Libera Università Internazionale degli Studi Sociali Guido Carli

Facoltà di Economia

Dottorato in Diritto ed Economia - XXII Ciclo

Essays on Incentives and Regulation

Tutor:

Prof. Simone M. Sepe

Candidato:

Mario Pietrunti

There are these two young fish swimming along, and they happen to meet an older fish swimming the other way, who nods at them and says, "Morning, boys, how's the water?" And the two young fish swim on for a bit, and then eventually one of them looks over at the other and goes, "What the hell is water?".

David Foster Wallace

E' il tempo che scorre lungo i bordi.

Emidio Clementi

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Introduction

This thesis is the result of a three-year research activity within the Ph.D. Program in Law and Economics at Luiss University. It is composed of three essays on different topics in Law and Economics, which have been presented separately in the form of papers in various conferences and seminars through the years and have benefited from the contribution of many people and institutions, as acknowledged in the introductory footnote of each essay.

Although related to seemingly unrelated topics, there is one fundamental link that connects the three essays: the theory of incentives. The idea that economic actors take decisions according to the economic environment in which they act goes back to the origins of economic thought. However, a formal treatment of a unified Theory of Incentives has been the highest achievement in economics in the last thirty years[1]. In this thesis, I apply the Theory of Incentives to three distinct issues in Law and Economics, trying to find similarities and common elements across different problems and turning each issue into a general and more easy to handle framework.

The most popular model of incentives in economic theory is the "principal-agent" model, which basically tends to capture all the situations in which there is an actor, the principal, that wants to induce another individual, the agent, to perform a task for the principal. This way of looking at many economic issues has completely reshaped economists' minds and has led to fruitful results in all areas of economics, including Law and Economics[2]. Therefore, the "principal-agent" model is the lens through which I will look at several economic phenomena, both from a positive and a normative point of view. The positive approach is needed,

[1] For a survey on Incentives in Economic Thought see Jean-Jacques Laffont and David Martimort, *The Theory of Incentives, The Principal-Agent Model*, Ch.1, Princeton University Press, 2002.
[2] See for instance Steven Shavell, *Foundations of Economic Analysis of Law*, Harvard University Press, 2004.

in the first instance, in order to assess the pros and the cons of the structure of incentives currently in place in a given economic environment. The normative approach is instead needed in order to ascertain the existence of welfare-improving changes in the institutional framework and to design enhanced incentive systems. The link to the classical Law and Economics literature is straightforward: the institutional framework and the structure of incentives are, in the real world, mainly dictated by the legal system.

Corporate Governance in a Multi-Principal Environment. The first essay revisits the theory of corporate governance, with a focus on the institutional governance of banking firms. The essay draws on a largely neglected contribution by Stiglitz (1985) and builds up a model in order to analyze the conflicts emerging between shareholders and debt- holders concerning the level of risk of the venture. The model is developed within a common agency framework, where managers are regarded as agent of both shareholders and debt-holders. In this setting, moral hazard on the behalf of the manager concerns two dimensions: shirking and risk taking. The common agency model highlights the conflicts emerging between the principals in terms of risk taking behavior and among the principals and the agent in terms of the level of effort undertaken by the agent.

The paper explores the optimal compensation structure for the manager that leads to Pareto efficiency. Then, the case in which shareholders and debt-holders conflict regarding the payment scheme is analyzed and the main conclusion is that a multiplicity of allocations can arise in equilibrium. Therefore, I refer to some legal institutions, concerning both the compensation structure and the extent of fiduciary duties, with the purpose of refining attainable equilibria. Hence, I first focus on the liability regime that can be activated by the debt-holder in case of failure of the project. Then, following Bernheim and Whinston (1986), I suggest two institutional remedies. The first institution relies on the role of intermediate bodies between the principals and the agent for implementing the optimal allocation through indirect mechanism designs. The second remedy is a regulatory intervention aimed at providing lower and upper bounds for the agent's aggregate transfers.

Myopia and Paternalism in the Design of Social Security Schemes. The second essay deals with a classical issue in Public Law and Economics: the optimal design of pension systems. Several rationales have been provided in order to explain the role of social security programs in modern welfare states. The most common explanation is that social security systems act as a paternalistic device that forces individuals who suffer from myopia regarding future consumption paths to adequately save for their retirement. The essay investigates the role of myopia under different assumptions. So far, the "myopia" argument has been based on the fact that people fail in fully taking into account their future behavior. This has led to a justification for public pensions that is related to compulsory savings. I analyze this literature in the light of the emerging trends in the field of behavioral economics. First I analyze the optimal pension scheme when all the agents in the economy are myopic, and then I extend the analysis to the case in which only part of the population is myopic, while the rest is made of fully rational individuals. I show that under the assumption of a paternalistic social planner, welfare improving "pay-as-you-go" schemes involve redistribution of resources from fully rational agents to myopics. In this last section, I suggest that myopia can be seen not only as a psychological bias, but also as a strategic tool. Indeed, challenging the classical view on myopia, I claim that the degree of myopia can be determined not only by psychological biases, but also, to a certain degree, by a strategic commitment of some individuals that aim at capturing the benefits of redistribution towards myopics.

Regulation and Investment Incentives for Broadband Access Networks. In the third essay, I focus on the telecommunications industry and on the incentives for the players to invest in new broadband infrastructures. Indeed, a fierce debate on how to stimulate investments in the access network is currently taking place in the EU. This debate is a consequence of the fact that the realization of new infrastructures becomes more and more urgent, in the light of the boost in the demand for on-line contents. Indeed, this transition phase brings new problems for the telecommunications industry and therefore a new regulatory approach is required. At the European level, this debate has conflicted with the review of the regulatory framework and has led to new regulatory proposals both from the Commission and from national authorities. A plurality of proposals have been suggested by both market players and institutional bodies. At the same time, many national regulators have already started pursuing their own strategies in order to spur investments.

The paper acknowledges the trade-off among investment incentives and degree of competition in the markets and accordingly sketches an optimal policy mix, taking both dynamic and static efficiency concerns into account. In particular, I propose a set of policy tools that can guarantee the achievement of an optimal level of investments through the sharing of both operative and regulatory risk among market players. In my opinion, the optimal mechanism consists of an auction among market players for wholesale interconnection. Essentially, the access division could auction physical and logical interconnection rights for different levels of the network and then set the initial price accordingly to the proximity of the interconnection point with the final customer, thus reflecting the costs of deploying the infrastructure up to the interconnection. The most attractive feature of an auction mechanism like this one relates to the creation of a risk-sharing device: indeed, if a competitor opts for a high level of interconnection, the latter will have to invest significantly to reach the final customer, but the auction price will be lower. From the market players point of view, an auction mechanism like this is equivalent to an auction for options whose exercise price is the price paid by the winner. Therefore, each player, once given the interconnection right, faces the option among investing (not exercising the option) or delaying the investment (thus exercising the option).

Moreover, the paper provides new empirical evidence on European broadband fixed markets with respect to both broadband adoption and investment choices by the market players, with the aim of assessing the effectiveness of the new EU regulatory framework of 2002 and to draw some lessons for the next-generation networks context.

The paper makes use of two different data sets. The first one is a country-level panel covering a time span of ten years (1997 – 2007) and 28 countries, mainly belonging to the EU, which includes regulatory indexes on 1) the presence of entry barriers in the sector, 2) the percentage of State ownership of telecom firms and 3) the degree of competition in the markets. From a regulatory point of view, the main result obtained from the estimation exercise is that a more competitive environment leads to higher adoption rates. The second data set is at a firm-level and is composed of 37 European firms (24 incumbents and 13 competitors), analyzed over a time span of five years (2003-2007). The analysis focuses on the investment behavior and the main finding is that more competitive markets tend to decrease the incentives to invest in the network. Therefore, the classical trade-off among static and dynamic efficiency is confirmed.

Contents

CHAPTER 1

Corporate governance in a Multi-Principal environment[1]

ABSTRACT. The paper explores the theory of corporate governance within a common agency framework, where managers are regarded as agent of both shareholders and debt holders. In this setting, moral hazard concerns two dimensions: effort and risk taking. The common agency model highlights the conflicts emerging between the principals in terms of risk taking behavior and among the principals and the agent in terms of the level of effort undertaken by the agent. The problem of the multiplicity of equilibria is tackled by imposing conditions on the monetary transfers and liability regimes. Policy considerations for managers' compensation and fiduciary duties are analyzed.

