F_{12} > \pi_2^c$, operate as monopolist and gain $\Pi_1 = \pi_1^m - \pi_1^c$. Indeed, $\pi_1^m - \pi_1^c > \pi_2^c$ under Assumption 4.

[30] In the continuation equilibria, either firm 1 is the monopolistic supplier, gaining $\pi^m - (1-k)\pi_m = k\pi^m$, or firm 2 is the monopolistic supplier, with firm 1 gaining $k\pi^m$. In both cases $\pi_3 = (1-k)\pi^m$.

[31] Notice that a third one would be to set $F_{12} < \pi_2^c$, but then 1 would have incentive to raise the fee further.

2. If $\pi_1^c < F_3 \leq \pi_1^m$, firm 1 would be active only if monopolist. Setting $F_{12} > \pi_2^m$, firm 1 would force firm 2 to stay out of the market and gain $\pi_1^m - F_3$, instead firm 3 would extract F_3 from 1. Otherwise, setting $F_{12} = \pi_2^m - \eta$, firm 1 would stay out and extract 2's profit, and firm 2, although monopolist, would be left with a zero payoff. Therefore, firm 1 optimal response is to fix $F_{12} = \pi_2^m - \eta$, at which firms' payoffs are $\Pi_1 = \pi_2^m - \eta$, $\Pi_2 = \eta$ and $\Pi_3 = 0$.

3. If $F_3 > \pi_1^m$, firm 1 would always stay out of the market. If firm 1 would set $F_{12} > \pi_2^m$, then firm 1 and firm 2 would be out of the market. Instead, if 1 would set $F_{12} = \pi_2^m - \eta$, 1 would stay out and extract firm 2's profit thorough the fee. Clearly, 1's best response is to set $F_{12} = \pi_2^m - \eta$, at which 3 and 2 would be left with nothing.

Equilibrium. At equilibrium, firm 1 sets $w_{12} = 0$ and firm 3 sets $w_3 = 0$. Moreover, the fee of firm 3 is given by $F_3 = \pi_1^c$ and firm 1 replies by setting F_{12} as to push firm 2 out of the downstream market. Consequently, $\Pi_1^{CP32} = \pi_1^m - \pi_1^c$, $\Pi_2^{CP32} = 0$ and $\Pi_3^{CP32} = \pi_1^c$.■

2.17 Appendix H

In case $CP23$, all three firms are active upstream: firm 1 licenses τ_1 to firm 2, firm 2 licenses τ_2 to firm 1 and firm 3 licenses τ_3 to firm 2.

Like in Lemmata 9 and 10, firm 3 sets $w_3 = 0$. If $w_{12} = 0$, were firm 2 to set a positive value of w_{21} then it would try to monopolize the downstream market. In this case, firms 1 and 3 would equally share π_2^m.[32]

If w_{21} were nil and firm 1 would reply by setting a positive value of w_{12}, then it would be firm 1 that tries to monopolize the downstream market. However, in this case it is firm 2 that gets the entire rent from 1, equal to π_1^m.

Now, if $w_{21} = w_{12} = 0$, firms 1, 2 and 3 would compete over the value of the fixed fee. Below, I analyze firm 2 best response to the fixed fees F_n and F_l set by 3 and 1, with $l, n = 3, 12$ and $l \neq n$.

1. If $0 \leq F_l \leq \pi_2^c$ and $0 \leq F_n \leq \pi_2^c - F_l$, then 2 is always active. Firm 2 can reply setting $F_{21} = \pi_1^c$, then both vertically integrated firms would be active downstream and firm 2 would gain $\Pi_2 = \pi_2^c - F_l - F_n + F_{21} = \pi_1^c$.[33] If firm 2 would set $F_{21} > \pi_1^c$, then it would

[32] Here, I am using the assumption for which firm 1 and firm 3 have equal probability of being first in approaching firm 2, as in case $S2$.

[33] Notice that if firm 2 would set a fee smaller than the Cournot rent, it would have incentive to raise it further.

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be monopolist and get $\pi_2^m - \pi_2^c$. Thus, the best response of firm 2 is to set $F_{21} > \pi_1^c$. Indeed, it can be shown that $\pi_2^m > \pi_2^c + \pi_1^c$ under Assumption 4. At this response, the firm that sets F_l gets $\Pi_l \in [0, \pi_2^c]$ and the firm that sets F_n gets $\Pi_n \in [0, \pi_2^c - F_l]$. The coordination problem that arises in this case is again solved by assuming that firm 1 and firm 3 have an equal probability to be the first in contracting with firm 2, like in Lemma 7, so that each firm gets $\pi_2^c/2$ in expectation.

2. If $0 \leq F_l \leq \pi_2^c$ and $\pi_2^c < F_n \leq \pi_2^m - F_l$, then 2 is active only if monopolist. Thus, firm 2 can reply setting $F_{21} = \pi_1^m - \eta$, with η positive and negligible, let firm 1 be monopolist and get π_1^m. Instead, if firm 2 would set $F_{21} > \pi_1^m$, it would be monopolist and gain $\pi_2^m - F_l - F_n = 0$. Hence, the best response of firm 2 is to set $F_{21} = \pi_1^m - \eta$, let 1 be the monopolist and squeeze its downstream profit.

3. If $\pi_2^c < F_l \leq \pi_2^m$ and $\pi_2^c < F_n \leq \pi_2^m - F_l$, then 2 is active only if monopolist. The analysis carries over as in the previous case, thus firm 2's best response is to set $F_{21} = \pi_1^m - \eta$ and let 1 be the monopolist.

4. If $\pi_2^c < F_l \leq \pi_2^m$ and $F_n > \pi_2^m - F_l$, then firm 2 is always out. Consequently, firm 2 would let firm 1 be active as monopolist and squeeze its downstream profit.

Therefore, under $w_{21} = w_{12} = 0$, it is a dominant strategy to firm 1 and firm 3 to set F_l and F_n such that $F_l + F_n \in [0, \pi_c]$, because for a bigger aggregate fee the best response of firm 2 would be to stay inactive and get firm 1 profit by setting $F_{21} = \pi_1^m - \eta$. Consequently, at an equilibrium with $w_{21} = w_{12} = 0$, firm 2 is monopolist and gains $\pi_2^m - \pi_2^c$, instead firm 1 and firm 3 equally share the Cournot profit of firm 2.

The last case to consider is the one at which $w_{21} > 0$ and $w_{12} > 0$. In this case, by using the results in Appendix A of the model with linear price and using $w_3 = 0$, one has that:

$$w_{12}(w_{21}) = \frac{5 - c(4\epsilon + 1) - w_{21}}{10}, \quad w_{21}(w_{21}) = \frac{5 - c(4 + \epsilon) - w_{12}}{10}.$$

Then,

$$\begin{cases} w_{12}^{CP23} = \frac{15 - c(2 + 13\epsilon)}{33} \\ w_{21}^{CP23} = \frac{15 - c(2\epsilon + 13)}{33} \end{cases} \tag{2.18}$$

and

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$$\begin{cases} q_1^{CP23} = \frac{2[3-c(7-4\epsilon)]}{33} \\ q_2^{CP23} = \frac{2[3-c(7\epsilon-4)]}{33}. \end{cases} \tag{2.19}$$

With q_1^{CP23} positive under Assumption 4. Consequently, the profits of firm 1 and firm 2 (gross of the fixed fees) are:

$$\begin{cases} \Pi_1^w = (q_2^{CP23})^2 + q_2^{CP23} w_{12}^{CP23} = \frac{2[21-2c(16\epsilon+5)+c^2(41\epsilon^2-50\epsilon+30)]}{363} \\ \Pi_2^w = (q_1^{CP23})^2 + q_1^{CP23} w_{21}^{CP23} = \frac{2[21-2c(16+5\epsilon)+c^2(41-50\epsilon+30\epsilon^2)]}{363} \end{cases} \tag{2.20}$$

Finally, by following the same procedure as in the case with $w_{21} = w_{12} = 0$, one would find that here the fixed fees would be such that firm 2 gets Π_1^w instead firm 1 and firm 3 equally share Π_2^w. Indeed, either firm 1 or firm 3 do not have incentive to deviate because by setting a higher fee firm 2 would stay inactive, let firm 1 be the monopolist and squeeze its profit. At the same time, firm 2 does not deviate and sets a higher fee on firm 1 because, given $w_{12} = w_{12}^{CP23} > 0$, its profit under monopoly is smaller than the sum of Π_1^w and Π_2^w.[34]

Equilibrium. The equilibrium in case $CP23$ is one at which $w_{21} = w_{12} = w_3 = 0$, $F_{21} > \pi_1^m$, and F_l and F_n are such that $F_l + F_n \in [0, \pi_c]$. Therefore, firm 2 gains $\Pi_2^{CP23} = \pi_2^m - \pi_2^c$, instead firm 1 and firm 3 get $\pi_2^c/2$ each. Notice that firms 1 and 2 do not have incentive to unilaterally deviate and set $w_{ij} > 0$ (with $i \neq j$ and $i, j = 1, 2$) because they would be left with a nil payoff. Also, the case in which both w_{21} and w_{12} are positive is not an equilibrium because firm 1 would have incentive to deviate, set $w_{12} = 0$ and gain $\pi_2^m/2 > \Pi_2^w/2$. ■

2.18 Appendix I

The adoption of $\mathcal{P}(\tau_1, \tau_2)$ as technology standard emerges at equilibrium if the following condition holds (see Table 2.8):

[TABLE 2.8 ABOUT HERE]

[34]The profit of a monopolist firm 2 at $w_{12} = w_{12}^{CP23}$ is equal to $[(9 + c - 10c\epsilon)/33]^2$.

$$\begin{aligned}
\frac{(1-\sigma c)^2}{8} &\geq \frac{(1-\epsilon c)^2}{4} - \frac{[1-c(2\epsilon-1)]^2}{9} \iff \\
\frac{(1-\sigma c)^2}{8} &\geq \frac{[1-c(2-\epsilon)][5-c(7\epsilon-2)]}{36} \iff \\
\sigma &\leq \tilde{\sigma}_{TT}(c,\epsilon) \equiv \frac{3-\sqrt{2}\sqrt{[1-c(2-\epsilon)][5-c(7\epsilon-2)]}}{3c}.
\end{aligned}$$

Otherwise, both firms have incentive to deviate from an equilibrium featuring the joint employment of τ_2. In particular, if $\sigma > \tilde{\sigma}_{TT}(c,\epsilon)$ strategy $\mathcal{P}(\tau_1,\tau_3)$ becomes weakly dominant to firm 2 and case $(CP23)$ emerges as Nash equilibrium of the adoption game. ■

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2.19 Tables and Figures

Table 2.1: Manufacturers' Marginal Cost of Production

		Firm 2	
		$\mathcal{P}(\tau_1, \tau_2)$	$\mathcal{P}(\tau_1, \tau_3)$
Firm 1	$\mathcal{P}(\tau_1, \tau_2)$	$\sigma c, \sigma c$	$c, \epsilon c$
	$\mathcal{P}(\tau_1, \tau_3)$	$\epsilon c, c$	$\epsilon\sigma c, \epsilon\sigma c$

Table 2.2: Results under the joint adoption of $\mathcal{P}(\tau_1, \tau_2)$

	Independent Licensing	**Cross-licensing**
w_{jk}	$5(1-\sigma c)/11$	$(1-\sigma c)/4$
q_j	$2(1-\sigma c)/11$	$(1-\sigma c)/4$
$Q, P(Q)$	$4(1-\sigma c)/11, (7+4\sigma c)/11$	$(1-\sigma c)/2, (1+\sigma c)/2$
CS	$8(1-\sigma c)^2/121$	$(1-\sigma c)^2/8$
Π_1, Π_2, Π_3	$14(1-\sigma c)^2/121, 14(1-\sigma c)^2/121, 0$	$(1-\sigma c)^2/8$, $(1-\sigma c)^2/8$, 0
$Total\ Welfare, TS$	$36(1-\sigma c)^2/121$	$3(1-\sigma c)^2/8$

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Table 2.3: Results under the joint adoption of $\mathcal{P}(\tau_1, \tau_3)$

w_{12}^{S3}, w_3^{S3}	$2(1-\epsilon\sigma c)/7, 3(1-\epsilon\sigma c)/7$
q_1^{S3}, q_2^{S3}	$2(1-\epsilon\sigma c)/7, 0$
$Q^{S3}, P(Q^{S3})$	$2(1-\epsilon\sigma c)/7, (5+2\epsilon\sigma c)/7$
CS^{S3}	$2(1-\epsilon\sigma c)^2/49$
$\Pi_1^{S3}, \Pi_2^{S3}, \Pi_3^{S3}$	$4(1-\epsilon\sigma c)^2/49, 0, 6(1-\epsilon\sigma c)^2/49$
$Total\ Welfare,\ TS^{S3}$	$12(1-\epsilon\sigma c)^2/49$

Table 2.4: Results under the adoption of $\mathcal{P}(\tau_1, \tau_3)$ by firm 1 and $\mathcal{P}(\tau_1, \tau_2)$ by firm 2

$w_{12}^{CP32}, w_3^{CP32}$	$\frac{19-c(2\epsilon+17)}{41}, \frac{3[5-c(7\epsilon-2)]}{41}$
q_1^{CP32}, q_2^{CP32}	$\frac{2[5-c(7\epsilon-2)]}{41}, \frac{2[3-c(7-4\epsilon)]}{41}$
$Q^{CP32}, P(Q^{CP32})$	$2\frac{8-c(3\epsilon+5)}{41}, \frac{25+2c(3\epsilon+5)}{41}$
CS^{CP32}	$2[\frac{8-c(3\epsilon+5)}{41}]^2$
$\Pi_1^{CP32}, \Pi_2^{CP32}, \Pi_3^{CP32}$	$2\frac{c^2(90\epsilon^2-110\epsilon+127)-2c(35\epsilon+72)+107}{1681}, 4\frac{[3-c(7-4\epsilon)]^2}{1681}, 6\frac{[5-c(7\epsilon-2)]^2}{1681}$
$Total\ Welfare,\ TS^{CP32}$	$4\frac{c^2(139\epsilon^2-138\epsilon+131)-4c(31+35\epsilon)+132}{1681}$

Table 2.5: Results under the adoption of $\mathcal{P}(\tau_1, \tau_2)$ by firm 1 and $\mathcal{P}(\tau_1, \tau_3)$ by firm 2

$w_{12}^{CP23}, w_{21}^{CP23}, w_3^{CP23}$	$\frac{21-c(8+13\epsilon)}{54}, \frac{12-c(\epsilon+11)}{27}, \frac{3-c(7\epsilon-4)}{18}$
q_1^{CP23}, q_2^{CP23}	$\frac{2[3-c(5-2\epsilon)]}{27}, \frac{3-c(7\epsilon-4)}{27}$
$Q^{CP23}, P(Q^{CP23})$	$\frac{3-c(2+\epsilon)}{9}, \frac{6+c(2+\epsilon)}{9}$
CS^{CP23}	$\frac{[3-c(2+\epsilon)]^2}{162}$
$\Pi_1^{CP23}, \Pi_2^{CP23}, \Pi_3^{CP23}$	$\frac{c^2(41\epsilon^2-52\epsilon+56)-30c(2+\epsilon)+45}{486}, \frac{c^2(5\epsilon^2-10\epsilon+14)+9(1-2c)}{81}, \frac{[3-c(7\epsilon-4)]^2}{486}$
$Total\ Welfare,\ TS^{CP23}$	$\frac{c^2(41\epsilon^2-52\epsilon+56)-30c(2+\epsilon)+45}{162}$

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Table 2.6: Adoption Game Nash Equilibrium, $\sigma > \tilde{\tilde{\sigma}}(c, \epsilon)$

		Firm 2	
		$\mathcal{P}(\tau_1, \tau_2)$	$\mathcal{P}(\tau_1, \tau_3)$
Firm 1	$\mathcal{P}(\tau_1, \tau_2)$	Π_1^{S2}, Π_2^{S2}	$\Pi_1^{CP23}, \Pi_2^{CP23}$
	$\mathcal{P}(\tau_1, \tau_3)$	$\underline{\Pi_1}^{CP32}, \underline{\Pi_2}^{CP32}$	Π_1^{S3}, Π_2^{S3}

Table 2.7: Adoption game under early licensing commitments

		Firm 2	
		$\mathcal{P}(\tau_1, \tau_2)$	$\mathcal{P}(\tau_1, \tau_3)$
Firm 1	$\mathcal{P}(\tau_1, \tau_2)$	$(1-\sigma c)^2/4, 0$	$(1-c)^2/4, 0$
	$\mathcal{P}(\tau_1, \tau_3)$	$(1-\epsilon c)^2/4, 0$	$(1-\epsilon\sigma c)^2/4, 0$

Table 2.8: Adoption game with Two-part tariffs

		Firm 2	
		$\mathcal{P}(\tau_1, \tau_2)$	$\mathcal{P}(\tau_1, \tau_3)$
Firm 1	$\mathcal{P}(\tau_1, \tau_2)$	$(1-\sigma c)^2/8, (1-\sigma c)^2/8$	$[1-c(2\epsilon-1)]^2/18, (1-\epsilon c)^2/4-(1-2\epsilon c+c)^2/9$
	$\mathcal{P}(\tau_1, \tau_3)$	$(1-\epsilon c)^2/4-(1-2\epsilon c+c)^2/9, 0$	$0, 0$

Figure 2.1: Framework

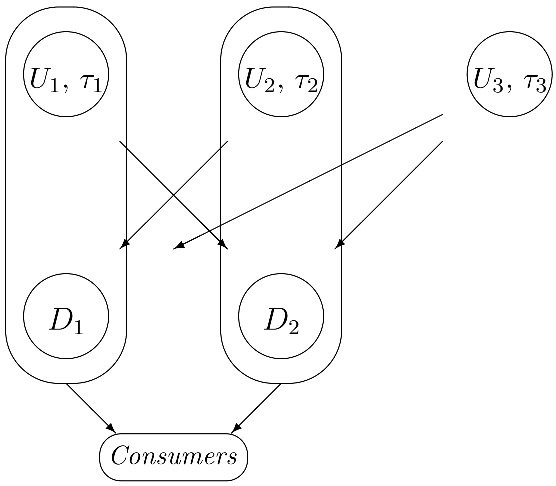
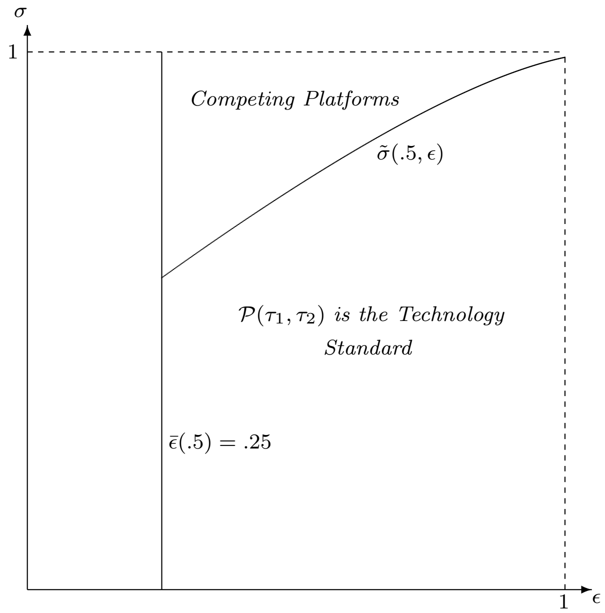
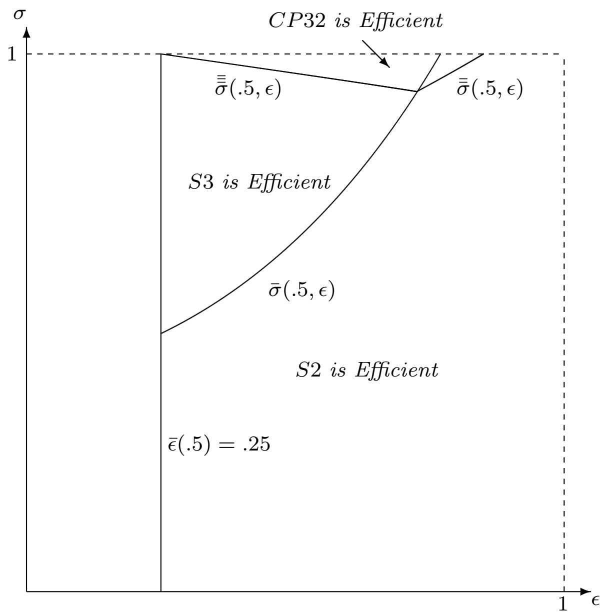


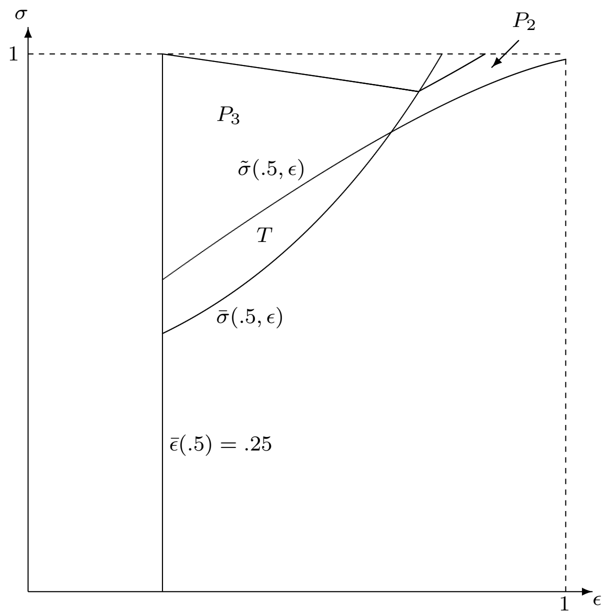
Figure 2.2: Linear Pricing - Numerical Example, $c = 1/2$



(a) **- Technology Adoption Nash Equilibria**



(b) **- Welfare Analysis**



(c) **- Adoption Equilibria and Inefficient Exclusion**

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Figure 2.3: Two-part tariffs - Numerical Example, $c = 1/5$

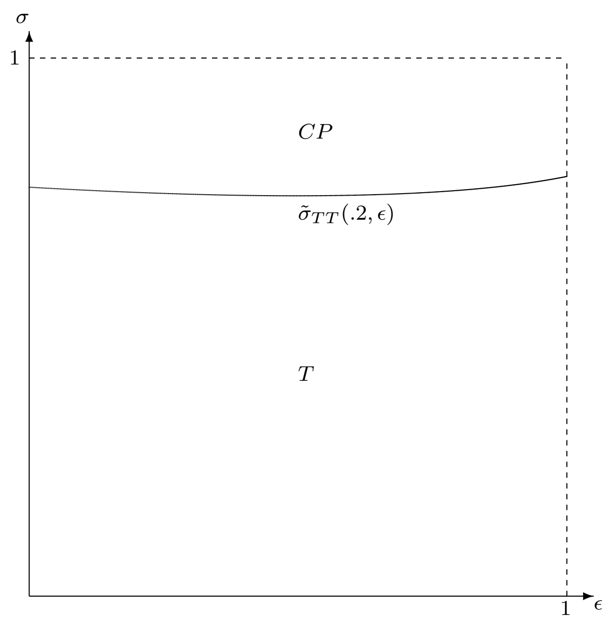

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Figure 2.4: Graph of $c_W(\epsilon)$

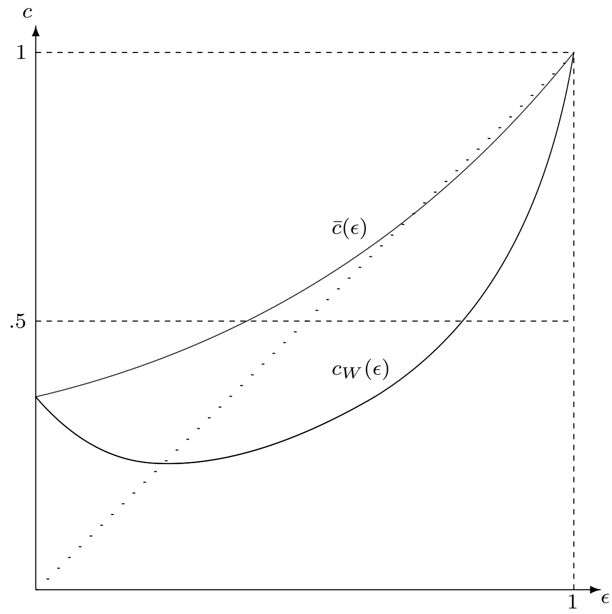
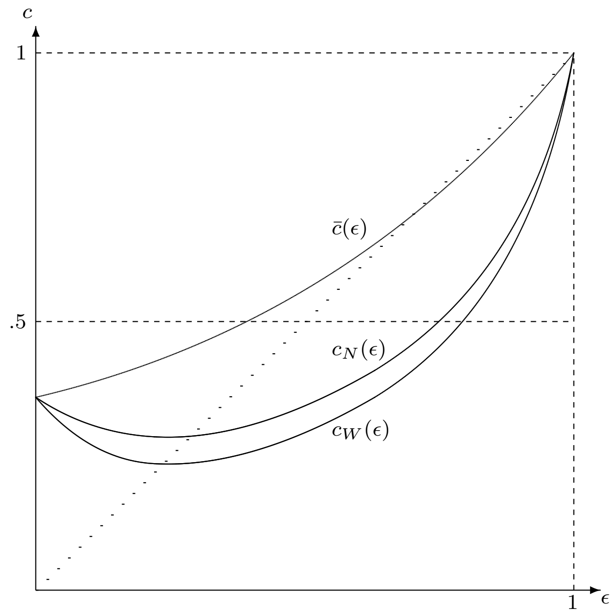


Figure 2.5: Graph of $c_N(\epsilon)$ and $c_W(\epsilon)$



Tarantino, Emanuele (2010), Three Essays in Industrial Organization and Corporate Finance
European University Institute DOI: 10.2870/23062

Bibliography

[1] Bernheim, B. Douglas, and Michael D. Whinston, 2000, Esclusive Dealing, *Journal of Political Economy*, 106(1), 64-103.

[2] Blind, Knut, and Nikolaus Thumm, 2004, The Interrelation between Patenting and Standardization Strategies: Empirical Evidence and Policy Implications, *Research Policy*, 33(10), 1583-1598.

[3] Bloch, Francis, 1995, Endogenous Structures of Association in Oligopolies, *RAND Journal of Economics*, 26(3), 537-556.

[4] Cabral, M. B. Luis, David J. Salant, 2009, Evolving Technologies and Standards Regulation, mimeo.

[5] Chiao, Benjamin, Josh Lerner, and Jean Tirole, 2007, The Rules of Standard Setting Organizations: An Empirical Study, *RAND Journal of Economics*, 38(4), 905-930.

[6] Cournot, Antoine Augustin, 1838, *Researches into the mathematical principles of the theory of wealth*, English edition of *Researches sur les principles mathematiques de la theorie des richesses* (Kelley, New York).

[7] DeLacey, J. Brian, Kerry Herman, David Kiron, and Josh Lerner, 2006, Strategic Behavior in Standard-Setting Organizations, Harvard Negotiation, Organizations & Markets Unit Working Paper No. 903214.

[8] Eswaran, Mukesh, 1994, Cross-Licensing of Competing Patents as a Facilitating Device, *Canadian Journal of Economics*, 27(3), 689-708.

[9] Farrell, Joseph, and Timothy S. Simcoe, 2009, Choosing the Rules for Formal Standardization, mimeo.

Tarantino, Emanuele (2010), Three Essays in Industrial Organization and Corporate Finance
European University Institute DOI: 10.2870/23062

[10] Feldman, P. Maryann, Stuart J. H. Graham, and Timothy S. Simcoe, 2009, Competing on Standards? Entrepreneurship, Intellectual Property and Platform technologies, *Journal of Economics and Management Strategy*, 18(3), 775-816.

[11] Gandal, Neil, David J. Salant, and Leonard Waverman, 2003, Standards in Wireless Telephone Networks, *Telecommunications Policy*, 27(5-6), 325-332.

[12] Layne-Farrar, Anne, and Josh Lerner, 2008, To Join or not to Join: Examining Patent Pool Participation and Rent Sharing Rules, mimeo.

[13] Lerner, Josh, and Jean Tirole, 2004, Efficient Patent Pools, *American Economic Review*, 94(3), 691-711.

[14] Lerner, Josh, and Jean Tirole, 2006, A Model of Forum Shopping, *American Economic Review*, 96(4), 1091-1113.

[15] Lin, Ping, 1996, Fixed-Fee Licensing of Innovations and Collusion, *Journal of Industrial Economics*, 44(4), 443-449.

[16] Rey, Patrick, and David Salant, 2009, Abuse of Dominance and Licensing of Intellectual Property, MPRA Paper No. 9454.

[17] Rey, Patrick and Jean Tirole, 2007, A Primer on Foreclosure, in: Armstrong, M., and R. H. Porter (eds.), *Handbook of Industrial Organization*, Vol. 3, North-Holland, pp. 2145-2220.

[18] Rysman, Marc, Timothy S. Simcoe, 2008, Patents and the Performance of Voluntary Standard Setting Organizations, *Management Science*, 54(11), 1920-1934.

[19] Salop, C. Steven, and David T. Scheffman, 1983, Raising Rivals Costs, *American Economic Review, Papers and Proceedings*, 73, 267-271.

[20] Salop, C. Steven, and David T. Scheffman, 1987, Cost-Raising Strategies, *Journal of Industrial Economics*, 36(1), 19-34.

[21] Schmalensee, Richard, 2009, Standard-Setting, Innovation Specialists, and Competition Policy, *Journal of Industrial Economics*, 57(3), 526-552.

[22] Schmidt, M. Klaus, 2008, Complementary Patents and Market Structure, CEPR Discussion Paper No. DP7005.

 DOI: 10.2870/23062

[23] Segal, R. Ilya, and Michael D. Whinston, 2000, Naked Exclusion: Comment, *American Economic Review*, 90(1), 296-309.

[24] Shapiro, Carl, 2001, Setting Compatibility Standards: Cooperation or Collusion?, in: Dreyfuss, R. C., D. L. Zimmerman and H. First (eds.), *Expanding the Boundaries of Intellectual Property: Innovation Policy for the Knowledge Society*, Oxford University Press, pp. 81-101.

[25] Sherry, F. Edward, and David J. Teece, 2003, Standard Setting and Antitrust, *Minnesota Law Review*, 87(6), 1913-1994.

[26] Updegrove, Andrew, 1993, Forming, Funding and Operating Standard-Setting Consortia, *IEEE Micro*, 13(6), 52-61.

[27] Wang, X. Henry, 1998, Fee Versus Royalty in a Cournot Duopoly Model, *Economics Letters*, 60(1), 55-62.