1.1. Introduction

The problem of risk taking by firms and in particular by financial intermediaries is at the core of the current debate on the genesis of financial crises and systemic risk[2]. The choice over the amount of risk that a firm can bear is made by the managers of the firm itself, although they can be led to choose a given profile of risk because of the incentives provided by the owners of the firm with respect to managers' compensation and liability regime.

The starting point of this work is the fact that managers' actions are constrained not only by their formal contract with the shareholders, but also by less explicit links with other stakeholders, especially external financiers. In a quite neglected paper, Stiglitz (1985) clearly highlights this fact:

> "[...] managers are partially controlled, directly and indirectly, through both explicit and implicit contracts and by both lenders and shareholders. The lenders exert control through both the formal terms

[1] I am immensely grateful to Jacques Crémer for his helpful comments and remarks and to all the participants to the SIDE Fifth Annual Conference, Florence, 4-5 December 2009.

[2] Covel et al. (2009) claim that "[a]t the core of the recent financial market crisis has been the discovery that these securities [i.e. collateralized debt obligations - CDOs] are actually far riskier than originally advertised". See also, for instance, "UBS admits excessive risk-taking led to $37bn writedown", April 21, 2008, www.marketwatch.com (12/12/2009).

> of their contract and their refusal to renew a loan; shareholders exert control through both the voting process and their refusal to provide additional capital. Managerial incentives are affected by both the explicit pay schedule - the rewards provided by other firms who might hire them away, provided their behavior is appropriate - and the implicit punishments provided by other firms in their treatment of those who are dismissed by their firms (or whose firms go bankrupt)" (p.141).

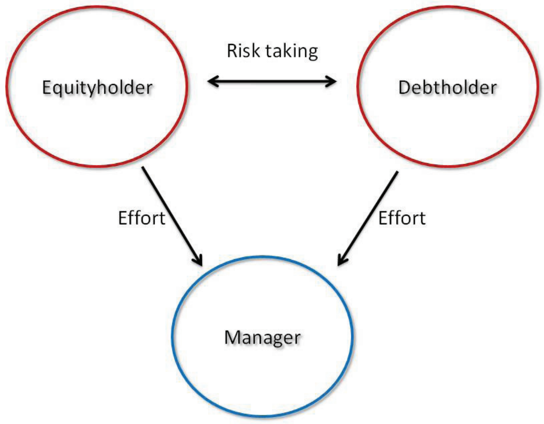
In the same paper, the author suggests also a possible way to model this relationship:

> "While the earlier literature attempted to view the manager as the agent of the supplier of credit (the "principal"), with the supplier of credit designing an efficient incentive contract for the agent, a more appropriate model is a multiple-principal- agent model, in which each principal is only allowed to set certain of the terms of the contract. These problems are, of course, ubiquitous in our economy, though they have received relatively little attention." (p.142).

Despite the powerful message of this paper, to the best of my knowledge no further work has been carried out in the literature to explore and formalize this idea. This work therefore can be considered a first (and incomplete) attempt to formalize the multi-principal-agent relationship within the corporation. The building block is the intrinsic conflict among shareholders and debt holders concerning the desirable level of risk of the venture. Indeed, as formally shown by Innes (1990), the payment schedule of standard debt and equity contracts leads the parties to share divergent preferences over risk. Indeed, while equity-holders face a convex payment schedule, and are thus willing to bear high levels of risk, debt-holders face a concave schedule, and are accordingly more inclined to pull for safe projects.

Therefore, I assume that, when hiring an agent, the principals agree of the fact that they both want him not to shirk (or, equivalently, to exert effort), but they disagree on the level of risk that should be chosen by the manager. This idea is represented in Figure 1. As a result, the compensation scheme of the manager and her liability regime will be influenced by these two dimensions of moral hazard: risk taking and effort.

FIGURE 1.1.1



Before turning to the literature review, a technical aside. The setting is considered here is one of *intrinsic* and *public* common agency. Intrinsic common agency means that the agent can either accept all contracts at once or reject them, while the game is public since both principals can contract over outcomes that are observable by both of them.

1.2. Literature review

This analysis attempted in this work can be considered an extension of the traditional Principal-Agent model within the corporation. This view traces its roots in the seminal paper by Jensen and Meckling (1976), which explores the agency relationship among managers and lenders of funds. This literature has been growing fast in the last thirty years and its findings are collected in a book by Tirole (2006), whose structure is drawn from the influential paper by Hölmstrom and Tirole (1997). Through this approach, one can view the lenders of funds acting as a principal with respect to an agent (the manager of the firm), who can take unobservable actions which can improve the profitability of the firm. The principal and the agent have divergent objective functions, since the first will tend to maximize the value of the investment in the firm, while the second will try to maximize her own utility function, by shirking or extracting “private benefits” from her activity within the firm. Therefore, a tension arises over the level of effort exerted by the manager. This approach leads to look at the firm as a “nexus of contracts”, with each agency relationship being treated separately[3]. Although very powerful,

[3]For a comparison among this view and the Transaction-Cost Economics literature, see Williamson (1988).

this approach fails in capturing many of the issues that arise in complex organizations, where more than two actors are involved. Indeed, situations may emerge, like in the case at hand, where some of the players involved have conflicting interests over different dimensions (e.g. risk taking and managerial effort), whose economic implications cannot be fully appreciated within the traditional framework.

In the paper at hand, I suggest to extend the canonical principal-agent model in the corporate finance literature to take into account two related features at the same time. The first is the multi-dimensional nature of moral-hazard, in the form of risk taking and effort, while the second one is the common agency approach, which extends the canonical model to the case of more than one principal.

With respect to the first issue (multi-dimensional moral hazard), the literature is not adequately developed (Tirole, 2006). The only two papers in the literature that try to combine the problem of excessive risk taking and managerial effort are Biais and Casamatta (1999) and Bester and Hellwig (1987). The first paper deals with a discrete effort, discrete outcomes model, in which managers exert unobservable effort and can take inefficient risk by switching to less profitable projects. However, the focus of the paper is more on the optimal capital structure, rather than on managers' compensation. They show that optimal financial contracts can be implemented by a combination of debt and equity when the risk-shifting problem is the most severe while stock options are also needed when the effort problem is the most severe. The second paper, instead, develops a continuous effort model through which the authors show that the presence of a pure-debt financial structure, the optimal level of effort is induced, although the manager tends to take excessive risk. By contrast, a pure-equity structure induces the manager to choose the optimal level of risk, at the expense of less effort. The authors conclude by stating that a second-best allocation can be implemented by a mixed capital structure.

The main reference for common agency literature, is the seminal paper by Bernheim and Whinston (1986). They explore a multi-principal relationship in a framework of delegated common agency games with moral hazard. In their paper, each principal observes an element from a set of possible outcomes with some probability and the action chosen by the agent affects the probability attached to each outcome. The conflict between principals arises from the differences in their sets of possible outcomes. One of the main findings of the paper is that no efficient equilibrium exists if the agent is risk averse. The literature on common agency games has been subsequently further developed by Martimort and Stole, whose main findings are summarized in Martimort (2006).

1.3. The model

The model, like in Biais and Casamatta (1999), is aimed at capturing two dimensions of moral hazard: exerting effort and risk shifting. However, the latter, as be considered both in the form of "over-investment" (asset substitution) and "underinvestment" (inefficiently low risk taking). A corporation has been set, whose capital structure is formed by a principal P_1 who owns equity S, and principal P_2 who owns debt $D/(1+\alpha)$ whose face value is equal to D and α is the net discount factor representing the market price of debt capital. Hence, for simplicity, debt is assumed to be zero coupon bond and, of course, has priority over equity capital. Equity and debt have been priced in accordance with the average market price of capital so to satisfy the principals' individual rationality constraints. In setting up this framework, I have in mind the case of an already existing firm, where the principals need to hire a a new manager.