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Chapter 3

Vertical Integration with Complementary Inputs

Joint work with Markus Reisinger

3.1 Introduction

The combination of complementary inputs is a pervasive characteristic of the production process in many industries. Downstream firms usually purchase several intermediate goods from the respective wholesale markets and employ them to produce their final products. As extensively discussed in the introduction to Chapter 2, in the information and communications sector many products are based on technological standards and require the use of multiple specialized inputs that are produced by different firms. In addition, high technology products can often only be produced when having access to multiple patents that are owned by different IP holders. All these inputs—and patents—are perfect complements. Another example is the supermarket industry. Here shopping costs on the consumer side induces them to bundle their purchases. This creates a complementarity in the demand of several goods which requires supermarkets to supply a large number of them.

In these industries vertical integration is also a prevalent feature. In the communication industry several handset makers like Nokia or Sony Ericsson develop and produce some parts of their handheld devices on their own, while stand alone firms hold essential patents for other technologies, e.g., Qualcomm for transmission of data packages. This can also be observed in the computer manufacturing industry, where manufacturers produce several inputs on their own but buy their microprocessors from Intel and AMD, firms that do not

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produce computers themselves. Also, supermarket chains often offer private label consumer products but buy other products from specialized firms that are not active in the distribution industry.

Thus, the question arises what the consequences of vertical integration for consumers and welfare are and under which conditions firms find it profitable to integrate given that complementary inputs are required. Surprisingly, although the need of two or more essential inputs is widespread, the received literature so far has almost exclusively focussed on the case where manufacturers need only one input. In particular, the theory of harm behind vertical integration and the resulting conclusions on antitrust policy are based on settings where only input is needed. A prominent idea behind this theory is that with downstream competition it can be difficult for a dominant upstream firm to achieve monopoly profit since it cannot commit to restrict its output to the monopoly level. However, via vertical integration, the firm can foreclose its downstream rivals, thereby reducing output and rendering vertical integration profitable but anticompetitive. This idea of raising rivals' costs is brought forward by Salop and Scheffman (1983, 1987), Hart and Tirole (1990), McAfee and Schwartz (1994) and is also discussed in the recent survey by Rey and Tirole (2007).[1]

The aim of this Chapter is to fill the aforementioned gap in the literature, i.e., we provide a model with complementary input producers that exert market power vis-a-vis downstream firms but also face competition from producers of substitute goods. In this framework, we assess the profitability and the consequences of vertical mergers. We show that the effects arising from vertical integration in an industry with complementary inputs are largely distinct from those characterizing a model with only substitute intermediate goods, even though they share some similarities. On the one hand, in analogy to the case with substitute inputs, an integrated firm may aim at weakening the position of its downstream rivals via increased input prices (*foreclosure motive*). On the other hand, since the downstream market power of the merged firm increases through integration, the integrated chain may be more vulnerable to an *expropriation conduct* by other inputs' producers. This leads the integrated firm to lower its wholesale price to the downstream rival to be able to extract more profit from it via the fixed payment. Thus, the anticompetitive effect of vertical integration is diminished. Vertical integration is nevertheless profitable because of an *information effect*: the downstream unit of the integrated firm now observes the wholesale price at which its

[1] Notice that the use of the term foreclosure to identify such a conduct may be misleading. The legal definition of foreclosure is relatively broad and includes all the strategic practices undertaken by a firm to limit the competitive pressure it faces on the market. Instead, here the term foreclosure is used for the specific practice of excessive pricing at the expenses of a competitor(s).

rival competitor bought the input and can optimally react on it via its downstream price. Finally, if the expropriation conduct of the complementary input producer is very large, vertical integration is *unprofitable* and firms stay separated. Therefore, in a model with complementary inputs the incentives to integrate and foreclose the downstream market are threatened by the expropriation behavior undertaken by suppliers of other essential and complementary intermediate goods.

More specifically, our framework embeds two upstream firms that provide perfectly complementary products. Each input supplier competes with an alternative and less efficient source (or bypass alternative), and formulates secret offers to downstream firms by means of contracts with two-part tariffs. On the downstream market, two firms compete and need both intermediate goods to produce the final good. Finally, suppliers serve downstream firms on order and the latter produce the output good.

In this framework, we obtain the following results. First, we show that foreclosure emerges at equilibrium only if the integrated firm is not "too efficient", that is, if the cost advantage over the second source is not too large. If a wholesale firm is not much more efficient than its bypass alternative, then, once integrated, the profit that it can extract from the downstream market via foreclosure is not overly large and the expropriation problem it faces from the complementary input provider is not a big concern. Thus, foreclosure is the optimal strategy and, in this case, our model is consistent with the conclusion that vertical integration leads to foreclosure.

However, as the efficiency of an upstream firm over its bypass alternative rises, the expropriation conduct that it would suffer under integration becomes a bigger concern. This is the case because, since market power is on the side of the upstream firms, the complementary input producer extracts as much profit as possible from the integrated firm and is only constrained by the second source for the respective input. Consequently, the merged company prefers to shield part of the rents it can squeeze from the downstream market by lowering the wholesale price it sets to its downstream competitor and levying a higher fixed fee. Therefore, foreclosure is no longer necessarily the optimal strategy for the integrated firm. In particular, we show that the fear of this expropriation conduct can lead the integrated firm to set the whole price to its competitor only slightly above marginal costs, thereby rendering vertical integration much less anticompetitive than previous literature would predict. The question arises why vertical integration occurs in the first place if the expropriation conduct is large and wholesale prices are similar as without integration. The reason is that there is a genuine information advantage effect retained by the integrated organization that is not present if a firm stands alone. This is that the downstream unit of the integrated firm knows

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if its downstream competitor has bought from its upstream division or from the inefficient source; hence, it can taylor its downstream quantity to the competitor's decision and be more aggressive if the competitor purchases from the bypass alternative at higher costs. Via that it can squeeze more profit from the competitor through the fee.[2]

Finally, we also show that firms may abstain from integration since it is less profitable than staying separated. This occurs if the expropriation conduct of the complementary input supplier is particularly effective. Interestingly, this result occurs if an upstream firm is "particularly efficient", i.e., its cost advantage over the bypass alternative is large. Indeed, when highly efficient, an upstream firm can extract a lot of profit from the downstream market if it stays independent. Instead, if the upstream firm integrates, it internally trades the input at marginal costs, whereby losing its power to extract profits from the downstream unit. To the converse, the provider of the second essential input can now fully exploit its power and extract more profits from the integrated chain. This prediction is opposite to the one delivered by the received literature, which concludes that vertical mergers are particularly profitable for very efficient firms, see e.g., Rey and Tirole (2007).

Our results are consitent with two recent antitrust cases in the information and communication technology: the FTC v. Rambus case and the EC v. Qualcomm case. Rambus and Qualcomm are stand-alone upstream firms active in the development of Intellectual Property Rights (IPRs). Qualcomm has been accused by Nokia and other vertically integrated firms, which produce handsets and develop IPRs, to have infringed its obligation to negotiate prices on fair, reasonable and nondiscriminatory terms. Strictly speaking, vertically integrated firms accused Qualcomm to charge an excessive royalty rate for the licensing of IPRs that are essential to the UMTS technology.[3]

In 2006, the FTC found Rambus guilty of manipulating the works in JEDEC, the Standard Setting Organization that was deciding on the specification of the SDRAM standard.[4] Interestingly, from the facts of this case emerges that Micron, IBM and other vertically integrated firms claimed that they would have strongly opposed the inclusion of Rambus

[2]This effect is also present in a framework with just one input, in which foreclosure is the unique equilibrium. However, it is never effective there because the raising rivals' costs strategy brings the wholesale price to a value at which the fixed payment required by the integrated firm is nil. In our framework, instead, as the concerns for the expropriation conduct rise, the wholesale price set by the integrated chain decreases and the fixed fee it sets increases.

[3]See EC MEMO/07/389, 01/10/2007.

[4]The FTC alleged that the deceptive conduct kept by Rambus allowed the firm to include some of its patented technologies in the final version of the standard. See In the Matter of Rambus Inc., Docket No. 9302.

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technology into the standard.

Summarizing, in both cases vertically integrated firms are threatened by stand-alone upstream suppliers that hold essential inputs for downstream production technology, a result that is consistent with the predictions of our model and that affects the conclusions on vertical mergers that are important for antitrust policy.

The rest of the paper is organized as follows. The next Section provides an overview over the related literature. Section 3.3 sets out the model and Section 3.4 analyzes the case without integration. Section 3.5 provides the analysis and the results of the case with a vertical merger. In Section 3.6 we discuss an extension with public offers and Section 3.7 concludes.

3.2 Related Literature

The problem of a dominant upstream firm to be unable to commit to the monopoly quantity when selling via multiple competing downstream firms was first pointed out by Hart and Tirole (1990) and is summarized in the survey by Rey and Tirole (2007). In their framework upstream firms' offers are made by means of secret contracts and downstream firms adopt passive beliefs to infer the offers received by their competitors when they face out-of-equilibrium offers. In these circumstances, the dominant upstream firm comes across a Coasian commitment problem that limits its ability to extract full monopoly profit and the unique equilibrium is characterized by Cournot quantities, price and profits. We take the same approach as in Rey and Tirole (2007) when modeling the structure of the contracting game between upstream and downstream firms. Consequently, the same commitment problem arises in our framework. Instead, the crucial twist of our framework compared to Rey and Tirole (2007) consists in the presence of producers of complementary inputs, which are rivals in extracting the surplus from downstream manufacturers.

The role of manufacturers' beliefs has been highly debated by the literature on vertical restraints. More specifically, the paradox inherent to the commitment problem was investigated later by O'Brien and Shaffer (1992), McAfee and Schwartz (1994) and Marx and Shaffer (2004). The general conclusion from these papers is that via vertical integration the dominant firm is able to restrict its quantity thereby moving closer to the monopoly level, which renders vertical integration profitable but highly anticompetitive.

An important assumption in these settings is that manufacturers have perfect information on the marginal cost of the intermediate goods' suppliers. White (2007) relaxes this hypothesis and introduces incomplete information about upstream firms' costs. She finds that even

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in a context with incomplete information it is still necessary to specify the downstream firms' beliefs concerning out-of-equilibrium offers made by wholesale firms. She also shows that with upstream marginal costs' uncertainty, vertical integration can result in high-cost types selling to downstream firms at lower prices than they would set if vertically separated, and this result is partly due to the kind of equilibrium selection employed.[5]

Baake, Kamecke, and Normann (2004) also show that vertical integration may enhance efficiency and makes it socially preferable to non-integration. In Baake, Kamecke, and Normann (2004) an upstream monopolist can publicly commit to a capacity level before formulating its offers to manufacturers. In this way, the monopolist can partly solve the Coasian conjecture problem, commit to underinvest in capacity and produce at a level that can even be below the monopoly output. Thus, vertical integration can deliver a pro-competitive outcome as output increases to the monopoly level.

The mechanism that leads to non-foreclosure in our model is markedly different from the above two papers. In particular, we show that due to the complementary input provider the integrated firm may have no incentive to engage in foreclosure, but sets the wholesale price to downstream rivals only slightly above marginal costs, while in the papers above foreclosure is still optimal but the monopolist produces even less when being unintegrated. In addition, vertical integration is always profitable in these papers while this is no longer true when complementary inputs are important.

There are several other papers that analyze the effects of vertical integration in different set-ups. For example, Ordover, Saloner and Salop (1990) or Chen (2001) consider the case of Bertrand competition between upstream producers with public offers in linear prices. They determine under which conditions vertical integration is profitable and analyze if counter mergers can occur. Choi and Yi (2003) provide a model in which upstream firms can choose to specialize their inputs to the needs of downstream firms and analyze the consequences of vertical integration in this case. Riordan (1998) considers a model with a dominant firm that has market power in a final and an intermediate good market. He shows that vertical integration of the dominant firm is anticompetitive due to foreclosure although production costs of the dominant fall. In contrast to our set-up, these papers just consider a single

[5]The adoption of incomplete information implies that suppliers may engage in strategic signaling and this leads to a multiplicity of equilibria. In order to eliminate equilibria that are not supported by out-of-equilibrium beliefs, White (2007) focuses on the Cho-Kreps intuitive criterion. This equilibrium features no output distortion for the low-cost types and a downward distortion of the high-cost types' output. Consequently, if the cost difference is low enough, a high-cost non integrated firm produces less than its monopoly output. Clearly, if high types are numerous enough, a policy that eliminates strategic signaling and restores the incentives to set the monopoly output—like vertical integration—improves welfare.

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input and are not concerned with complementary inputs. In addition, they all show that integrated firms have an incentive to foreclose their downstream rivals.

Finally, papers that consider the case of complementary inputs usually look at markets where upstream firms hold essential patents that are required for the production of a final good, see e.g., Shapiro (2001). However, this literature is not concerned with the consequences of vertical integration. The only exception is Schmidt (2007). He considers a model in which each patent holder is monopolist for its patent while there are several downstream firms competing on the product market. Schmidt (2007) shows that vertical integration leads to foreclosure of rival downstream firms and to a reduction of output although the integrated firm produces more due to double-marginalization. In Schmidt (2007), patent holders compete via public contracts, instead we consider the case of private contracts and allow for a richer market structure in the upstream market where a (less efficient) competitor exists for each input. As mentioned, in this set-up we obtain starkly different results to the previous literature.

3.3 The Model

There are two downstream firms, denoted by D_1 and D_2, that produce an homogeneous good: to produce one unit of the output good each downstream firm needs one unit of two input goods (or intermediate goods). In other words, the two input goods are perfect complements and used in fixed proportions for the production of the final good. In the following, we denote the output of firm D_i by q_i, $i = 1, 2$.

Each input good i is produced by two firms, U_i and $\hat{U}_i$. Firm U_i is assumed to be more efficient than firm $\hat{U}_i$, namely it can produce input i at a marginal cost of c_i, while firm $\hat{U}_i$ incurs a marginal cost of production given by $\hat{c}_i > c_i$. The inefficient source needs not to be just one firm; one can also interpret it as a fringe of firms that produce the input i using a less than efficient technology and are in perfect competition to each other. The framework is given in Figure 3.1.

[FIGURE 3.1 ABOUT HERE]

The demand faced by the downstream firms is equal to $p = P(q_1 + q_2)$ and is assumed to be "well-behaved", in that the profit functions are (strictly) quasi-concave and the Cournot game exhibits strategic substitutability.

The game proceeds as in the following.

1. In the *first stage* each upstream firm U_i and $\hat{U}_i$ makes a take-it-or-leave-it offer to each D_i consisting of two-part tariffs, which are denoted by $T_{U_i}^{D_i} = w_{U_i}^{D_i} x_i + F_{U_i}^{D_i}$ ($T_{\hat{U}_i}^{D_i} = w_{\hat{U}_i}^{D_i} x_i + F_{\hat{U}_i}^{D_i}$ for firms $\hat{U}_i$), where x_i is the input i's quantity demanded by D_i. The offer game proceeds as follows. The offers for input i and $-i$ are made in sequential order. This implies that first U_i and $\hat{U}_i$ simultaneously make an offer to D_i and then U_{-i} and $\hat{U}_{-i}$ simultaneously make an offer. Also, U_{-i} and $\hat{U}_{-i}$ observe the first pair of offers made by U_i and $\hat{U}_i$.[6] To ensure equal bargaining power to input firms we assume that each pair of upstream firms has equal probability of being first.

   After having observed all offers, D_i decides whether (and where) to buy the intermediate goods, orders quantities x_1 and x_2 and pays the respective tariffs.[7]

2. In the *second stage*, each downstream firm transforms the intermediate goods into output, observes the output of its rival and sets its price on the product market.

The equilibrium concept we employ is perfect Bayesian equilibrium. Given the quantity purchased in the first stage, in the second stage downstream firms transform their purchased input units to output by competing à la Cournot.[8] It is assumed that if firms purchase x_1 and x_2 in the viable range, it is optimal for them to transform all units into output. The price in the second stage of the game is then given by $P(q_1 + q_2)$.

As for the first stage, the game is solved under the assumption that upstream firms supply on order and that wholesale contracts are secret. The latter assumption implies that each D_i observes all contracts it is offered by the upstream firms, but not the tariffs that are offered to D_{-i}. In particular, by using the common agency taxonomy, we restrict our attention to a bidding game with *passive (out-of-equilibrium) beliefs*. The assumption of passive beliefs implies that if a downstream firm faces an out-of-equilibrium offer by a supplier, then it does not revise its beliefs concerning the offers made to its rival. More precisely, passive beliefs imply that a downstream firm D_i presumes that, regardless of the offer received by a supplier, its downstream rival D_{-i} produces the candidate equilibrium quantity.[9]

[6] The assumption that U_{-i} and $\hat{U}_{-i}$ observe the first pair of offers is just for simplicity. All of our results remain valid if the first pair of offers is only observable to D_i but not to U_{-i} and $\hat{U}_{-i}$. However, U_{-i} and $\hat{U}_{-i}$ know that they are second to offer. See footnote 15 in Appendix A.

[7] We choose this structure because only after observing all offers D_i knows if it can make weakly positive profits. This rules out cases of mis-coordination in which the sum of the offers exceeds the profit of D_i.

[8] Equivalently, following Rey and Tirole (2007), in the second stage downstream firms play a Bertrand-Edgeworth game of price competition with capacity constraints à la Kreps and Scheinkman (1983).

[9] See Rey and Tirole (2007) for an extensive discussion on the role of beliefs in settings with secret contracts.

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Before solving the model, it is useful to introduce some additional notation. In particular, in the following we shall denote by Q^m, p^m and Π^m the industry monopoly quantity, price and profit:

$$Q^m = \arg\max_q \{[P(q) - c_1 - c_2]q\},$$

$$p^m = P(Q^m),$$

$$\Pi^m = (p^m - c_1 - c_2)Q^m.$$

Instead, Π^c denotes the Cournot profit of one manufacturer if both downstream firms face a marginal cost of production given by $c_1 + c_2$. Hence,

$$q^c = \arg\max_q \{[P(q + q^c) - c_1 - c_2]q\},$$

$$\Pi^c = [P(2q^c) - c_1 - c_2]q^c.$$

Moreover, we shall solve the model under the assumption that $\hat{c}_i$ is low enough, so that the downstream firms' threat to buy from the alternative sources matters. In particular, we assume that the following holds:

Assumption 5
$\max_q \{[P(q + q^c) - \hat{c}_i - c_{-i}]q\} > 0$, *with* $i = 1, 2$.

3.4 Set-up without Integration

In this section, we present the case where no firm is vertically integrated.

Proposition 10
The perfect Bayesian equilibrium of the game exhibits the following properties:

- *The equilibrium quantities are given by* $q_1 = q_2 = q^c = \arg\max_q \{[P(q+q^c) - c_1 - c_2]q\}$.

- *The per-unit price in any wholesale contract is given by* $w_{U_i}^{D_i} = c_i$, $i = 1, 2$, *that is, each upstream firm offers a per-unit price equal to its marginal cost to each downstream firm.*

- *If* U_i *is the first to offer, it proposes a fixed fee that is given by* $F_{U_i}^{D_i} = \Pi^c - \max_q \{[P(q + q^c) - \hat{c}_i - c_{-i}]q$ *to downstream firm* D_i.

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- *If U_i is the second to offer, it proposes a fixed fee that is given by* $F_{U_i}^{D_i} = \max_q\{[P(q + q^c) - c_i - \hat{c}_{-i}]q - \max[\max_q\{[P(q + q^c) - \hat{c}_i - \hat{c}_{-i}]q, 0]$ *to downstream firm D_i.*

Proof See Appendix A.

The perfect Bayesian equilibrium of the game with non-integration features the same commitment problem that arises in Rey and Tirole (2007); both downstream firms buy the inputs from the efficient upstream firms at marginal cost and produce respective Cournot quantities. Since a downstream firm does not observe the contract offers to its rival and holds passive beliefs, upstream firms cannot commit to sell the monopoly quantity.

The presence of second sources also constrains the ability of upstream firms to extract profits from the downstream firms. From Proposition 9 it is evident that the fixed fees are larger the more efficient are U_i and U_{-i} than the bypass alternatives. If an upstream firm U_i is the first to propose a contract to a downstream firm, it extracts the Cournot profit from the downstream market minus the profit that the downstream firm would get when buying from the bypass alternative. Thus, the fixed fee is increasing in $\Delta_i = \hat{c}_i - c_i$, i.e., it is the larger the more efficient U_i is. If instead U_i is the second to propose the contract, it must take into account that D_i can also resort to the offers of the bypass alternatives. Thus, in this case U_i proposes as a fixed fee the profit that U_{-i} had to leave minus the profit that D_i can ensure when buying from the bypass alternatives. Naturally, since U_i and U_{-i} are the efficient firms, in equilibrium they supply to both downstream firms while $\hat{U}_1$ and $\hat{U}_2$ stay inactive.

We can now move on to analyze the profitability of a vertical merger between firms U_i and D_i. Before doing so we have to determine the profits that U_i and D_i receive when staying independent. From Proposition 9 it is evident that the profit of D_i in case of non-integration is given by $\max[\max_q\{[P(q + q^c) - \hat{c}_i - \hat{c}_{-i}]q, 0]$. Determining the profit of U_i—and recognizing that U_i is the first to offer to both downstream firms with probability 1/2—we obtain that its expected profit under non-integration is given by

$$\Pi^c + \max_q\{[P(q+q^c) - c_i - \hat{c}_{-i}]q\} - \max_q\{[P(q+q^c) - \hat{c}_i - c_{-i}]q\} - \max[\max_q\{[P(q+q^c) - \hat{c}_i - \hat{c}_{-i}]q\}, 0].$$

Thus, the sum of profits of U_i and D_i is equal to

$$\Pi^c + \max_q\{[P(q + q^c) - c_i - \hat{c}_{-i}]q\} - \max_q\{[P(q + q^c) - \hat{c}_i - c_{-i}]q\}.$$

We can now use this value to determine the profitability of a vertical merger.

3.5 Vertical Merger between U_1 and D_1

Suppose that U_1 and D_1 are integrated and the other firms are independent. The new framework is given in Figure 3.2.

[FIGURE 3.2 ABOUT HERE]

The integrated firm trades the input good internally at marginal cost. This assumption is standard in the literature (see e.g., Ordover, Saloner and Salop, 1990, Chen, 2001, or Choi and Yi, 2001) and is justified by the fact that pricing at marginal cost is (ex-post) the optimal strategy for the integrated firm. Even if it would like to credibly commit to outsiders that the internal wholesale price is above marginal costs, it cannot do so, since it has an incentive to secretly change the price afterwards, and it can do so via exchanging payments between the upstream and the downstream unit, which is unobservable to outsiders.

3.5.1 Profitability of foreclosure

Rey and Tirole (2007) show that an integrated firm finds it profitable to soften downstream product market competition via foreclosure. We will now analyze if this is still true if there are complementary inputs.

In the following, we assess the profitability of a "foreclosure" strategy of the integrated operator $U_1 - D_1$, at which it raises the input price to the downstream competitor D_2 as much as possible.[10]

As in the case without integration, the firms delivering the inputs still have all the bargaining power; this implies that U_2 makes a take-it-or-leave-it-offer to the newly integrated firm. In other words, vertical integration does not imply a change of the bargaining power positions. It only changes the strategic position of the newly integrated firm, which now maximizes its joint profit.

Given that D_2 has access to the input good 1 through $\hat{U}_1$, in case of a foreclosure strategy the integrated firm serves D_2 but by making its marginal cost of production as high as possible. However, $U_1 - D_1$ is bounded by $\hat{c}_1$ due to the bypass alternative and has to offer a fixed fee of zero. This means that the offer made by $U_1 - D_1$ to D_2 consists only of the linear component and is given by

$$T_{U_1}^{D_2} = \hat{c}_1 x_1.$$

[10] We will later analyze under which conditions such a foreclosure strategy is no longer optimal and the implications on optimal tariffs.

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Consequently, following the reasoning employed in the proof of Proposition 9, at an equilibrium quantities are given by

$$q_1^c = \arg\max_q \{[P(q + q_2^c) - c_1 - c_2]q\}$$

and

$$q_2^c = \arg\max_q \{[P(q_1^c + q) - \hat{c}_1 - c_2]q\}. \tag{3.1}$$

That is, the downstream market features an asymmetric Cournot oligopoly.

Since U_2 has the bargaining power vis-à-vis D_1 and D_2, the fixed component of the tariffs set by U_2 in this case are

$$F_{U_2}^{D_1} = \Pi_1^c - \max_q \{[P(q + q_2^c) - c_1 - \hat{c}_2]q\}$$

and

$$F_{U_2}^{D_2} = \Pi_2^c - \max_q \{[P(q + q_1^c) - \hat{c}_1 - \hat{c}_2]q\}.$$

Π_i^c indexes the Cournot profit of firm i in this asymmetric case. Consequently, the profit of the integrated firm $U_1 - D_1$ is equal to

$$\begin{aligned} \Pi_{U_1-D_1} &= \Pi_1^c + q_2^c(\hat{c}_1 - c_1) - F_{U_2}^{D_1} \\ &= \Pi_1^c + q_2^c(\hat{c}_1 - c_1) - \Pi_1^c + \max_q \{[P(q + q_2^c) - c_1 - \hat{c}_2]q\} \\ &= \max_q \{[P(q + q_2^c) - c_1 - \hat{c}_2]q\} + q_2^c(\hat{c}_1 - c_1). \end{aligned}$$

In a setting without a complementary input, the integrated firm would be able to extract the full downstream rent, Π_1^c, and the upstream rent, $q_2^c(\hat{c}_1 - c_1)$. Instead, here $U_1 - D_1$ obtains a rent in the downstream market that corresponds to the profit it would receive when using the competitive provider of input 2. This rent is equal to $\max_q\{[P(q + q_2^c) - c_1 - \hat{c}_2]q\} < \Pi_1^c$.

For completeness, the profit of firm U_2 is equal to $\Pi_{U_2} = F_{U_2}^{D_1} + F_{U_2}^{D_2}$, the profit of D_2 is given by $\Pi_{D_2} = \max[\max_q\{[P(q + q_1^c) - \hat{c}_1 - \hat{c}_2]q\}, 0]$ and the alternative sources, $\hat{U}_1$ and $\hat{U}_2$, stay inactive.

We can now determine if vertical integration is more profitable than staying independent. To do so we have to compare $\Pi_{U_1-D_1}$ with $\Pi_{U_1} + \Pi_{D_1}$. As shown above, the expected sum $\Pi_{U_1} + \Pi_{D_1}$ in the case of no integration is given by

$$\Pi^c - \max_q \{[P(q + q^c) - \hat{c}_1 - c_2]q\} + \max_q \{[P(q + q^c) - c_1 - \hat{c}_2]q\}. \tag{3.2}$$

We thus get the following proposition.

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Proposition 11
A strategy of market foreclosure by a vertically-integrated firm is more profitable than non-integration if and only if

$$\Pi_{U_1-D_1} - (\Pi_{U_1} + \Pi_{D_1}) = \max_q\{[P(q+q_2^c) - c_1 - \hat{c}_2]q\} + q_2^c(\hat{c}_1 - c_1) - \Pi^c + \\ + \max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\} - \max_q\{[P(q+q^c) - c_1 - \hat{c}_2]q\} > 0. \tag{3.3}$$

In Rey and Tirole (2007) a strategy of vertical integration and foreclosure is always more profitable than non-integration. Rey and Tirole (2007)'s result is obtained because the integrated firm gets the entire rent generated in the downstream market and this rent is bigger than the corresponding profit of D_1 in the non-integration case. Instead, in our setting, the fact that U_1-D_1 is able to extract a higher downstream rent under the foreclosure strategy than under non-integration leaves more room to the expropriation conduct of U_2.

Consequently, differently from a framework without a provider of a complementary input, the sign of condition (3.3), which determines the profitability of vertical integration under a foreclosure strategy, is ambiguous. To see the difference to the framework without complementary inputs in a clear way, suppose that the market for input 2 is perfectly competitive, i.e. $\hat{c}_2 = c_2$, which implies that U_2 has no bargaining power. Under this assumption, the profit of U_1 and D_1 in case of no integration is given by $\Pi^c - \max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\}$ while the profit of $U_1 - D_1$ after integration is $\max_q\{[P(q+q_2^c) - c_1 - c_2]q\} + q_2^c(\hat{c}_1 - c_1)$. Thus, foreclosure is profitable if

$$\max_q\{[P(q+q_2^c) - c_1 - c_2]q\} + q_2^c(\hat{c}_1 - c_1) - \Pi^c + \max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\} > 0. \tag{3.4}$$

We know that $q_2^c < q^c$ since q^c is the optimal quantity of D_2 given that its marginal costs are $c_1 + c_2$, instead q_2^c is the optimal quantity given that its marginal costs are $\hat{c}_1 + c_2$. Thus, $\max_q\{[P(q+q_2^c) - c_1 - c_2]q\} - \Pi^c > 0$, which implies that (3.4) holds. As a consequence, vertical integration is always profitable.

Now let us have a closer look at (3.3). Both in (3.3) and (3.4) the term

$$\max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\} + q_2^c(\hat{c}_1 - c_1) - \Pi^c \tag{3.5}$$

is present. One can easily check that (3.5) is smaller than zero.[11] In the case where U_2 has no bargaining power, the profit of the integrated firm in the downstream market, given by

[11] To see this, denote q' by

$$q' \equiv \arg\max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\}.$$

$\max_q\{[P(q+q_2^c)-c_1-c_2]q\}$, must be added to the terms in (3.5), and we know that this asymmetric Cournot profit is so large that it dominates the terms in (3.5). By contrast, if U_2 has bargaining power, that is $\hat{c}_2 > c_2$, the expression

$$\max_q\{[P(q+q_2^c)-c_1-\hat{c}_2]q\} - \max_q\{[P(q+q^c)-c_1-\hat{c}_2]q\} > 0 \tag{3.6}$$

is added to (3.5). This expression is smaller than $\max_q\{[P(q+q_2^c)-c_1-c_2]q\}$ for two reasons. First, due to the bargaining power of U_2, the integrated firm receives only a part of its downstream profit, namely $\max_q\{[P(q+q_2^c)-c_1-\hat{c}_2]q\}$, while in the case where $\hat{U}_2$ is as efficient as U_2 the integrated firm keeps the full downstream profit. On top of that, in case of no integration, D_1 has to leave to U_2 a rent equal to $\max_q\{[P(q+q^c)-c_1-\hat{c}_2]q\}$ and this rent would be nil if $\hat{c}_2 = c_2$.

Concluding, under complementary inputs, the profitability of vertical integration is threatened by the *expropriation incentive* of the efficient producer of the complementary input. Therefore, via staying independent U_1 can shield some of its revenue from the bargaining power of U_2 and it can indeed be profitable to do so.

3.5.2 General analysis

In the absence of the suppliers of the complementary good, we know from Rey and Tirole (2007) that the integrated firm's dominant strategy would prescribe to raise rival's marginal costs of production to the highest possible value by setting $T_{D_2}^{U_1} = \hat{c}_1 x_1$. However, the expropriation incentive of U_2 implies that as $U_1 - D_1$ raises its wholesale price to $\hat{c}_1$, the profit of $U_1 - D_1$ increases but this profit can now be squeezed by U_2 via the fixed fee. For that reason it can be optimal for the integrated firm not to follow a foreclosure strategy. In the following, we analyze the optimal strategy of $U_1 - D_1$ and then determine under which conditions foreclosure is optimal.