The structural assumptions are the following:

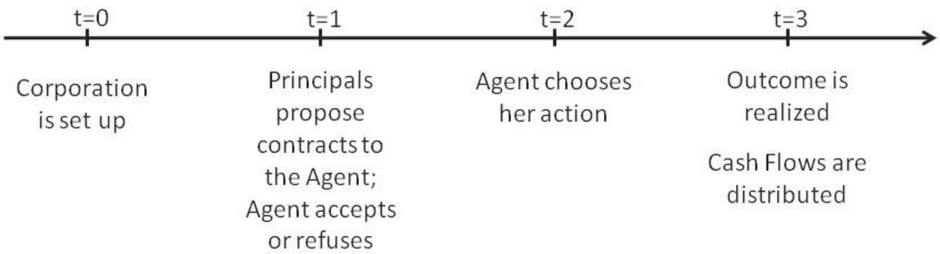
- (A1): equilibrium interest rate is equal to zero;
- (A2): the agent and the principals are risk neutral;
- (A3): the firm is the project it pursues;
- (A4): the principals are protected by limited liability;

(A1) and (A3) are simplifying assumptions. (A2) is standard for principals. Most of corporate finance models consider the agent as being risk averse, however, the qualitative results of the paper still hold under risk aversion of the agent. (A3) says that all the funds of the corporation, $S + D/(1 + \alpha) = I$, are allocated to the undertaking of a specific project. Hence, the principals cannot contract on the capital structure, but they take it as given. (A4) is also standard for principals; however I do not assume the agent protected by limited liability since corporate fiduciary law allows the principals to pay negative transfers to the agent.

After being hired, the agent chooses the vector of actions $a = (e_i, \sigma_j)$, where $e_i \epsilon E$ is the level effort exerted in the project and $\sigma_j \epsilon \Sigma$ is the level of risk associated with the project. So the space of actions can be defined as $A = E \times \Sigma$. As we shall see later on, effort has an impact over the cash flows distribution in terms of First

Order Stochastic Dominance (FOSD), while the choice over σ_j is a mean preserving action which affects the distribution in the sense of Second Order Stochastic Dominance (SOSD).

The time-line is as follows. At $t = 0$ the corporation has been set up and the two investors have provided respectively equity and debt to the entity. At time $t = 1$ each principal proposes a contract to the agent, which can either accept or refuse. Given the nature of the *intrinsic* common agency problem, the agent can either accept both offers at once or refuse them. At $t = 2$ the possibility for moral hazard arises: the agent chooses her action, $a = (e_i, \sigma_j)$ from the set A. At $t = 3$ the outcome is realized and cash flows are distributed.



The outcome of the project $\tilde{R} := \left\{R; \frac{R}{2}; 0\right\}$ is stochastic and defined according to three equiprobable states of the world (High, Intermediate and Low). Moreover, to make things interesting, the following conditions hold:

$$R > I > \frac{R}{2} > D.$$

This implies that debt is fully repaid both in the High and Intermediate states, whereas equity grasps the surplus in the High state and it is partially repaid in the Intermediate state. In the Low state, both principals get nothing.

As anticipated, effort e_i can improve the distribution of the outcomes in the sense of FOSD, while σ_j affects the distribution in the sense of SOSD. Hence, depending on action a chosen by the agent, the NPV of the project is the following:

$$NPV(e_i, \sigma_j) = \left(\frac{1}{3} + e_i + \sigma_j\right) R + \left(\frac{1}{3} - 2\sigma_j\right) \frac{R}{2} - \psi_i(e_i) - \phi_j(\sigma_j) - I$$

with $i = U, D$ and $j = U, M, D$, where

- $e_i = \{e_U = e, e_D = 0\}$
- $\sigma_j = \{\sigma_U = \sigma, \sigma_M = 0, \sigma_D = -\sigma\}$
- $\psi_i(e_i) = \{\psi_U = \psi, \psi_D = 0\}$
- $\phi_j(\sigma_j) = \{\phi_U = \phi, \phi_M = 0, \phi_D = \phi, \}$.

Therefore, the combined effect of effort and risk taking induces six probability distributions, that can be thought as six different projects. Improving the distribution in the sense of FOSD comes at a cost equal to $\psi_i(e_i)$, while SOSD has a cost $\phi_j(\sigma_j)$. The cost of effort, $\psi_i(e_i)$, is borne by the agent and can be deemed in a multiple way; for instance, it can be considered as managerial shirking, the undertaking of a self dealing transaction, consumption of perks, etc. Similarly, $\phi_j(\sigma_j)$ is a cost borne by the principals. This can be interpreted as the inefficiency cost associated with any departure from the socially efficient risk technology. For simplicity, and coherently with the nature of the corporation, this cost is fully absorbed by P_1 as the residual claimant.

In this setting I assume that exerting effort is socially efficient; however, the risk shifting problem dominates the effort problem. So the following three conditions hold:

1.1 $eR > \psi$

1.2 $eR < \psi + \phi$

1.3 $\sigma > e$

Condition 1.1 says that the benefits from exerting effort are higher than the cost. Condition 1.2 says that exerting effort does not compensate its cost when risk shifting occurs. Condition 1.3 says that the qualitative impact of σ over the distribution of cash flows is more significant than the impact of e. A link can be made between condition 1.2 and 1.3 and the nature of the corporation. For instance it is reasonable to assume that the risk shifting problem is more severe than the effort problem for a financial corporation[4].

These three conditions allow us to rank the NPV of the projects as follows:

[4]Indeed, note that if $eR > \psi + \phi$ and $\sigma < e$, the social cost from mismanagement dominates the social cost from risk shifting, and thus the order of the NPV is slightly modified:

$$NPV(e_U, \sigma_M) > NPV(e_U, \sigma_U) = NPV(e_U, \sigma_D) >$$
$$> NPV(e_D, \sigma_M) > NPV(e_D, \sigma_U) = NPV(e_D, \sigma_D)$$

$$NPV(e_U, \sigma_M) > NPV(e_D, \sigma_M) > NPV(e_U, \sigma_U) = \\ = NPV(e_U, \sigma_D) > NPV(e_D, \sigma_U) = NPV(e_D, \sigma_D) \tag{1.3.1}$$

Thus, the highest NPV is attained when $e_i = e$ and there is no modification of risk ($\sigma_j = 0$). This condition can be written in a more compact way as

$$NPV(e, 0) = max_{e,\sigma} \{NPV(e_i, \sigma_j)\} \qquad \forall\, i, j.$$

1.3.1. The implementation problem. As specified at the outset, the capital structure is exogenously given and is composed by equity and debt, whose sharing rules are standard and already agreed. Therefore P_1's indirect utility function will be

$$V_1 = \left(\tfrac{1}{3} + e_i + \sigma_j\right)\left(R - D - t_1^H\right) + \left(\tfrac{1}{3} - 2\sigma_j\right)\left(\tfrac{R}{2} - D - t_1^M\right) - \\ - \left(\tfrac{1}{3} - e_i + \sigma_j\right) t_1^L - \phi_j(\sigma_j) - S$$

where $\phi_j(\sigma_j) = \{\phi_U = \phi, \phi_M = 0, \phi_L = \phi\}$. P_2's indirect utility function will be instead

$$V_2 = \left(\frac{1}{3} + e_i + \sigma_j\right)\left(D - t_2^H\right) + \left(\frac{1}{3} - 2\sigma_j\right)\left(D - t_2^M\right) - \\ - \left(\frac{1}{3} - e_i + \sigma_j\right) t_2^L - -\alpha D$$

Finally the manager's indirect utility will be

$$U(e_i, \sigma_j) = \sum_{k=1,2}\left[\left(\frac{1}{3} + e_i + \sigma_j\right) t_k^H + \left(\frac{1}{3} - 2\sigma_j\right) t_k^M + \left(\frac{1}{3} - e_i + \sigma_j\right) t_k^L\right] - \psi_i(e_i)$$

For simplicity, I assume that the reservation utility of the agent is normalized to zero.

Therefore, as opposed to the standard principal-agent model, in which the only source of conflict is the hidden action problem, within a common agency framework, a coordination problem between principals arises.

Absent this problem, in a context of full information, the identification of the First-Best allocation and the subsequent implementation problem are straightforward. Indeed, given (1.3.1), the allocation that will be reached under full information is the one which corresponds to the action

$$a^{FB} = (e_i = e_D = e, \sigma_j = \sigma_M = 0).$$

Under complete information, this action can be implemented through a contingent transfer such that

$$\begin{cases} t^H = t^M = t^L = \psi & if\, e_i = e\, and\, \sigma_j = 0 \\ \\ t^H = t^M = t^L = 0 & otherwise. \end{cases}$$

1.3.2. Incomplete information equilibria. I turn next to the problem of the implementation of this First-Best allocation under incomplete information. However, one should distinguish two different contexts. In the first, I look at the case in which the two principals collude and act as a merged entity. This provides a benchmark for the pure common agency context, which is obtained when the principals act separately with different preferences over the projects. In the first case, the cooperative equilibrium arises when the capital structure is such that the preferences of the principals are aligned. This happens when either capital structure is sole equity or when the preferences of P_2 are aligned to the ones of P_1 through a financial security technology such as convertible securities.

The common agency context arises when principals cannot collude. For instance, this is the case of bank corporations, where depositors cannot write complex financial contracts in order to realign the preferences.

1.3.2.1. *Coalitional equilibrium.* For simplicity in this section I assume that there is just one principal, the equity-holder, who fully owns the firm ($S = I$). This case is equivalent to the *merged principals* case in the common agency literature, in which the principals collude with each other. Therefore we are in a standard principal-agent model, with bi-dimensional moral hazard. The principal proposes a contract $\{t^H, t^M, t^L\}$ to the agent, which must induce the agent to undertake effort, without modifying the structure of risk and satisfying the agent's individual rationality constraint. Thus, the principal's problem becomes:

$$(\mathcal{P})\begin{cases}\max_{\{t^H,t^M,t^L\}} & \left(\frac{1}{3}+e\right)\left(R-t^H\right)+\frac{1}{3}\left(\frac{R}{2}-t^M\right)-\left(\frac{1}{3}-e\right)t^L-I\\ \\ s.t. & (e_i=e,\sigma_j=0)=argmax\,U(e_i,\sigma_j)\quad (IC_{e,0})\\ & U(e_i=e,\sigma_j=0)\geq 0\qquad\qquad (IR_{e,0})\end{cases}$$

In the next proposition I show that the equilibrium reached is unique and coincides with the First-Best allocation.

Proposition 1 *Under (A2) and (A4), collusion among the principals leads to a unique monotonically increasing schedule of equilibrium transfers that implements the first best allocation* a^{FB}.

As shown in the appendix, the optimal schedule is as follows:

$$t^*=\left\{t^H=\frac{\psi}{2e};t^M=0;t^L=-\frac{\psi}{2e}\right\}.$$

Proof: see Appendix.

The result is in line with moral hazard implementation in absence of limited liability (Laffont and Martimort, 2002)[5].

1.3.2.2. *Competitive equilibria.* I now turn to the analysis of the equilibrium outcomes in a pure common agency setting. The two principals, P_1 and P_2, will solve separately their own maximization problems, taking however into account the transfers paid to the agent by the other principal. A significant feature of the problem is the *intrinsic common agency* nature of the game at hand. Indeed, both principals have convergence of preferences over the effort, but, being the equity payment schedule convex and the debt payment schedule concave, the principals have opposite preferences over the risk structure of the project. To make things interesting and better capturing the risk shifting problem, I imagine that the corporation is so leveraged that the two conditions hold:

2.1 $\sigma D\geq\phi$

2.2 $\sigma D-\phi\geq e(R-D)$

[5]The case with limited liability is straightforward: setting $t^L=0$, one obtains $t^H=\frac{\psi}{e}$ and $t^M=\frac{\psi}{2e}$. This result, however, is obtained by simply shifting upward the schedule by $\frac{\psi}{2e}$ and leaves the agent with a strictly positive rent.

Condition 2.1 means that P_1 wants to undertake over-investment and P_2 wants to undertake underinvestment. Condition 2.2 combined with 1.3, means that P_1 prefers over-investment over effort and similarly P_2 prefers underinvestment over effort.

Hence, on the one hand P_1has the following order of preferences over effort and risk taking:

$$V_1(e_U, \sigma_U) \succ V_1(e_D, \sigma_U) \succ V_1(e_U, \sigma_M) \succ V_1(e_D, \sigma_M) \succ V_1(e_U, \sigma_L) \succ V_1(e_D, \sigma_L)$$

On the other, P_2 has the following order of preferences:

$$V_2(e_U, \sigma_L) \succ V_2(e_D, \sigma_L) \succ V_2(e_U, \sigma_M) \succ V_2(e_U, \sigma_U) \succ V_2(e_D, \sigma_M) \succ V_2(e_D, \sigma_U).$$

Following Martimort (2006), I separate the problem considering the two possible coalitions with each principal and the agent.

Therefore P_1 wants to implement the action $a^{P_1} = (e_i = e, \sigma_j = \sigma)$ which maximizes the payoff of his bilateral coalition with the agent. The program for P_1 can be written as:

$$(\mathcal{P}_1) \begin{cases} \max\limits_{\{t_1^H, t_1^M, t_1^L\}} & \left(\frac{1}{3} + e + \sigma\right)\left(R - D - t_1^H\right) + \left(\frac{1}{3} - 2\sigma\right)\left(\frac{R}{2} - D - t_1^M\right) + \\ & - \left(\frac{1}{3} - e + \sigma\right) t_1^L - \phi - S \\ s.t. & (e_i = e, \sigma_j = \sigma) = argmax\, U(e_i, \sigma_j) \qquad (IC_{e,\sigma}) \\ & U(e_i = e, \sigma_j = \sigma) \geq 0 \qquad (IR_{e,\sigma}) \end{cases}$$

Likewise, P_2 wants to implement the action $a^{P_2} = (e_i = e, \sigma_j = -\sigma)$ which maximizes the payoff of his bilateral coalition with the agent. The program for P_2 can be written as:

$$(\mathcal{P}_2) \begin{cases} \max\limits_{\{t_2^H, t_2^M, t_2^L\}} & \left(\frac{1}{3} + e - \sigma\right)\left(D - t_2^H\right) + \left(\frac{1}{3} + 2\sigma\right)\left(D - t_2^M\right) + \\ & - \left(\frac{1}{3} - e - \sigma\right) t_2^L - \alpha D \\ s.t. & (e_i = e, \sigma_j = \sigma) = argmax\, U(e_i, \sigma_j) \qquad (IC_{e,-\sigma}) \\ & U(e_i = e, \sigma_j = \sigma) \geq 0 \qquad (IR_{e,-\sigma}) \end{cases}$$

Note that in $(\mathcal{P}_1)$, the shareholder solves the problem taking as given t_2^H, t_2^M and t_2^L, which are included in $(IC_{e,\sigma})$ and $(IR_{e,\sigma})$. Similarly in $(\mathcal{P}_2)$, the debt-holder takes as given t_1^H, t_1^M and t_1^L, which are included in $(IC_{e,-\sigma})$ and $(IR_{e,-\sigma})$. As shown in the next proposition, these strategies lead to a multiplicity of Bayes-Nash equilibria of this game that can be attained through an infinite combination of transfers.

Proposition 2 *Under (A2) and (A4),*

(1) *each action of the agent can be induced by an infinite set of transfers which must satisfy:*
   (a) *monotonicity at an aggregate level and*
   (b) $\sum_{k=1,2} t_k^H = \frac{\psi}{e} + \sum_{k=1,2} t_k^L$;

(2) *the intersection of the sets of solutions of* $(\mathcal{P}_1)$ *and* $(\mathcal{P}_2)$ *leads to a multiplicity of Bayes-Nash equilibria, where the First-Best is still attainable.*

Proof: see Appendix.

The Proposition highlights the core problem of common agency within the corporation. Indeed, as shown by Bernheim and Whinston (1986), in a context of public common agency with conflicting principals and moral hazard, when setting the transfers, a principal first tries to undo the transfers of the principals, and then sets the aggregate transfer.

In this context, the problem is less straightforward. Indeed, the principals have conflicting objectives only as to the risk dimension of moral hazard. But since this dimension dominates the effort one, the coordination problem cannot be overcome. This leads to the multiplicity of equilibria problem, which is the most severe under public agency.