We can then write

$$\max_q\{[P(q+q^c)-\hat{c}_1-c_2]q\} + q_2^c(\hat{c}_1-c_1)$$

as

$$[P(q'+q^c)-c_1-c_2]q' - (q'-q_2^c)(\hat{c}_1-c_1).$$

Since $\hat{c}_1 > c_1$, we have that $q' < q^c$. Then, $[P(q'+q^c)-c_1-c_2]q' < \Pi^c$. In addition, $q_1^c > q^c$, which implies that $q' > q_2^c$ (q_2^c is defined in (3.1)). Therefore, $(q'-q_2^c)(\hat{c}_1-c_1) > 0$ and the overall expression

$$[P(q'+q^c)-c_1-c_2]q' - (q'-q_2^c)(\hat{c}_1-c_1)$$

must be smaller than Π^c.

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We start with the case in which $U_1 - D_1$ is first in negotiating with D_2. The inefficient source $\hat{U}_1$ is willing to offer a contract of $w^{D_2}_{\hat{U}_1} = \hat{c}_1$ and $F^{D_2}_{\hat{U}_1} = 0$. The maximization problem of $U_1 - D_1$ is then given by

$$\max_{w^{D_2}_{U_1}} \quad \max_q\{(P(q + q^c_2(w^{D_2}_{U_1})) - c_1 - \hat{c}_2)q\} + x^{D_2}_{U_1}(w^{D_2}_{U_1}, E[w_2])(w^{D_2}_{U_1} - c_1) + F^{D_2}_{U_1}, \tag{3.7}$$

$$s.t. \quad \max_q\{(P(q + q^c_1(w^{D_2}_{U_1})) - w^{D_2}_{U_1} - E[w_2])q\} - F^{D_2}_{U_1} \geq \max_q\{(P(q + q^c_1(\hat{c}_1)) - \hat{c}_1 - E[w_2])q\}, \tag{3.8}$$

where

$$q^c_2(w^{D_2}_{U_1}) = \arg\max_q\{[P(q + q^c_1(w^{D_2}_{U_1})) - w^{D_2}_{U_1} - c_2]\},$$
$$q^c_1(w^{D_2}_{U_1}) = \arg\max_q\{[P(q + q^c_2(w^{D_2}_{U_1})) - c_1 - c_2]\},$$

and $q^c_1(\hat{c}_1)$ is defined by

$$q^c_1(\hat{c}_1) = \arg\max_q\{[P(q + q^c_2(\hat{c}_1) - c_1 - c_2]q\},$$

with

$$q^c_2(\hat{c}_1) = \arg\max_q\{[P(q + q^c_1(\hat{c}_1)) - \hat{c}_1 - c_2]q\}.$$

$E[w_2]$ denotes the wholesale price at which U_1 expects firm D_2 to buy input 2. Differently from the case without integration, in (3.8) $U_1 - D_1$ takes into account that it is operating on the downstream market, where it raises a rent equal to $\max_q\{(P(q + q^c_2(w^{D_2}_{U_1})) - c_1 - \hat{c}_2)q\}$. Indeed, by the same token as in Proposition 9, the formulation of (3.8) uses the result that downstream firms produce the Cournot quantity, and that $w^{D_1}_{U_2} = c_2$ and $F^{D_1}_{U_2} = \max_q\{(P(q + q^c_2(w^{D_2}_{U_1})) - c_1 - c_2)q\} - \max_q\{(P(q + q^c_2(\hat{c}_1)) - c_1 - \hat{c}_2)q\}$.

Firm U_1 receives as a profit from D_2 the margin of its wholesale price over marginal costs times the quantity that D_2 buys, denoted by $x^{D_2}_{U_1}$, plus the fixed fee. The constraint faced by the integrated firm is that D_2 accepts the offer of U_1 only in case D_2 can ensure itself weakly larger profits from accepting U_1's offer than from buying the input from $\hat{U}_1$ at a price of $\hat{c}_1$ and a fixed fee of zero. Note that in the latter case the integrated firm observes that D_2 does not buy from it. Thus, the downstream unit D_1 adjusts its quantity accordingly, i.e. it produces $q^c_1(\hat{c}_1)$ instead of $q^c_1(w^{D_2}_{U_1})$.

By solving for the fixed fee $F^{U_1}_{D_2}$ from a binding constraint, the problem that determines the value of the linear price set by the integrated firm can be rewritten as:

$$\begin{aligned} \max_{w^{D_2}_{U_1}} \quad & \max_q\{(P(q + q^c_2(w^{D_2}_{U_1})) - c_1 - \hat{c}_2)q\} + x^{D_2}_{U_1}(w^{D_2}_{U_1}, E[w_2])(w^{D_2}_{U_1} - c_1) + \\ & + \max_q\{(P(q + q^c_1(w^{D_2}_{U_1})) - w^{D_2}_{U_1} - E[w_2])q\} - \max_q\{(P(q + q^c_1(\hat{c}_1)) - \hat{c}_1 - E[w_2])q\}, \end{aligned} \tag{3.9}$$

where the last term does not depend on $w^{D_2}_{U_1}$.

Instead, suppose $U_1 - D_1$ is second in negotiating with D_2. $U_1 - D_1$ solves the following problem.

$$\max_{w_{U_1}^{D_2}} \Big\{ \max_q\{(P(q+q_2^c(w_{U_1}^{D_2})) - c_1 - \hat{c}_2)q\} + x_{U_1}^{D_2}(w_{U_1}^{D_2}, E[w_2])(w_{U_1}^{D_2} - c_1) + F_{U_1}^{D_2}\Big\},$$
$$s.t.(i) \max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - E[w_2])q\} - F_{U_1}^{D_2} \geq \max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - \hat{c}_1 - E[w_2])q\},$$
$$(ii) \max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - E[w_2])q\} - F_{U_1}^{D_2} - F_{U_2}^{D_2} \geq \max[\max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2])q\}, 0].$$

Constraint (i) ensures that D_2 prefers to buy from $U_1 - D_1$ rather than from $\hat{U}_1$. Constraint (ii) implies that D_2's profit when accepting the offers from U_1 and U_2 is larger than the maximum of the profits when either accepting the offers from $\hat{U}_1$ and $\hat{U}_2$, which is $\max q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2])q\}$, or when rejecting all offers—which gives a profit of zero. U_1 optimally sets $F_{U_1}^{D_2}$ such that the binding constraint between (i) and (ii) holds with equality. So, the value of $F_{U_1}^{D_2}$ is equal to

$$\min\Big[\max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - E[w_2])q\} - \max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - \hat{c}_1 - E[w_2])q\}, \tag{3.10}$$
$$\max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - E[w_2])q\} - \max[\max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2])q\}, 0] - F_{U_2}^{D_2}\Big].$$

Plugging this expression into the objective function, we obtain the following problem.

$$\max_{w_{U_1}^{D_2}} \quad \max q\{(P(q+q_2^c(w_{U_1}^{D_2})) - c_1 - \hat{c}_2)q\} + x_{U_1}^{D_2}(w_{U_1}^{D_2}, E[w_2])(w_{U_1}^{D_2} - c_1) +$$
$$+ \min\Big[\max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - E[w_2])q\} - \max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - E[w_2])q\},$$
$$\max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - E[w_2])q\} - \max[\max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2])q\}, 0] - F_{U_2}^{D_2}\Big] \tag{3.11}$$

Therefore, independently from which term is the minimum in expression (3.11), the maximization problem with respect to $w_{U_1}^{D_2}$ is the same and is given by

$$\max_{w_{U_1}^{D_2}} \quad \max q\{(P(q+q_2^c(w_{U_1}^{D_2})) - c_1 - \hat{c}_2)q\} + x_{U_1}^{D_2}(w_{U_1}^{D_2}, E[w_2])(w_{U_1}^{D_2} - c_1) + \tag{3.12}$$
$$+ \max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - E[w_2])q\},$$

because the terms in (3.9) and (3.11) that depend on $w_{U_1}^{D_2}$ are the same. As a consequence, we have that independent of the order of offers, in equilibrium $U_1 - D_1$ sets $w_{U_i}^{D_i}$ by solving problem (3.12). This also applies to U_2 and the incentives it has when setting $w_{U_2}^{D_2}$, implying that $w_{U_2}^{D_2} = c_2$.

We obtain that the integrated firm follows a foreclosure strategy if the optimal $w_{U_1}^{D_2}$ resulting from problem (3.12) is larger than $\hat{c}_1$. Since $U_1 - D_1$'s wholesale price to D_2 is

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bounded by $\hat{c}_1$, it is optimal in this case to set $w_{U_1}^{D_2} = \hat{c}_1$. Otherwise, we have that $w_{U_1}^{D_2} < \hat{c}_1$ is the optimal strategy for the integrated firm.

Finally, we can determine the payoff from integration. If $U_1 - D_1$ is the first to offer, it receives a profit that is equal to the following expression:

$$\begin{aligned}\Pi^{U_1-D_1}(w_{U_1}^{D_2}) &= \max q\{(P(q+q_2^c(w_{U_1}^{D_2})) - c_1 - \hat{c}_2)q\} + q_2^c(w_{U_1}^{D_2}, c_2)(w_{U_1}^{D_2} - c_1) + \\ &+ \max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2)q\} - \max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2)q\}, \quad (3.13)\end{aligned}$$

which uses the fact that $q_2^c = x_{U_1}^{D_2}$, since downstream firms transform all input into output. Instead, if the integrated firm is second to offer, the expression for its profits is given by:

$$\begin{aligned}\Pi^{U_1-D_1}(w_{U_1}^{D_2}) &= \max q\{(P(q+q_2^c(w_{U_1}^{D_2})) - c_1 - \hat{c}_2)q\} + q_2^c(w_{U_1}^{D_2}, c_2)(w_{U_1}^{D_2} - c_1) + \\ &+ \min\Big[\max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2)q\} - \max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2)q\}, \\ &\max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - \hat{c}_2)q\} - \max[\max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2])q\}, 0]\Big], \quad (3.14)\end{aligned}$$

which uses the fact that $F_{U_2}^{D_2} = \max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2)q\} - \max_q\{(P(q+q_1^c(\hat{c}_1)) - w_{U_1}^{D_2} - \hat{c}_2])q\}$ when U_2 is first in negotiating with D_2.

Concluding, the expected profit of $U_1 - D_1$ is given by (3.13) in case the first term in expression (3.11) is smaller than the second. Otherwise, since each upstream firm is equally likely to be first in approaching D_2, the expected profits of $U_1 - D_1$ are equal to:

$$\begin{aligned}\Pi^{U_1-D_1}(w_{U_1}^{D_2}) &= \max q\{(P(q+q_2^c(w_{U_1}^{D_2})) - c_1 - \hat{c}_2)q\} + q_2^c(w_{U_1}^{D_2}, c_2)(w_{U_1}^{D_2} - c_1) + \\ &+ \frac{1}{2}\left[\max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2)q\} - \max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2)q\}\right] + \\ &+ \frac{1}{2}\left[\max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - \hat{c}_2)q\} - \max[\max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2])q\}, 0]\right]. \quad (3.15)\end{aligned}$$

3.5.3 Analysis with linear demand

In the following, we compare the results under integration and non-integration and we restrict ourselves to the case of linear demand by using the function $P(q_1+q_2) = \max\{0, 1-q_1-q_2\}$. It is easy to check that Assumption 5 is fulfilled in this case if $\Delta_i < (1-c_1-c_2)/2$, where $\Delta_i = \hat{c}_i - c_i$. We obtain the following results.

Proposition 12

- *If* $\Delta_2 \in (0, (1-c_1-c_2)/3)$ *one has that:*

- *If* $0 < \Delta_1 \leq (1 - c_1 - c_2 - 3\Delta_2)/2 \equiv \underline{\Delta}_1$, *the integrated firm* $U_1 - D_1$ *optimally follows a foreclosure strategy and sets* $w_{D_2}^{U_1} = \hat{c}_1$. *Moreover, it is profitable for* U_1 *and* D_1 *to integrate.*
- *Define*

$$\tilde{\Delta}_1 \equiv [2(1 - c_1 - c_2) - 6\Delta_2 + \sqrt{[9\Delta_2 + 11(1 - c_1 - c_2)][(1 - c_1 - c_2) - 3\Delta_2}]/7$$

and

$$\tilde{\tilde{\Delta}}_1 \equiv 2(1 - c_1 - c_2) - \sqrt{(1 - c_1 - c_2)(6\Delta_2 + 1 - c_1 - c_2) + 9/2\Delta_2^2}.$$

If $\underline{\Delta}_1 < \Delta_1 \leq \min\{\tilde{\tilde{\Delta}}_1, \tilde{\Delta}_1\}$, *it is profitable for* U_1 *and* D_1 *to integrate and set* $w_{D_2}^{U_1} = (1 + c_1 + 2c_2 - 3\hat{c}_2)/2 < \hat{c}_1$.

- *If* $\min\{\tilde{\Delta}_1, \tilde{\tilde{\Delta}}_1\} < \Delta_1 < (1 - c_1 - c_2)/2$, *it is not profitable for* U_1 *and* D_1 *to integrate.*

- *If* $\Delta_2 \in ((1 - c_1 - c_2)/3, (1 - c_1 - c_2)/2)$ *integration is not profitable.*

Proof See Appendix B.

First, the proposition shows that if Δ_2 were nil, then foreclosure is always more profitable than non-integration.[12] Indeed, as already alluded to after Proposition 10, if Δ_2 is equal to zero then the rent that the provider of the complementary input would be able to extract from the integrated firm collapses, and so does the expropriation problem faced by $U_1 - D_1$. Therefore, the mechanism in this case is the same as in the framework of Rey and Tirole (2007) and the presence of a complementary input does not play any role.

Second, we find that following a foreclosure strategy is not necessarily optimal for the integrated firm. This depends on the efficiency of U_1 with respect to $\hat{U}_1$. If Δ_1 is in a middle range, it is optimal for the integrated firm to raise the per-unit price charged to D_2 only to a value that is smaller than $\hat{c}_1$. The reason is that via doing so it leaves more profit to D_2. Since the bargaining power that $U_1 - D_1$ and U_2 have on D_2 is the same, the integrated firm can extract these profits to some extent. However, the profit that the integrated firm makes on the downstream market can be squeezed by U_2, where the only constraint is that $U_1 - D_1$ can buy from $\hat{U}_2$. Thus, it might pay off for the integrated firm to leave some profits to D_2.

[12]This is the case because from Assumption (5) we know that $\Delta_1 \leq (1 - c_1 - c_2)/2$, and thus at $\Delta_2 = 0$ we are always in the first region.

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There are two main reasons for why in this middle range of values of Δ_1, U_1 and D_1 may still find optimal to integrate. One is mentioned above and consists in the fact that $U_1 - D_1$ can shield part of its profits via lowering the linear price set on D_2. The second is that the downstream unit of the integrated firm now knows if its downstream competitor has bought from U_1 or the inefficient source for input 1, $\hat{U}_1$. Thus, it can tailor its downstream quantity to the competitor's decision and produce a different quantity if the competitor has bought from $\hat{U}_1$ than if it has bought from its upstream unit. As a consequence, the integrated firm can extract more from D_2: if D_2 buys at the higher input price $\hat{c}_1$, $U_1 - D_1$ reacts by increasing its quantity, this in turn induces D_2 to lower its quantity, thereby leaving less profit to D_2. Thus, the effect that D_1 is informed about the outcome of the offer game of U_1 inherently gives the integrated firm an advantage in extracting profits.