1.3.3. Competitive equilibria refinements. The results obtained in Proposition 2 are not conclusive from a policy perspective. Institutions can serve the purpose of refining the attainable equilibria. Therefore, I first focus on the liability regime that can be activated by the debt-holder in case of failure of the project. The second and third remedies are suggested in Bernheim and Whinston (1986). The second institution relies on the role of intermediate bodies between the principals and the agent for implementing the optimal allocation through indirect mechanism designs. The third is the role of regulation in providing lower and upper bound for the agent's aggregate transfers.

1.3.3.1. *Allowing for negative transfersIntermediation.* In the real world, debt-holders are not allowed to negotiate the transfers with the agent. However, a directors' duty to creditors may allow P_2 for the payment of negative transfers: t_2 in this case should be interpreted as the claim that debt-holders can have toward the managers in case of default. The liability rule can, of course, be activated by P_2 only in the bad state ($\tilde{R} = 0$). Then the contract offered by P_2 must have the following form: $t_2 := \left\{t_2^H = 0; t_2^M = 0; t_2^L < 0\right\}$.

Given the restriction on t_2, one gets the following condition of the transfers that can be activated by P_1:

$$t_1^M = t_1^L - \frac{\psi}{2e} < t_1^L.$$

This means that the payment schedule offered by P_1 must be either non increasing or non monotonic. Since P_1 can undo what P_2 has done, Proposition 2 still applies. Therefore, fiduciary duties to creditors have the perverse effect of increasing the likelihood that an over-investment equilibrium arises.

An improvement can be reached instead if the regulator establishes an upper and lower bound for the aggregate level of transfers. In a more practical context, one can assume that

$$\sum_{k=1,2} t_k^H \leq \frac{\psi}{2e}$$

and

$$\sum_{k=1,2} t_k^L \geq -\frac{\psi}{2e}.$$

This leads to a decentralization of the First-Best allocation, with

$$t_1 := \left\{t_1^H = \frac{\psi}{2e}; t_1^M = 0, t_1^L = 0\right\}$$

and

$$t_2 := \left\{t_2^H = 0; t_2^M = 0, t_2^L = -\frac{\psi}{2e}\right\}.$$

Alternatively, the regulator can impose a fixed payment for the agent. Of course, this schedule would not give the agent the incentive to exert effort, but will provide her the incentive to take the efficient level of risk. This solution will lead to a second best, which may be desirable when the risk dominates dominates the effort problem.

1.3.3.2. *Intermediation.* Turning to other institutional arrangements to restore uniqueness of the equilibrium, I suggest to refer to an intermediate body in order to solve the coordination problem. In the words of Bernheim and Whinston (1986, p. 937) a "possibility is to bring in a risk-neutral intermediary: the principals each individually offer outcome-contingent compensation to the intermediary, who, in turn, makes some outcome-contingent offer to the agent (the principals are proscribed from dealing with the agent directly)".

Such a mechanism can be implemented through an Compensation Committee whose members are Independent Directors, which sets the payment schedule of the agent equal to

$$t^* = \left\{ t^H = \frac{\psi}{2e}; t^M = 0; t^L = -\frac{\psi}{2e} \right\}.$$

However to make the members of the Committee unbiased, the corporation pays the members a fixed compensation and exempts them from liability.

1.4. Conclusion

This paper represent a preliminary attempt to model common agency within a corporation with multi-dimensional moral hazard. It is shown that when the principals have conflicting views over the level of risk that should be undertaken by the manager, a multiplicity of equilibria arise. This is due to the fact that each principal can "undo" what the other principal has done in terms of incentives to the manager. Then possible institutional refinements are suggested, and it is shown that some institutional arrangements such as the set up of a Compensation Committee can restore Pareto efficiency in the economy.

This line of research can be extended in several ways. Indeed, a better way of modeling the issue would be to assume that effort and risk taking are continuous variables rather than discrete. Besides, equilibrium refinements can be better investigated under small variations of the model (such as assuming a risk averse agent).

Moreover, it would be worthwhile to explore a setting in which a regulator comes into play. This could be done by assuming the existence of a a third principal (the regulator) interacting with both shareholders and debt-holders. Finally, extending the model to the case in which a shareholder acts as a debt-holder within another firm (and viceversa) could help in providing a link between the model and the literature on agency costs, liquidity and business cycles.

Appendix

Proof of Proposition 1. The $(IC_{e,0})$ is satisfied when the following two conditions hold simultaneously:

$$t^H - t^L \geq \frac{\psi}{e} \tag{1.4.1}$$

and

$$t^H - t^M = t^M - t^L. \tag{1.4.2}$$

(1.4.2) means that the payment schedule must be monotonic and symmetric. (1.4.1) means that the payment schedule must be increasing. Together, (1.4.1) and (1.4.2) imply that the payment schedule must be such that $t^H > t^M > t^L$. Making binding $(IR_{e,0})$ and because of (1.4.2), one can set $t^M = 0$. Making (1.4.1) binding, one finally gets the optimal schedule:

$$t^* := \left\{ t^H = \frac{\psi}{2e}; t^M = 0; t^L = -\frac{\psi}{2e} \right\}.$$

Note that, by construction, the over-investment problem is offset by the underinvestment problem. For this reason, the payment schedule is aimed at inducing effort. Therefore, as shown in Hölmstrom (1979), under the realization of $R/2$, it is reasonable to pay the agent just her reservation utility.

Proof of Proposition 2. Similarly to the case of Proof of Proposition 1, $(IC_{e,\sigma})$ in $(\mathcal{P}_1)$ must satisfy the two conditions:

$$t_1^H + t_2^H - t_1^L - t_2^L \geq \frac{\psi}{e}$$

and

$$t_1^H + t_2^H - t_1^M - t_2^M \geq t_1^M + t_2^M - t_1^L - t_2^L.$$

whereas $(IR_{e,\sigma})$ can be rewritten as:

$$U(e,\sigma) = \sum_{k=1,2} \left[\left(\frac{1}{3} + e + \sigma \right) t_k^H + \left(\frac{1}{3} - 2\sigma \right) t_k^M + \left(\frac{1}{3} - e + \sigma \right) t_k^L \right] \geq \psi$$

In the same way, $(IC_{e,-\sigma})$ in $(\mathcal{P}_2)$ must satisfy the two conditions

$$t_1^H + t_2^H - t_1^L - t_2^L \geq \frac{\psi}{e}$$

and

$$t_1^H + t_2^H - t_1^M - t_2^M \leq t_1^M + t_2^M - t_1^L - t_2^L.$$

whereas $(IR_{e,-\sigma})$ can be rewritten as:

$$U(e,\sigma) = \sum_{k=1,2} \left[\left(\frac{1}{3} + e - \sigma \right) t_k^H + \left(\frac{1}{3} + 2\sigma \right) t_k^M + \left(\frac{1}{3} - e - \sigma \right) t_k^L \right] \geq \psi.$$

Therefore, the intersection of these constraints leaves us with just 2 equations in 6 unknowns:

$$(IC_{e,\sigma}) \cap (IR_{e,\sigma}) \cap (IC_{e,-\sigma}) \cap (IR_{e,-\sigma}) \begin{cases} t_1^H + t_2^H - t_1^M - t_2^M = t_1^M + t_2^M - t_1^L - t_2^L \\ \\ t_1^H + t_2^H - t_1^L - t_2^L = \frac{\psi}{e} \end{cases}$$

Therefore one ends up with a parametric solution of transfers. Note that monotonicity here is required at an aggregate level, while the transfers are not necessarily monotonic at an individual level.

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CHAPTER 2

Myopia and paternalism in the design of social security schemes[1]

ABSTRACT. Several rationales have been provided in order to explain the role of social security programs in modern welfare states. The current work investigates the role of myopia under different assumptions. So far, the "myopia" argument has been based on the fact that people fail in fully taking into account their future behavior. This has led to a justification for public pensions that is related to compulsory savings. I analyze this literature in the light of the emerging trends in the field of behavioral economics. Moreover, in the last part of the work, I challenge this view, claiming that the degree of myopia can be determined not only by psychological biases, but also, to a certain degree, by a strategic commitment of some individuals that aim at capturing the benefits of redistribution towards myopics.

2.1. Introduction

Social security programs play a significant role in modern welfare states. The total expenditure for public pensions in the OECD Countries accounts on average for 7% of the GDP and its impact on total public spending is significant as well: in 2005, it accounted for 20.3% in France, 24% in Germany and Italy, 18.3% in the UK, 14.5% in the US and 30% in Japan[2]. These figures are deemed to increase in the next decades, following an increasing trend that started after the Second World War and that is related to the issue of population aging.

The most common explanations which have been given in the public economics literature to the existence of social security systems are four. First of all, social security systems act as a paternalistic device that forces individuals who suffer from

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[1]I am greatly indebted to Prof. Helmut Cremer who first raised my interest in the topic and provided constant advice and support during the research activity. I am also grateful to Philippe de Donder, Jean-Marie Lozachmeur and Marianna Belloc for their helpful comments and remarks on previous drafts and to all the participants to the XXVI European Association of Law and Economics annual Conference, September 2009.

[2]Source: OECD (2007).

myopia regarding future consumption paths to adequately save for their retirement[3].

Furthermore, they allow for redistribution of resources among generations and among individuals belonging to the same cohort. The main advantage of this policy tool compared to income taxation in the pursue of redistribution goals is that social security allows for redistribution of income on a lifetime, rather than annual, basis[4]. This feature is helpful in avoiding the complications arising from a system of recurring annual taxes[5].

The third justification for social security is the insurance motive. In the light of this view, social security acts as an insurance device, providing “avenues for risk sharing that are not otherwise available or are very costly in private markets” (Imrohoroglu et al., 2003, p. 745).

Sometimes a fourth rationale is provided, related to possible free-riding incentives in the presence of altruism. According to Feldstein and Liebman (2002, p. 2253), “if individuals know that other members of the society are altruistic and will provide for them if they reach old age without resources, then there will be an incentive for people to undersave and take advantage of the good will of others. This free-riding leads to an inefficient outcome that can potentially be ameliorated with a compulsory program of old age assistance”. In the light of this, public pension systems act as a tool against “rational prodigality”: social security is viewed as a tool for avoiding strategic behavior on the behalf of some agents in the economy which could impose excessive costs on other agents.

This work is primarily concerned with the “myopia” argument, although a proposal is advanced for reconciling myopia and rational prodigality, under the claim that the coexistence of agents that have different behaviors can lead to socially inefficient outcomes.

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[3]In the words of Kaplow (2008): “it is widely accepted that paternalistically motivated forced savings constitutes an important, and to some the most important, rationale for social security retirement systems”.

[4]Diamond (2004, p. 12) claims that since income taxation and social security “work on different tax bases and provide payments at different times, there is room for each of them to contribute despite the presence of the other”.

[5]Diamond (2003, p. 16) points out that this complications arise because of the links among subsequent years, “links that occur because of savings, because of “human capital investments” that affect earnings in later years and because of the ability to adjust the timing of the the realization of the taxable income”.

The argument according to which people suffer from myopia concerning saving decisions is supported by empirical evidence. Several studies have highlighted a significant tendency in dropping consumption near retirement (Bernheim and Rangel, 2005), which is quite puzzling for standard theories on consumption smoothing and can be justified on psychological grounds[6].

This justification for paternalistic public intervention has been recently revived in the literature on Behavioral Public Economics, which basically stresses the point that psychological biases and failures in individual decision making can lead to inefficient choices that sometimes are *ex post* regretted by the agents. Public intervention, the argument goes, is therefore needed to correct this kind of mistakes[7]. Hence, in the light of this literature, myopia provides a reason for social security programs which is not related to market failures, but to failures in individual decision-making. Accordingly, by imposing a program of compulsory savings, the government leads individuals to internalize a negative externality (overconsumption in the working life) that agents are imposing on their future selves.

However, beside the benefits discussed above, a social security program, especially in the form of a pay-as-you-go (PAYG) system, involves also costs for society. In particular, these costs are related to the reduction in the level of social welfare which results from the distortion of individual decisions concerning retirement age, labor supply and the level of savings (Imrohoroglu et al., 2003).

The existence of these costs and the fact that returns on private savings tend to dominate returns generated by the PAYG system may lead to conclude that the rise of social security programs can be explained in a political economy framework as a willingness to redistribute among generations (Cremer et al., 2007). However, for the purposes of the present work, I take here a normative approach, focusing on PAYG schemes[8].

Rational prodigality, on the other hand, is a somewhat less developed argument in the literature on social security. The literature can be traced back to the work of Buchanan (1975) on the so called "Samaritan's Dilemma" and to the contribution of Lindbeck and Weibull (1988) on intergenerational altruism. More recent

[6]See, however, Scholz, Seshadri and Khitatrakun (2006) for a different perspective.

[7]See Bernheim and Rangel (2005) for a general survey of the literature on Behavioral Public Economics.

[8]For a comparison among funded systems and PAYG under hyperbolic discounting see Schwarz and Sheshinski (2007).

studies on the topic have been pursued by Homburg (2000, 2006), Fenge and von Weizsäcker (2001) and von Weizsäcker (2003).

The work proceeds as follows: in section 2 the literature on time inconsistency is discussed. In section 3 the optimal design of a linear social security scheme is considered. I start with a baseline model that is due to Feldstein (1985) with exogenous labor supply and then I discuss some possible extensions, adding endogenous labor supply, wage heterogeneity and early retirement issues. Furthermore, I rely on Cremer et al. (2008a) to extend the analysis to the case of partly redistributive (or Beveridgean) social security schemes. In section 4 the case of a non-linear pension system is discussed. In Section 5 a model with time inconsistent choices is sketched. Finally, section 6 provides suggestions for further research, claiming the need to investigate the case for "rational myopia", i.e. the situation in which some agents strategically choose to discount the future at a low rate in order to profit from the redistributive aspect of the social security system.

2.2. How do we model myopia?

According to Imrohoroglu et al. (2003), there are basically two strands of literature that have tried to model myopia in the context of social security. The first stems from the work of Feldstein (1985) and takes an overlapping generations (OLG) approach. In this type of models, individuals work in the first period and retire in the second and they have a utility function which is separable in consumption in each period. Time inconsistency is introduced by assuming that the utility attached to consumption in the second period is discounted at a rate that is lower than the true one. Moreover, in the work of Feldstein (1985), myopia is assumed to be also reflected in pension pessimism, meaning that the benefits deriving from the pension in the future are not fully taken into account in the first period.

A second type of modeling, that stands much closer to the recent behavioral economics literature, deals instead with more general time-inconsistent consumption-saving paths. These models extend the life cycle of the agents to more than two periods, trying in this way to capture the "systematic conflict between actors' long-and short-term preference" (Laibson et al., 1998, p. 97)[9]. This preference reversal property is modeled by adopting a utility function of the following form:

$$u(c_0) + \beta \sum_{t=1}^{T} \delta^t u(c_t).$$

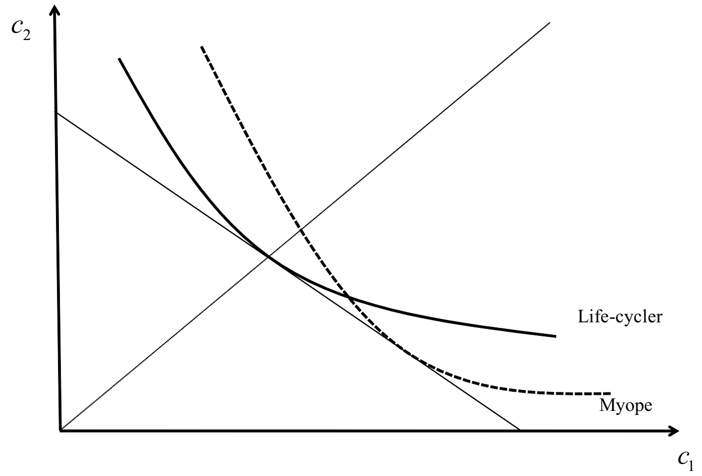
This utility function is characterized by a quasi-hyperbolic discounting of future consumption patterns. This implies that with a quasi-hyperbolic discount function "e-vents in the near future are discounted at a higher implicit discount rate than events in the distant future" (Laibson, 1997, p. 449). Therefore, the difference with discounting at an exponential rate lies in the fact that the hyperbolic discount function is steeper in the short term, but flatter in the long run (Finley and Caliendo, 2008). An interesting feature of this form of discounting lies in the fact that it generates intertemporal conflicts among the different selves of the same agent (Diamond and Koszegi, 2003). The current paper makes use of both functions. In the first part, the optimal pension schemes will be derived under and OLG approach and then this framework will be enriched with more than two periods and thus the quasi-hyperbolic utility will be employed in order to capture time inconsistency.