Finally, if Δ_1 and Δ_2 are relatively large, vertical integration is no longer profitable. In case of no integration U_1 could extract a lot of profit from D_1 due to Δ_1 being large. After integration, U_2 is the only one exerting bargaining power vis-à-vis D_1 and is more able to extract profits from D_1 the bigger is the value of Δ_2. Therefore, if Δ_1 and Δ_2 are above a certain threshold, these effects dominate any positive effect due to vertical integration and arising from the information effect. Thus, it is profitable for U_1 and D_1 to stay independent.[13]

This last result is markedly different from the conclusion in Rey and Tirole (2007) that vertical integration is particularly profitable for efficient firms. An interesting (and perhaps counter-intuitive) implication of our analysis is that in an industry with highly complementary inputs very efficient firms are less likely to vertically integrate than firms that are only slightly more efficient than their competitors.

3.6 Public offers

In this section, we briefly discuss the case in which offers are public, that is, each downstream firm observes not only the offers to itself but also the ones to its rival. As mentioned by e.g., Rey and Tirole (2007), public offers are less realistic in many circumstances because negotiations often take place privately and hard information about these contracts is relatively difficult to communicate. However, the analysis can serve as benchmark case to the secret offers case.

The goal of this section is to demonstrate in a simple way that vertical integration is

[13]Note that if an integrated firm could credibly commit to set its internal wholesale price above marginal costs, this result would not occur. However, since this is impossible due to secret internal renegotiation's incentives, vertical integration can be unprofitable.

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never profitable in case of public offers. The reason is that, the upstream firm can extract as much as possible from the downstream firms already under non-integration, given the constraint that downstream firms can buy from the bypass alternatives. Thus, foreclosure is not necessary to increase industry profits, and so vertical integration cannot improve the profits of the upstream firm. In addition, the integrated firm's problem of expropriation conduct by the complementary input provider remains. As a consequence, vertical integration yields weakly lower profits to the integrated firms and, therefore, does not occur in equilibrium.

To show this intuition in a simple way, we concentrate our analysis to the case in which upstream firms do not charge wholesale prices that are below marginal costs. This simplifies the analysis dramatically without affecting the main point.

Now consider the framework with public offers and no integration. The goal of the upstream firms is to maximize industry profits in order to extract these profits from the downstream firms, given the alternative sources. The easiest way to do so is to offer per-unit prices of $w_{U_1}^{D_i} = c_1$ and $w_{U_2}^{D_i} = c_2$ to firm D_i and very high wholesale prices to firm D_{-i}. If there are no alternative sources, D_i would then buy the monopoly quantity and each upstream firm receives expected profits of half of the monopoly profit. However, firm D_{-i} would buy from the alternative sources in this case. Therefore, it is optimal for the upstream firms to serve D_{-i} themselves at wholesale prices of $w_{U_1}^{D_{-i}} = \hat{c}_1$ and $w_{U_2}^{D_{-i}} = \hat{c}_2$. This implies that downstream firms play an asymmetric Cournot game in the downstream market in which they produce quantities of

$$q(c) = \arg\max_q \{(P(q + q(\hat{c})) - c_1 - c_2)q\}$$

and

$$q(\hat{c}) = \max\left[\arg\max_q \{(P(q + q(c)) - \hat{c}_1 - \hat{c}_2)q\}, 0\right].$$

Via inducing these quantities, the upstream firms are as close as possible to the monopoly profit.

As a consequence, we have that the fixed fees to firm D_{-i} are nil, while the fixed fees to firm D_i are given by

$$w_{U_i}^{D_i} = \max_q \{(P(q + q(\hat{c})) - c_i - c_{-i})q\} - \max_q \{(P(q + q(\hat{c})) - \hat{c}_i - c_{-i})q\}, \qquad (3.16)$$

in case firm U_i is the first to offer to D_i, and by

$$w_{U_i}^{D_i} = \max_q \{(P(q + q(\hat{c})) - c_i - \hat{c}_{-i})q\} - \max\left[\max_q \{(P(q + q(\hat{c})) - \hat{c}_i - \hat{c}_{-i})q\}, 0\right], \quad (3.17)$$

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in case firm U_i is the second to offer to D_i.[14]

Now, let us look the case of a vertical merger between U_i and D_i. Since D_{-i} is operating with the highest possible marginal costs in case of no integration, such a vertical merger cannot raise industry profits because they are already as close as possible to the monopoly profits. In addition, there is no information effect either, since D_{-i} buys input i at a price of $\hat{c}_i$ in case of no integration already, and D_i knows this. The only effect that is present is that U_{-i} can now extract more profits from D_i than in case of no integration since U_i has no more bargaining power on D_i. Overall, the result is that the merged firm would be put in difficulty as much as in a framework with secret offers due to the expropriation conduct of the complementary input provider but the degree of downstream competition is not affected by the vertical merger. As a consequence, a vertical merger cannot be profitable.

3.7 Conclusion

This Chapter analyzed the profitability and consequences of vertical integration in a model where downstream firms need complementary inputs, and these inputs are supplied by producers that exert market power vis-á-vis downstream firms. We showed that the presence of the complementary input supplier gives rise to an expropriation conduct that is not present in the case when only one input is necessary for production. A consequence of this is that an integrated organization may not find it optimal to foreclose its downstream rival since the complementary input supplier can then extract large profits from the integrated firm. Instead, via setting a lower wholesale price to the downstream rival, the integrated shields some downstream profits from the expropriation conduct. Vertical integration is nevertheless profitable because the downstream unit of the integrated can now observe from which upstream firm the rival buys, taylor its quantity accordingly and extract more profits from the same rival. Finally, we show that vertical mergers are unprofitable in case the upstream units are very efficient because the expropriation conduct of the complementary input producer is most harmful.

[14] If upstream firms had the possibility to set wholesale prices below marginal costs, it can be profitable for them to do so under some circumstances. The reason is that $q(\hat{c})$ is then more likely to be zero and so upstream firms have to leave a smaller rent to downstream firms. However, the quantity in the downstream market is biased to a too large one, which has a profit reducing effect on upstream firms. To determine which of these effects dominates is a tedious matter because it depends on the particular shape of the demand function and the cost differences. Thus, we confined our analysis to this simpler case. As will become clear from the next paragraph, the result on the profitability of vertical mergers is not affected by this assumption.

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We restricted our attention to the case in which there is just one vertical merger. However, in our set-up it is also natural to consider the case of a counter-merger between U_2 and D_2. In particular, it is interesting to analyze if the first merger increases or decreases the incentives for a second merger. This can give new insights under which conditions an asymmetric outcome in an industry can arise, in which some firms stay separated while others are integrated. Such an analysis would also show how the new effects identified in this Chapter—e.g., the expropriation conduct and the information effect—play out in case both chains are integrated and how this affects output prices and welfare.

Another direction for future research is to consider the case of Bertrand competition in the downstream market. In our analysis we focussed on the case of Cournot competition—in line with Rey and Tirole (2007)—which implies that firms' strategy variables are strategic substitutes. It is also natural to consider the opposite case of strategic complements, for example, via analyzing a model with differentiated Bertrand competition as in O'Brien and Shaffer (1992). It is of interest how the problem of being expropriated, that drives many of our results, is attenuated once the mode of competition in the downstream market is changed and if our results are robust to this extension.

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3.8 Appendix A

We first show that upstream firm U_i sets the per-unit price equal to marginal costs when making an offer to a downstream firm D_i.

We solve the game by backward induction. Thus, we start with the second stage, the downstream stage. Since contracts offers to a downstream firm D_i, $i = 1, 2$, are non-observable to the rival firm D_{-i}, and downstream firms hold passive conjectures, D_i, independent of the contract offers it receives, expects D_{-i} to produce the candidate equilibrium quantity $q_{D_{-i}}$. Therefore, if D_i accepts offers such that its input costs are w_i for input i and w_{-i} for input $-i$, due to the one-to-one technology it will produce a quantity q_{D_i} that is given by

$$q_{D_i} \;=\; \arg\max_q \;\left\{\left(P(q+q_{D_{-i}}) - w_i - w_{-i}\right) q\right\}. \tag{3.18}$$

In the following, we denote the downstream profit $(P(q_{D_i}+q_{D_{-i}})-w_i-w_{-i})q_{D_i}$ by $\Pi_{D_i}(q_{D_i}(w_i, w_{-i}), q_{D_{-i}})$.

We turn to the first stage, the offer game. Suppose that U_i is the first to offer to D_i. Since $\hat{U}_i$ is less efficient than U_i, it is willing to offer a contract of $w_{\hat{U}_i}^{D_i} = \hat{c}_i$ and $F_{\hat{U}_i}^{D_i} = 0$. The maximization problem of U_i with respect to $w_{U_i}^{D_i}$ is then given by

$$\max_{w_{U_i}^{D_i}} \qquad x_{U_i}^{D_i}(w_{U_i}^{D_i}, E[w_{-i}])(w_{U_i}^{D_i} - c_i) + F_{U_i}^{D_i} \tag{3.19}$$

$$s.t.\quad \Pi_{D_i}(q_{D_i}(w_{U_i}^{D_i}, E[w_{-i}]), q_{D_{-i}}) - F_{U_i}^{D_i} \geq \Pi_{D_i}(q_{D_i}(\hat{c}_i, E[w_{-i}]), q_{D_{-i}}). \tag{3.20}$$

Here, $E[w_{-i}]$ denotes the wholesale price at which U_i expects firm D_i to buy input $-i$. Thus, firm U_i receives as a profit from D_i the margin of its wholesale price over marginal costs times the quantity that D_i buys, denoted by $x_{U_i}^{D_i}$, plus the fixed fee. The constraint that it faces is that D_i accepts the offer of U_i only in case D_i can ensure itself weakly larger profits from accepting U_i's offer than from buying the input from $\hat{U}_i$ at a price of $\hat{c}_i$ and a fixed fee of zero. Since the downstream competitor D_{-i} does not observe the offer made to D_i and holds passive beliefs, the quantity that D_{-i} produces, $q_{D_{-i}}$, does not change if the tariff offered to D_i changes. Thus, we can treat $q_{D_{-i}}$ as a constant in the above maximization problem.

It is optimal for U_i to set F_i as large as possible, which implies that

$$F_{U_i}^{D_i} = \Pi_{D_i}(q_{D_i}(w_{U_i}^{D_i}, E[w_{-i}]), q_{D_{-i}}) - \Pi_{D_i}(q_{D_i}(\hat{c}_i, E[w_{-i}]), q_{D_{-i}}).$$

The maximization problem can then be written as

$$\max_{w_{U_i}^{D_i}} \; x_{U_i}^{D_i}(w_{U_i}^{D_i}, E[w_{-i}])(w_{U_i}^{D_i}-c_i)+\Pi_{D_i}(q_{D_i}(w_{U_i}^{D_i}, E[w_{-i}]), q_{D_{-i}})-\Pi_{D_i}(q_{D_i}(\hat{c}_i, E[c_{-i}]), q_{D_{-i}}). \tag{3.21}$$

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The last term is independent of $w_{U_i}^{D_i}$.

Because of the envelope theorem, the effect of a change in q_{D_i} in response to a change in $w_{U_i}^{D_i}$ on the profit of D_i is zero. Thus, differentiating (3.21) with respect to $w_{U_i}^{D_i}$ gives

$$(w_{U_i}^{D_i} - c_i)\frac{\partial x_{U_i}^{D_i}}{\partial w_{U_i}^{D_i}} + x_{U_i}^{D_i} - q_{U_i}^{D_i} = 0.$$

Since downstream transformation technology is one-to-one and downstream firms transform all input to output we have $q_{U_i}^{D_i} = x_{U_i}^{D_i}$. Since $(\partial x_{U_i}^{D_i}/\partial w_{U_i}^{D_i}) < 0$, we obtain $w_{U_i}^{D_i} = c_i$, i.e., U_i optimally sets the per-unit price equal to marginal cost.

Suppose that U_i is the second to offer. As above, $\hat{U}_i$ offers $w_{\hat{U}_i}^{D_i} = \hat{c}_i$ and $F_{\hat{U}_i}^{D_i} = 0$. If U_i is the second to offer, it faces two constraints. First, it has to set its tariff such that D_i prefers to buy the input from U_i and not from $\hat{U}_i$, given that it also accepts the offer from U_{-i}. Second, U_i's tariff has to be such that D_i does not prefer to buy from both bypass alternatives instead of U_i and U_{-i}. Therefore, U_i's optimization problem can be written as

$$\max_{w_{U_i}^{D_i}} \quad x_{U_i}^{D_i}(w_{U_i}^{D_i}, c_{-i})(w_{U_i}^{D_i} - c_i) + F_{U_i}^{D_i} \tag{3.22}$$

$$s.t. \quad (i) \quad \Pi_{D_i}(q_{D_i}(w_{U_i}^{D_i}, c_{-i}), q_{D_{-i}}) - F_{U_{-i}}^{D_i} - F_{U_i}^{D_i} \geq \Pi_{D_i}(q_{D_i}(\hat{c}_i, c_{-i}), q_{D_{-i}}) - F_{U_{-i}}^{D_i} \tag{3.23}$$

$$(ii) \quad \Pi_{D_i}(q_{D_i}(w_{U_i}^{D_i}, c_{-i}), q_{D_{-i}}) - F_{U_{-i}}^{D_i} - F_{U_i}^{D_i} \geq \max\left[\Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q_{D_{-i}}), 0\right]. \tag{3.24}$$

Constraint (i) states that the profit of D_i from accepting the offer of U_i must be weakly larger than accepting the offer of $\hat{U}_i$ given that D_i also accepts the offer of U_{-i} which, by the arguments above, offers a wholesale price of $w_{U_{-i}}^{D_i} = c_{-i}$. Constraint (ii) implies that D_i's profit when accepting the offers from U_i and U_{-i} is larger than the maximum of the profits when either accepting the offers from $\hat{U}_i$ and $\hat{U}_{-i}$, which is $\Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q_{D_{-i}})$, or when rejecting all offers–which gives a profit of zero.[15] As above, independently from constraint (i) or (ii) being the binding one, U_i optimally sets $F_{U_i}^{D_i}$ such that the binding constraint holds with equality. Now, inserting the respective $F_{U_i}^{D_i}$ of each constraint into the objective function and maximizing with respect to $w_{U_i}^{D_i}$, we obtain by the same arguments as above that $w_{U_i}^{D_i} = c_i$. Therefore, we have that independent of the order of offers, in equilibrium U_i sets $w_{U_i}^{D_i} = c_i$ and U_{-i} sets $w_{U_{-i}}^{D_i} = c_{-i}$.

[15] In case the first-stage offers were not observable to U_i, constraints (i) and (ii) have to be modified by writing $E[F_{U_{-i}}^{D_i}]$ instead of $F_{U_{-i}}^{D_i}$, i.e., U_i has to form expectations about $F_{U_{-i}}^{D_i}$. However, it is easy to show that, since U_i knows that it is the second to offer and since expectations are correct in equilibrium, the result is the same as in the case of observability of first-stage offers.