2.3. The linear pension scheme model

I start with a simple model, with the aim of capturing the rationale justifying the existence of compulsory PAYG social security schemes under the assumption of myopia on the behalf of some individuals. Therefore, I have a two periods overlapping generations model in which individuals work in the first period and retire in the second. I assume that agents differ: 1) in the degree of myopia regarding future consumption and 2) in their productivity. I assume that within the cohort of the workers there are both myopic and rational individuals, whereas all the pensioners are fully rational. In this way, I introduce the idea that people recognize their past mistakes: individuals that have been myopics in the first period regret their consumption and saving choices when they retire. Moreover, each agent has attached a productivity type, which is reflected in his wage w. Types are distributed according to a cumulative distribution $F(w)$ over the support $[\underline{w}, \overline{w}]$.

[9]A classical exemplification of this concept is provided by some evidence according to which people tend prefer 1 euro today over 2 euro tomorrow, whereas they tend to reverse their preference if the choice is between 1 euro in 100 days and 2 euro in 101 days.

FIGURE 2.3.1. Intertemporal utility functions for myopics and life-cyclers



I assume that there are two classes of workers: life-cyclers, who discount the future at the true rate ($\beta^c = \beta = 1$) and which represent a fraction π_c of the workers, and myopics, which discount the future at a lower rate ($\beta^m < \beta$) and are in a proportion of π_m (with $\pi_m + \pi_c = 1$).

I assume that all agents in the economy share the same utility function, which is separable in its arguments. In the first period agents work an amount equal to l, for which they receive a wage w, and consume c_1, whereas in period two they just consume c_2, and their income is made of both private savings and the pension they receive.

The interest rate for private savings, $r > 0$, is exogenously determined by a linear storage technology, so that the pension system, which has a zero rate of return, is dominated by the private savings technology[10].

The most general structure of the pension for each agent is the following:

$$p = \alpha\tau wl + (1-\alpha)\tau\hat{y}$$

where $\hat{y} = E(w) = \int_{\underline{w}}^{\overline{w}} wl(w;\alpha,\tau)dF(w)$ represents the average income. In this general form, the pension is made of a Bismarckian component (the first part of the RHS) and of a redistributive (Beveridgean) part. The nature of the pension system is therefore given by the value of α, which is usually called the Bismarckian factor: if $\alpha = 1$ the pension is actuarially fair and fully reflects the individual contribution. If, however, $\alpha = 0$, we have a flat pension for everybody, reflecting the

[10]Note, in passing, that in this two periods model, the parameter for myopia can be expressed also in terms of a discount rate $r^m > 0$, so that $\beta^m = \frac{1}{1+r^m} < 1 = \beta$.

average contribution to the pension system.

In the light of this taxonomy, in the following table I characterize some OECD Countries according to the characteristics of their public pension systems. In particular, I classify countries according to the generosity of the system and the degree of redistribution they allow for.

TABLE 1. Pension systems in some OECD countries

	Bismarckian	**Mixed**	**Beveridgean**
High generosity	Finland, Greece, Italy, Netherlands, Spain, Sweden	Austria, Denmark	
Low generosity	France, Germany	Belgium, Japan, Norway	Australia, Canada, Ireland, New Zealand, UK, US

Source: OECD (2007). See the appendix for details.

As shown in Figure 2, the presence of a pension scheme affects the shape of the intertemporal budget constraint. Since the individual is compelled to save in period 1 an amount equal to τwl, the budget constraint will shift to the left. However, this reduction in consumption set is (partially) compensated in period two by the pension he receives. The idea underlying the adoption of a social security regime is that the new shape of the budget constraint can allow myopic individuals to attain higher levels of utility, although this increase comes at a cost for the life-cyclers. If the overall gains of the myopics are greater than the loss suffered by the life-cyclers, the pension system generates a net welfare gain.

An important remark lies in the acknowledgment of the fact that a system of compulsory savings is the only available tool for correcting mistakes made by myopic agents. Indeed, in principle, one would aim at "correcting" myopia, making myopic individuals apply the true discount rate $\beta = 1$. This intervention however is not feasible since it would require full knowledge on the behalf of the government of the preferences of each individual.

In order to determine the optimal level of pensions and payroll taxes in the economy, I first solve the utility maximization problem for each agent (both myopic and fully rational):

$$\max_{c_1,c_2,s\geq 0} \quad u(c_1)+\beta^j u(c_2)-v(l)$$

$$\begin{aligned} s.t. \quad & c_1+s\leq(1-\tau)wl \\ & c_2\leq(1+r)s+\alpha\tau wl+(1-\alpha)\tau\hat{y} \end{aligned}$$

where $j=m,\ c$[11]. Then I make use of the values of consumption and saving to solve the problem of the social planner and find the optimal payroll tax.

2.3.1. A baseline Bismarckian model with fixed labor supply. To introduce the problem, I restrict for the moment the attention to a PAYG scheme with no redistribution among the pensioners (i.e. $\alpha=0$). Moreover, in this baseline model, I treat labor supply as exogenous and set it equal to 1. This is the case which is the closest to the original contribution by Feldstein (1985). However, in contrast with this contribution, I exclude any form of pension pessimism and I add the assumption that all pensioners, although myopics in the previous period, are fully rational.

The problem faced by each agent (whether life-cycler or myopic) is the following:

$$\max_{c_1,c_2,s} \quad u(c_1)+\beta^j u(c_2)$$

$$\begin{aligned} s.t. \quad & c_1+s\leq(1-\tau)w \\ & c_2\leq(1+r)s+\tau w \\ & s\geq 0 \end{aligned}$$

where *j=c, m*. I assume that the utility function satisfies all the good properties: in particular, I require that $u'>0$ and $u''<0$. From the first order condition I obtain:

$$u'(c_1^j)=\beta^j u'(c_2^j)(1+r) \tag{2.3.1}$$

[11]Note the requirement that private savings are positive. This is needed to rule out the possibility of claiming future pensions as a collateral for loans in the first period.

Note that with a *laissez-faire* solution, life-cyclers attain the first best, whereas myopics do not, since they end up consuming too much in the first period[12]. The first best could be achieved in this simple economy by subsidizing the savings of all the myopic individuals for an amount equal to $\frac{\beta-\beta^m}{\beta} = \frac{r^m}{1+r^m}$ (i.e. their degree of myopia compared to the life cyclers)[13].

To see the effects of social security on savings, I compute the derivative of the previous expression with respect to τ (Blanchard and Fisher, 1989). In this way I measure the impact of the payroll tax on the amount of savings:

$$-u''(c_1^j)\left[w + \frac{ds^j(\tau)}{\tau}\right] = (1+r)\beta^j u''(c_2^j)\left[(1+r)\frac{ds^j(\tau)}{\tau} + w\right]$$

which gives us the response of private savings to a variation in the payroll tax rate:

$$\frac{ds^j(\tau)}{d\tau} = -\frac{w\left[u''(c_1^j) + (1+r)\beta^j u''(c_2^j)\right]}{u''(c_1^j) + \beta^j u''(c_2^j)(1+r)^2} < 0. \tag{2.3.2}$$

This expression, which is always negative, measures the impact of the crowding out effect on private savings by the social security scheme. Indeed, we can see that the amount of savings is decreasing both in the degree of myopia and in the relative rate of return of the PAYG system compared to the return on private savings[14].

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[12]Indeed, since $\beta = 1$, a life cycler sets the marginal utilities from consumption in the two periods equal, whereas for a myopic we have $u'(c_1^M) < u'(c_2^M)$, so that he tends to consume more in the first period compared to the second.