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As a consequence, both downstream firms face marginal costs of $c_1 + c_2$. Therefore, the maximization problem of downstream firm i is given by

$$\max_q \left\{ \left(P(q + q_{D_{-i}}) - c_1 - c_2 \right) q \right\}, \ i = 1, 2.$$

It thus follows that each downstream firm produces the Cournot quantity for marginal costs of $c_1 + c_2$, that is

$$q_1 = q_2 = q^c = \arg \max_q \ \{ (P(q + q^c) - c_1 - c_2) \, q \} .$$

Finally, we turn to the fixed fees. From above, it is evident that if U_i is the first to offer to D_i, it sets a fixed fee of

$$F_{U_i}^{D_i} = \Pi_{D_i}(q^c, q^c) - \Pi_{D_i}(q_{D_i}(\hat{c}_i, c_{-i}), q^c). \tag{3.25}$$

To the contrary, if U_i is the second to offer to D_i, the fixed fee depends on constraint (i) or constraint (ii) being the tighter one. Since it is optimal for U_i to set $w_{U_i}^{D_i} = c_i$, constraint (i) can be written as

$$F_{U_i}^{D_i} = \Pi_{D_i}(q^c, q^c) - \Pi_{D_i}(q_{D_i}(\hat{c}_i, c_{-i}), q^c). \tag{3.26}$$

Turning to the second constraint we know that if U_{-i} is the first to offer its fixed fee is given by

$$F_{U_{-i}}^{D_i} = \Pi_{D_i}(q^c, q^c) - \Pi_{D_i}(q_{D_i}(c_i, \hat{c}_{-i}), q^c).$$

Inserting this into constraint (ii) and rearranging, we obtain

$$F_{U_i}^{D_i} = \Pi_{D_i}(q_{D_i}(c_i, \hat{c}_{-i}), q^c) - \max \left[\Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q^c), 0 \right] . \tag{3.27}$$

To determine which of the two constraints is binding, we have to compare the right-hand sides of (3.26) and (3.27). Subtracting the right-hand side of (3.27) from the right-hand side of (3.26) and rearranging, we obtain that the right-hand side of (3.26) is larger than the one of (3.27) if

$$\Pi_{D_i}(q^c, q^c) + \max \left[\Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q^c), 0 \right] > \Pi_{D_i}(q_{D_i}(\hat{c}_i, c_{-i}), q^c) + \Pi_{D_i}(q_{D_i}(c_i, \hat{c}_{-i}), q^c). \tag{3.28}$$

Let us rewrite (3.28) as

$$\Pi_{D_i}(q^c, q^c) + \Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q^c) > \Pi_{D_i}(q_{D_i}(\hat{c}_i, c_{-i}), q^c) + \Pi_{D_i}(q_{D_i}(c_i, \hat{c}_{-i}), q^c). \tag{3.29}$$

The first term on the left-hand side of (3.29) is the profit of firm D_i given that its marginal costs are $c_1 + c_2$, while the second term on the left-hand side is the profit of firm D_i given that its marginal costs are $\hat{c}_1 + \hat{c}_2$. To the contrary, the two terms on the right-hand side of (3.29) represent firm D_i's profit given that its marginal costs are $\hat{c}_1 + c_2$ and $c_1 + \hat{c}_2$, respectively.[16] By Jensen's inequality, (3.29) is fulfilled if the profit function of D_i is convex in marginal costs. Now, differentiating Π_{D_i} with respect to marginal costs $C_i := c_1' + c_2'$ and using the envelope theorem, we obtain

$$\frac{\partial \Pi_{D_i}}{\partial C_i} = -q_{D_i} < 0$$

and

$$\frac{\partial^2 \Pi_{D_i}}{\partial C^2} = -\frac{\partial q_{D_i}}{\partial C_i} > 0.$$

Thus, Π_{D_i} is convex in marginal costs and (3.29) holds. The only difference between (3.28) and (3.29) is that in (3.28) the second term is given by the maximum of $\Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q^c)$ and 0 while in (3.29) it is just $\Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q^c)$, but the convexity of the profit function implies that (3.29) holds independently from the sign of $\Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q^c)$, so we necessarily have that (3.28) is fulfilled as well. All this implies that the fixed fee given by (3.26) is larger than the one given by (3.27), constraint (ii) is the tighter one and if firm U_i is the second to offer it sets a fixed fee that is given by (3.27).

Therefore, we have that if firm U_i is the first to offer to D_i, it proposes a contract in which the wholesale price is given by $w_{U_i}^{D_i} = c_i$ and the fixed fee is given by $F_{U_i}^{D_i} = \Pi_{D_i}(q^c, q^c) - \Pi_{D_i}(q_{D_i}(\hat{c}_i, c_{-i}), q^c)$ or $F_{U_i}^{D_i} = \Pi^c - \max_q \{(P(q + q^c) - \hat{c}_i - c_{-i})\, q\}$. Instead, if firm U_i is the second to offer to D_i, it proposes a contract in which the wholesale price is again given by $w_{U_i}^{D_i} = c_i$ and the fixed fee is given by $F_{U_i}^{D_i} = \Pi_{D_i}(q_{D_i}(c_i, \hat{c}_{-i}), q^c) - \max[\Pi_{D_i}(q_{D_i}(\hat{c}_i, \hat{c}_{-i}), q^c), 0]$ or $F_{U_i}^{D_i} = \max_q \{(P(q + q^c) - c_i - \hat{c}_{-i})\, q\} - \max[\max_q \{(P(q + q^c) - \hat{c}_i - \hat{c}_{-i})\, q\}, 0]$.$\blacksquare$

3.9 Appendix B

We first determine the following expression

$$\Pi^c - \max_q\{[P(q + q^c) - \hat{c}_1 - c_2]q\} + \max_q\{[P(q + q^c) - c_1 - \hat{c}_2]q\}, \tag{3.30}$$

which would give us the value of the profits under non-integration and linear demand. As for the Cournot profit Π^c, standard computations yield to

$$q^c = \frac{1 - c_1 - c_2}{3}$$

[16]Note that in each of the four terms in (3.29) firm D_{-i} produces a quantity of q^c.

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and $\Pi^c = (q^c)^2$.

Next we determine $\max_q\{[P(q+q^c) - c_1 - \hat{c}_2]q\}$. We first calculate the value of q' such that

$$q' = \arg\max_q\{[P(q+q^c) - c_1 - \hat{c}_2]q\}$$

which in case of linear demand can be written as

$$\arg\max_q\{[1 - c_1 - \hat{c}_2 - (1 - c_1 - c_2)/3 - q]q\}.$$

It turns out that:

$$q' = \frac{2(1-c_1-c_2) - 3\Delta_2}{6},$$

with $q' > 0$ under our assumption $\Delta_i < (1 - c_1 - c_2)/2$, and

$$\max_q\{[P(q+q^c) - c_1 - \hat{c}_2]q = (q')^2.$$

Finally, we compute $\max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\}$. Defining q'' such that

$$q'' = \arg\max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\} = \arg\max_q\{[1 - \hat{c}_1 - c_2 - (1 - c_1 - c_2)/3 - q]q\},$$

we obtain

$$q'' = \frac{2(1-c_1-c_2) - 3\Delta_1}{6},$$

thus $\max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\} = (q'')^2$.

Then, the sum of U_1 and D_1 profits under non-integration is equal to

$$\Pi^c - \max_q\{[P(q+q^c) - \hat{c}_1 - c_2]q\} + \max_q\{[P(q+q^c) - \hat{c}_2 - c_1]q\} =$$

$$= \Big(\frac{1-c_1-c_2}{3}\Big)^2 - \Big[\frac{2(1-c_1-c_2) - 3\Delta_1}{6}\Big]^2 + \Big[\frac{2(1-c_1-c_2) - 3\Delta_2}{6}\Big]^2 =$$

$$= \frac{3\Delta_1[4(1-c_1-c_2) - 3\Delta_1] + [2(1-c_1-c_2) - 3\Delta_2]^2}{36}. \tag{3.31}$$

Now, we turn to the computation of the profit under vertical integration. First of all,

$$q_2^c(w_{U_1}^{D_2}) = (1 - 2w_{U_1}^{D_2} - c_2 + c_1)/3 = [1 - c_1 - c_2 - 2(w_{U_1}^{D_2} - c_1)]/3$$

and

$$q_1^c(w_{U_1}^{D_2}) = (1 - 2c_1 - c_2 + w_{U_1}^{D_2})/3 = (1 - c_1 - c_2 + w_{U_1}^{D_2} - c_1)/3.$$

Thus,

$$q_2^c(w_{U_1}^{D_2})(w_{U_1}^{D_2}-c_1)=(w_{U_1}^{D_2}-c_1)[1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)]/3$$

and

$$\max_q\{[P(q+q_1^c(w_{U_1}^{D_2}))-w_{U_1}^{D_2}-c_2]q\}=(q_2^c(w_{U_1}^{D_2}))^2.$$

Then, we compute the value of $q_1'''(w_{U_1}^{D_2})$, where $q_1'''(w_{U_1}^{D_2})$ is given by

$$q_1'''(w_{U_1}^{D_2})=\arg\max_q\{[P(q+q_2^c(w_{U_1}^{D_2}))-c_1-\hat{c}_2]q\}=\arg\max_q\{[1-c_1-\hat{c}_2-(1-2w_{U_1}^{D_2}+c_1-c_2)/3-q]q\}.$$

We obtain

$$q_1'''(w_{U_1}^{D_2})=\frac{2(1-c_1-c_2)+2(w_{U_1}^{D_2}-c_1)-3\Delta_2}{6}$$

and

$$\max_q\{[P(q+q_2^c(w_{U_1}^{D_2}))-c_1-\hat{c}_2]q\}=(q_1'''(w_{U_1}^{D_2}))^2.$$

Finally, to determine the value of $\max_q\{[P(q+q_1^c(\hat{c}_1))-\hat{c}_1-c_2]q\}$ we use the fact that the vertically integrated firm U_1-D_1 now knows when D_2 is buying from the bypass alternative and it can react promptly on the product market. Therefore, one has that

$$q_2^c(\hat{c}_1)=\arg\max_q\{[P(q+q_1^c(\hat{c}_1))-\hat{c}_1-c_2]q\}=(1-c_1-c_2-2\Delta_1)/3.$$

Thus,

$$q_2^c(\hat{c}_1)=(1-c_1-c_2-2\Delta_1)/3$$

and

$$\max_q\{[P(q+q_1^c(\hat{c}_1))-\hat{c}_1-c_2]q\}=(q_2^c(\hat{c}_1))^2.$$

We showed in the main text that the problem of maximization of the integrated firm can be rewritten in the following way, independently from the negotiation order of U_1-D_1 with D_2:

$$\max_{w_{U_1}^{D_2}}\Pi^{U_1-D_1}(w_{U_1}^{D_2})=\max_q\{[P(q+q_2^c(w_{U_1}^{D_2}))-c_1-\hat{c}_2]q\}+q_2^c(w_{U_1}^{D_2})(w_{U_1}^{D_2}-c_1)+$$

$$+\max_q\{[P(q+q_1^c(w_{U_1}^{D_2}))-w_{U_1}^{D_2}-c_2]q\}=$$

$$=\Big[\frac{2(1-c_1-c_2)+2(w_{U_1}^{D_2}-c_1)-3\Delta_2}{6}\Big]^2+(w_{U_1}^{D_2}-c_1)\frac{1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)}{3}+$$

$$+\Big[\frac{1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)}{3}\Big]^2. \tag{3.32}$$

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The resulting first order condition with respect to $w_{U_1}^{D_2}$ is

$$\frac{c_1 - 3\Delta_2 - 2w_{U_1}^{D_2} + 1 - c_2}{9}.$$

Thus, the second order condition is fulfilled and the expression for the optimal value of $w_{U_1}^{D_2}$ is given below:

$$w_{U_1}^{D_2} = c_1 + \frac{1 - c_1 - c_2 - 3\Delta_2}{2},$$

with

$$w_{U_1}^{D_2} \begin{cases} = \hat{c}_1 & \text{if} \quad \Delta_1 < (1 - c_1 - c_2)/2 - 3\Delta_2/2 = \underline{\Delta}_1. \\ \\ < \hat{c}_1 & \text{otherwise.} \end{cases}$$

Now, if

$$\max_q\{(P(q + q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2)q\} - \max_q\{(P(q + q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2)q\} =$$

$$= \min\Big[\max_q\{(P(q + q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2)q\} - \max_q\{(P(q + q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2)q\},$$
$$\max_q\{(P(q + q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - \hat{c}_2)q\} - \max[\max_q\{(P(q + q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2)q\}, 0]\Big], \quad (3.33)$$

the profit of $U_1 - D_1$ is equal to:

$$\max_q\{[P(q + q_2^c(w_{U_1}^{D_2})) - c_1 - \hat{c}_2]q\} + q_2^c(w_{U_1}^{D_2})(w_{U_1}^{D_2} - c_1) +$$

$$+ \max_q\{[P(q + q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2]q\} - \max_q\{[P(q + q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2]q\} =$$

$$= \Big[\frac{2(1 - c_1 - c_2) + 2(w_{U_1}^{D_2} - c_1) - 3\Delta_2}{6}\Big]^2 + (w_{U_1}^{D_2} - c_1)\frac{1 - c_1 - c_2 - 2(w_{U_1}^{D_2} - c_1)}{3} +$$

$$+ \Big[\frac{1 - c_1 - c_2 - 2(w_{U_1}^{D_2} - c_1)}{3}\Big]^2 - \Big[\frac{1 - c_1 - c_2 - 2\Delta_1}{3}\Big]^2. \quad (3.34)$$

Instead, if

$$\min\Big[\max_q\{(P(q + q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2)q\} - \max_q\{(P(q + q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2)q\},$$
$$\max_q\{(P(q + q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - \hat{c}_2)q\} - \max[\max_q\{(P(q + q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2)q\}, 0]\Big] =$$

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$$= \max_q\{(P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - \hat{c}_2)q\} - \max[\max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2)q\}, 0],$$

the expected profit of profit of $U_1 - D_1$ is equal to

$$q_2^c(w_{U_1}^{D_2})(w_{U_1}^{D_2} - c_1) + \max_q\{[P(q+q_2^c(w_{U_1}^{D_2})) - c_1 - \hat{c}_2]q\}+$$

$$+\frac{1}{2}\Big[\max_q\{[P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2]q\} - \max_q\{[P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2]q\}\Big]+$$

$$+\frac{1}{2}\Big[\max_q\{[P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - \hat{c}_2]q\} - \max[\max_q\{(P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2)q\}, 0]\Big].$$

The rent that D_2 raises when getting the inputs from firms $\hat{U}_i$ is equal to $\max_q\{[P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - \hat{c}_2]q\} = \left[\frac{2(1-c_1-c_2)-3\Delta_2-4\Delta_1}{6}\right]^2$, with

$$\frac{2(1-c_1-c_2)-3\Delta_2-4\Delta_1}{6}\begin{cases} \geq 0 & \text{if} \quad \Delta_1 \leq (1-c_1-c_2)/2 - 3\Delta_2/4 \equiv \bar{\Delta}_1. \\ < 0 & \text{otherwise.} \end{cases}$$

Consequently, if $\Delta_1 \leq \bar{\Delta}_1$, the value of the expression above is equal to

$$= \left[\frac{2(1-c_1-c_2)+2(w_{U_1}^{D_2}-c_1)-3\Delta_2}{6}\right]^2 + (w_{U_1}^{D_2}-c_1)\frac{1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)}{3}+$$

$$+\frac{1}{2}\left\{\left[\frac{1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)}{3}\right]^2 - \left[\frac{1-c_1-c_2-2\Delta_1}{3}\right]^2\right\}+$$

$$+\frac{1}{2}\left\{\left[\frac{2(1-c_1-c_2)-3\Delta_2-4(w_{U_1}^{D_2}-c_1)}{6}\right]^2 - \left[\frac{2(1-c_1-c_2)-3\Delta_2-4\Delta_1}{6}\right]^2\right\}. \quad (3.35)$$

Instead, if $\Delta_1 > \bar{\Delta}_1$, the value of the expected profits is

$$\left[\frac{2(1-c_1-c_2)+2(w_{U_1}^{D_2}-c_1)-3\Delta_2}{6}\right]^2 + (w_{U_1}^{D_2}-c_1)\frac{1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)}{3}+$$

$$+\frac{1}{2}\left\{\left[\frac{1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)}{3}\right]^2 - \left[\frac{1-c_1-c_2-2\Delta_1}{3}\right]^2 + \left[\frac{2(1-c_1-c_2)-3\Delta_2-4(w_{U_1}^{D_2}-c_1)}{6}\right]^2\right\} \quad (3.36)$$

The condition that determines which between (3.34) and (3.36) or (3.35) gives the profits under integration is obtained by discussing (3.33) above, which boils down to

$$\max_q\{[P(q+q_1^c(w_{U_1}^{D_2})) - w_{U_1}^{D_2} - c_2]q\} - \max_q\{[P(q+q_1^c(\hat{c}_1)) - \hat{c}_1 - c_2]q\} \leq$$

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$$\max_q\{[P(q+q_1^c(w_{U_1}^{D_2}))-w_{U_1}^{D_2}-\hat{c}_2]q\}-\max[\max_q\{(P(q+q_1^c(\hat{c}_1))-\hat{c}_1-\hat{c}_2)q\},0] \quad (3.37)$$

If $\Delta_1 < (1-c_1-c_2)/2 - 3\Delta_2/2 = \underline{\Delta}_1$, one has that $w_{U_1}^{D_2} = \hat{c}_1$ and the condition above is always satisfied. Indeed, at $w_{U_1}^{D_2} = \hat{c}_1$ one has that (3.37) is equal to

$$\left[\frac{1-c_1-c_2-2\Delta_1}{3}\right]^2 - \left[\frac{1-c_1-c_2-2\Delta_1}{3}\right]^2 =$$

$$= \left[\frac{2(1-c_1-c_2)-3\Delta_2-4\Delta_1}{6}\right]^2 - \left[\frac{2(1-c_1-c_2)-3\Delta_2-4\Delta_1}{6}\right]^2 = 0.$$

Therefore, expression (3.34) evaluated at $w_{U_1}^{D_2} = \hat{c}_1$ gives the profit of $U_1 - D_1$.

If $\Delta_1 \in [(1-c_1-c_2)/2-3\Delta_2/2, (1-c_1-c_2)/2-3\Delta_2/4)$–that is, into $[\underline{\Delta}_1, \bar{\Delta}_1)$–, $w_{U_1}^{D_2} < \hat{c}_1$ and condition (3.37) becomes

$$\left[\frac{1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)}{3}\right]^2 - \left[\frac{1-c_1-c_2-2\Delta_1}{3}\right]^2 \leq$$

$$\left[\frac{2(1-c_1-c_2)-3\Delta_2-4(w_{U_1}^{D_2}-c_1)}{6}\right]^2 - \left[\frac{2(1-c_1-c_2)-3\Delta_2-4\Delta_1}{6}\right]^2,$$

which is satisfied for all $\Delta_1 \leq (1-c_1-c_2)/2-3\Delta_2/2 = \underline{\Delta}_1$, meaning that for all $\Delta_1 \in [\underline{\Delta}_1, \bar{\Delta}_1)$ (3.35) is the relevant expression for the profits of $U_1 - D_1$. Finally, if $\Delta_1 \in [\bar{\Delta}_1, (1-c_1-c_2)/2)$ we know from above that one has that

$$\max\left[\frac{2(1-c_1-c_2)-3\Delta_2-4\Delta_1}{6}, 0\right] = 0.$$

Instead,

$$\frac{2(1-c_1-c_2)-3\Delta_2-4(w_{U_1}^{D_2}-c_1)}{6} = \frac{\Delta_2^2}{4} > 0.$$

Therefore, condition (3.37) is given by

$$\left[\frac{1-c_1-c_2-2(w_{U_1}^{D_2}-c_1)}{3}\right]^2 - \left[\frac{1-c_1-c_2-2\Delta_1}{3}\right]^2 \leq$$

$$\left[\frac{2(1-c_1-c_2)-3\Delta_2-4(w_{U_1}^{D_2}-c_1)}{6}\right]^2.$$

This is satisfied for all $\Delta_1 \leq (1-c_1-c_2)/2 - 3\sqrt{3}\Delta_2/4 < (1-c_1-c_2)/2 - 3\Delta_2/4 = \bar{\Delta}_1$. Hence, for $\Delta_1 \in [\bar{\Delta}_1, (1-c_1-c_2)/2)$ (3.36) determines the profits of $U_1 - D_1$.

We can conclude that the threshold below which (3.34) must be used is equal to the threshold below which foreclosure is optimal, this is given by

$$\underline{\Delta}_1 = (1-c_1-c_2)/2 - 3\Delta_2/2.$$

We now turn to the analysis of the profitability of integration.

Below $\underline{\Delta}_1$, where foreclosure is optimal, the profits of the integrated firm are equal to

$$\frac{[2(1-c_1-c_2)+2\Delta_1-3\Delta_2]^2+12\Delta_1[(1-c_1-c_2)-2\Delta_1]}{36},$$

and the value of this expression is bigger than the one of the profits under non integration (3.31) in the range of interest (that is, below $\underline{\Delta}_1$).

In the interval $[\underline{\Delta}_1, \bar{\Delta}_1)$, with $\bar{\Delta}_1 \equiv (1-c_1-c_2)/2 - 3\Delta_2/4$, the profits under integration are given by expression (3.35) evaluated at $w_{D_2}^{U_1} < \hat{c}_1$. In particular, they are equal to

$$\frac{4[(1-c_1-c_2)(4\Delta_1-3\Delta_2)-\Delta_1(4\Delta_1+3\Delta_2)]+5(1-c_1-c_2)^2}{36}.$$

By comparing this expression with the profits under non integration, (3.31), one has that

$$\frac{4[(1-c_1-c_2)(4\Delta_1-3\Delta_2)-\Delta_1(4\Delta_1+3\Delta_2)]+5(1-c_1-c_2)^2}{36}-$$
$$+\frac{3\Delta_1[4(1-c_1-c_2)-3\Delta_1]+[2(1-c_1-c_2)-3\Delta_2]^2}{36}=$$
$$=\frac{4\Delta_1[(1-c_1-c_2)-3\Delta_2]+(1-c_1-c_2)^2-7\Delta_1^2-9\Delta_2^2}{36}$$

and

$$\frac{4\Delta_1[(1-c_1-c_2)-3\Delta_2]+(1-c_1-c_2)^2-7\Delta_1^2-9\Delta_2^2}{36}\geq 0 \iff$$
$$\Delta_1 \leq \frac{2(1-c_1-c_2)-6\Delta_2+\sqrt{[9\Delta_2+11(1-c_1-c_2)][(1-c_1-c_2)-3\Delta_2]}}{7} \equiv \tilde{\Delta}_1.$$

In the interval $[\bar{\Delta}_1, (1-c_1-c_2)/2)$ the profits under integration are given by expression (3.36) evaluated at $w_{D_2}^{U_1} < \hat{c}_1$. In particular, they are equal to

$$\frac{16\Delta_1(1-c_1-c_2-\Delta_1)-9\Delta_2[4(1-c_1-c_2)-\Delta_2]+14(1-c_1-c_2)^2}{72}.$$

By comparing this expression with the profits under non integration one has that

$$\frac{16\Delta_1(1-c_1-c_2-\Delta_1)-9\Delta_2[4(1-c_1-c_2)-\Delta_2]+14(1-c_1-c_2)^2}{72}-$$
$$+\frac{3\Delta_1[4(1-c_1-c_2)-3\Delta_1]+[2(1-c_1-c_2)-3\Delta_2]^2}{36}=$$
$$=\frac{-9\Delta_2^2+2[\Delta_1^2-4\Delta_1(1-c_1-c_2)+3(1-c_1-c_2)(1-c_1-c_2-2\Delta_2)]}{72}$$

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and

$$\frac{-9\Delta_2^2 + 2[\Delta_1^2 - 4\Delta_1(1-c_1-c_2) + 3(1-c_1-c_2)(1-c_1-c_2-2\Delta_2)]}{72} \geq 0 \iff$$

$$\Delta_1 \leq 2(1-c_1-c_2) - \sqrt{\frac{9\Delta_2^2}{2} + (1-c_1-c_2)(1-c_1-c_2+6\Delta_2)} \equiv \tilde{\tilde{\Delta}}_1.$$

Notice that if $\Delta_2 < 2(2\sqrt{15}-5)/21$ one has that

$$\tilde{\Delta}_1 - \bar{\Delta}_1 \geq 0 \quad \text{and} \quad \tilde{\tilde{\Delta}}_1 - \bar{\Delta}_1 \geq 0.$$

So, if $\Delta_2 < 2(1-c_1-c_2)(2\sqrt{15}-5)/21$ then $\bar{\Delta}_1 < \min\{\tilde{\Delta}_1, \tilde{\tilde{\Delta}}_1\}$. Instead, if $\Delta_2 > 2(1-c_1-c_2)(2\sqrt{15}-5)/21$ then $\bar{\Delta}_1 > \max\{\tilde{\Delta}_1, \tilde{\tilde{\Delta}}_1\}$.

Concluding, if $\Delta_2 \in (0, 2(1-c_1-c_2)(2\sqrt{15}-5)/21)$ we obtain the following result:

- If $0 < \Delta_1 \leq \underline{\Delta}_1$, the integrated firm sets $w_{D_2}^{U_1} = \hat{c}_1$ and integration is profitable.
- If $\underline{\Delta}_1 < \Delta_1 \leq \tilde{\tilde{\Delta}}_1$, the integrated firm sets $c_1 < w_{D_2}^{U_1} < \hat{c}_1$ and integration is profitable.
- If $\tilde{\tilde{\Delta}}_1 < \Delta_1 < (1-c_1-c_2)/2$, the integrated firm would set $w_{D_2}^{U_1} < \hat{c}_1$, but integration is not profitable.

If instead $\Delta_2 \in (2(1-c_1-c_2)(2\sqrt{15}-5)/21), (1-c_1-c_2)/3)$ we obtain the following result

- If $0 < \Delta_1 \leq \underline{\Delta}_1$, the integrated firm sets $w_{D_2}^{U_1} = \hat{c}_1$ and integration is profitable.
- If $\underline{\Delta}_1 < \Delta_1 \leq \tilde{\Delta}_1$, the integrated firm sets $w_{D_2}^{U_1} < \hat{c}_1$ and integration is profitable.
- If $\tilde{\Delta}_1 < \Delta_1 < (1-c_1-c_2)/2$, the integrated firm would set $c_1 < w_{D_2}^{U_1} < \hat{c}_1$, but integration is not profitable.

Finally, for $\Delta_2 \in ((1-c_1-c_2)/3, (1-c_1-c_2)/2)$ the integrated firm would set $w_{D_2}^{U_1} \leq c_1$, but integration is not profitable.$\blacksquare$

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3.10 Figures

Figure 3.1: Framework.

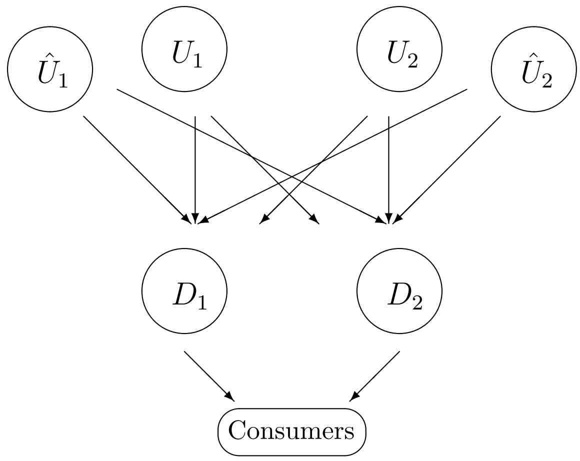
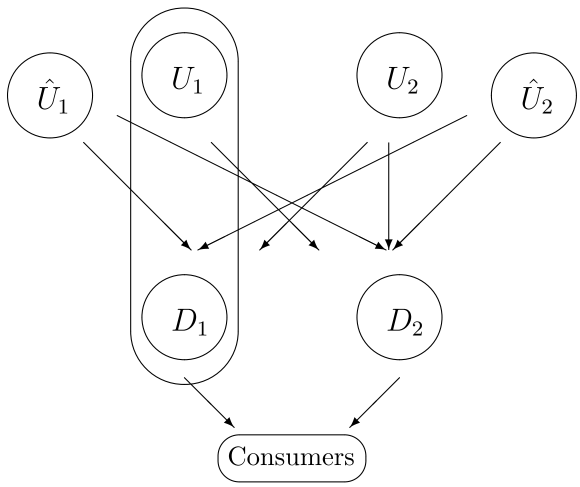


Figure 3.2: Framework with Integration.



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European University Institute DOI: 10.2870/23062

Bibliography

[1] Baake, Pio, Ulrich Kamecke, and Hans-Theo Normann, 2004, Vertical Foreclosure versus Down- stream Competition with Capital Precommitment, *International Journal of Industrial Organization*, 22, 185-192.

[2] Chen, Yongmin, 2001, On Vertical Mergers and Their Competitive Effects, *Rand Journal of Economics*, 32, 667-685.

[3] Choi, Jay Pil and Sang-Seung Yi, 2000, Vertical Foreclosure with the Choice of Input Specifications, *Rand Journal of Economics*, 30, 717-743.

[4] Hart, Oliver and Jean Tirole, 1990, Vertical Integration and Market Foreclosure, *Brookings Papers on Economic Activity (Microeconomics)*, 205-285.

[5] Kreps, David and Jose Scheinkman, 1983, Quantity Pre-Commitment and Bertrand Competition yield Cournot Outcomes, *Bell Journal of Economics*, 14, 326-337.

[6] Marx, Leslie M. and Greg Shaffer, 2004, Opportunism in Multilateral Vertical Contracting: Nondiscrimination, Exclusivity, and Uniformity: Comment, *American Economic Review*, 94(1), 796-801.

[7] McAfee, R. Preston and Marius Schwartz, 1994, Opportunism in Multilateral Vertical Contracting: Nondiscrimination, Exclusivity, and Uniformity, *American Economic Review*, 84, 210-230.

[8] O'Brien, Daniel and Greg Shaffer, 1992, Vertical Control with Bilateral Contracts, *RAND Journal of Economics*, 23, 299-308.

[9] Ordover, Janusz, Garth Saloner and Steven C. Salop, 1990, Equilibrium Market Foreclosure, *American Economic Review*, 80, 127-142.

Tarantino, Emanuele (2010), Three Essays in Industrial Organization and Corporate Finance
European University Institute DOI: 10.2870/23062

[10] Rey, Patrick and Jean Tirole, 2007, A Primer on Foreclosure, in: Armstrong, M., and R. H. Porter (eds.), *Handbook of Industrial Organization*, Vol. 3, (North-Hollan.

[11] Riordan, Michael, 1996, Anticompetitive Vertical Integration by a Dominant Firm, *American Economic Review*, 88, 1232-1248.

[12] Salop, Steven C. and Scheffman, David T., 1983, Raising Rivals' Costs, *American Economic Review, Papers and Proceedings*, 73, 267-271.

[13] Salop, Steven C. and Scheffman, David T., 1987, Cost-Raising Strategies, *The Journal of Industrial Economics*, 36, 19-34.

[14] Schmidt, Klaus M., 2008, Complementary Patents and Market Structure, *CEPR Discussion Paper*, No. DP7005.

[15] Shapiro, Carl, 2001, Navigating the Patent Thicket: Cross Licensing, Patent Pools, and Standard Setting, in: Jaffe, Adam, Josh Lerner and Scott Stern (eds.): *Innovation Policy and the Economy*, Vol. 1, (MIT Press, Cambridge MA).

[16] White, Lucy, 2007, Foreclosure with Incomplete Information, *Journal of Economics and Management Strategy*, 16(2), 507-535.

Tarantino, Emanuele (2010), Three Essays in Industrial Organization and Corporate Finance
European University Institute DOI: 10.2870/23062