[13]To see this, note that in the first best I want (1.3.1) to be fulfilled by the myopics for the true discount rate, β. Indeed the suggested subsidy achieves this goal:

$$u'(c_1^m)\left(1 - \frac{\beta-\beta^m}{\beta}\right) = \beta^m u'(c_2^m)(1+r) \Leftrightarrow u'(c_1^m) = \beta u'(c_2^m)(1+r)$$

[14]To provide an illustration, consider the log-linear utility case $u(.) = log(.)$. Condition (1.3.1) gives us an explicit value for savings:

$$(1-\tau)w - s^j(\tau) = [(1+r)s + \tau w][(1+r)\beta^j]^{\frac{1}{\gamma}} \qquad j = c, m$$

$$s^j(\tau) = w\left[1 - \tau\left(1 + \frac{1}{1+r}\frac{1}{1+\beta^j}\right)\right] \qquad j = c, m$$

from which I can compute

$$\frac{ds^j(\tau)}{d\tau} = -\left(1 + \frac{1}{1+r}\frac{1}{1+\beta^j}\right).$$

Turning to the social planner problem, I assume that he acts in a paternalistic way, i.e. he maximizes the sum of individual utilities in absence of myopia, the rationale being that the objective of the social planner is to maximize *ex post* social welfare. Retirees that have been myopic when young would *ex post* be grateful to the social planner, since they regret their consumption choices made under myopia.

Therefore the problem of the social planner is the following:

$$\underset{\tau,p}{max} \int_{\underline{w}}^{\overline{w}} \sum_{j=m,c} \pi_j [u(c_1^j) + \beta u(c_2^j)] dF(w)$$

I can rewrite the problem as follows:

$$\underset{\tau}{max}\ \mathcal{L} = \int_{\underline{w}}^{\overline{w}} \sum_{j=m,c} \pi_j \left\{ u[(1-\tau)w - s^j(\tau)] + \beta u[(1+r)s^j(\tau) + \tau w)] \right\} dF(w)$$

Proceeding by pointwise maximization, I get the following expression:

$$\frac{d\mathcal{L}}{d\tau} = \sum_{j=m,c} \pi_j \left\{ -u'(c_1^j) \left[w + \frac{ds^j(\tau)}{\tau} \right] + \beta u'(c_2^j) \left[(1+r)\frac{ds^j(\tau)}{\tau} + w \right] \right\} = 0. \tag{2.3.3}$$

Before dealing with a general solution to this problem, I consider two special cases.

Case 1: no myopia ($\pi^m = 0$). Consider first the case in which there is no myopia in the economy and each agent acts in a fully rational way (i.e. $\pi^m = 0$). In this case I can state the following:

Proposition: 1: *with a population of fully rational agents, a mandatory social security system with a strictly positive linear payroll tax always leads to a decrease in social welfare.*

Proof: see the appendix.

This result goes back to Aaron (1966) and Samuelson (1958) and the intuition behind it is that in order for the FOC to be fulfilled, and a positive payroll tax to arise, I need the rate of return on private savings to be equal to the implicit returns of the PAYG system. This means that, for the PAYG to be efficient, the private savings technology and the PAYG program should yield the same returns. In this case, the two alternatives would be perfect substitutes and the agent would be indifferent among the two. However, given the assumptions, this can never be the case and therefore the optimal payroll tax would be equal to zero.

Therefore, in the case of a population of fully rational agents the introduction of a compulsory social security program always leads to a decrease in the overall level of social welfare.

Case 2: full myopia ($\pi^m = 1$). The previous result does not hold anymore if I take the opposite extreme case of a population of myopic individuals (i.e. $\pi^m = 1$).

In this case, I can derive a threshold in the degree of myopia that makes worthwhile to introduce a Bismarckian pension system:

Proposition: 2: *under the assumption of a population of myopic individuals, the optimal linear pension is positive if and only if*

$$\beta^m \leq \frac{1}{1+r} < 1 \tag{2.3.4}$$

Proof: see the appendix.

This proposition implies that myopia has to be strong enough for a social security system to be welfare improving.

Heterogeneous population. Turning now to the most general case of a population of both life-cyclers and myopics, it is worth noting that while rational individuals satisfy equation (2.3.1) for the true discount rate, this is not true for myopic individuals. Let's assume for the rest of the section that (2.3.4) holds. I can now solve (2.3.3) to obtain

$$\frac{d\mathcal{L}}{d\tau} = \sum_{j=m,c} \pi_j u'(c_2^j) \left\{ (\beta - \beta^j)(1+r)\frac{ds^j(\tau)}{\tau} + \left[\beta - \beta^j(1+r)\right] w \right\} = 0.$$

After some rearrangements of the previous expression, we obtain Proposition 3.

Proposition: 3: *under (2.3.4), an optimal Bismarckian social security system leads to an increase in the social welfare if and only if the proportion of myopics in the population is higher than γ:*

$$\frac{\pi^m}{\pi^c} \geq \gamma \geq 0$$

where $\gamma = \frac{1}{\frac{u'(c_2^m)}{u'(c_2^c)}\left[\left(\frac{1+r}{1+r^m}\right)^2 u''(c_2^m) - u''(c_1^m)\right]} \leq 1.$

Proof: see the appendix.

Therefore, in this simple setting, I have shown that the PAYG system, although dynamically inefficient, can lead to a Pareto improvement if the losses borne by the life-cyclers through the social security scheme are more than compensated by the gains of the myopics[15]. Two conditions are needed for this result to hold: the myopic individuals have to be sufficiently numerous in the population and their degree of myopia has to be sufficiently high.

2.3.2. A baseline Beveridgean model with fixed labor supply. I now turn to the opposite case of a fully Beveridgean system ($\alpha = 1$). This implies that the pension system serves a pure redistributive goal.

While (2.3.1), i.e. the solution to the problem of the individuals (both life-cyclers and myopics), remains the same[16], the problem of the social planner becomes the following:

$$\underset{\tau}{max} \;\; \mathcal{L} = \int_{\underline{w}}^{\overline{w}} \sum_{j=m,c} \pi_j \left\{ u[(1-\tau)w - s^j(\tau)] + \beta u[(1+r)s^j(\tau) + \tau\hat{w})] \right\} dF(w)$$

The problem is similar to the previous one, however here there are two redistributive concerns: indeed, the social planner wants to redistribute from life-cyclers to myopics and from rich individuals to poor individuals. To see this, I write the FOC for the previous expression, where, to simplify the notation I make use of expectations rather than integrals:

$$\frac{d\mathcal{L}}{d\tau} = \sum_{j=m,c} \pi_j E \left\{ \left[(1+r)\left(\beta - \beta^j\right) \frac{ds^j}{d\tau} + \beta\hat{w} - (1+r)\beta^j w \right] u'(c_2^j) \right\} = 0.$$

Focusing on the expression within the square brackets, I see that it is composed of three terms. The first one, which is zero for the life-cyclers and negative for the

[15] An extension of the paper by Feldstein has been proposed by Andersen and Bhattacharya (2008), and it is related to the attempt of endogenizing the interest rate, by assuming a neoclassical storage technology. The rationale for this approach can be found in Blanchard and Fischer (1989).

[16] However, the response of private savings to a variation in the tax rate becomes:

$$\frac{ds^j(\tau)}{\tau} = -\frac{u''(c_1^j)w + (1+r)\beta^j u''(c_2^j)\hat{w}}{u''(c_1^j) + \beta^j u''(c_2^j)(1+r)^2} < 0.$$

which is coincides with (2.3.2) only for the individual with a productivity equal to the average of the population.

myopics, is similar to the one in the Bismarckian case, and measures the distortion on savings. The second and third term should be analyzed together, since they measure the redistribution operated through the system. Indeed, assuming (2.3.4) to hold, we can have different cases, which are summarized in the following table.

$d\mathcal{L}/\partial\tau$	Myopic $\left(\beta^m \leq \frac{1}{1+r}\right)$	Life-cycler $(\beta^c = 1)$
$(1+r)w > \hat{w}$	$\lesseqgtr 0$	<0
$\hat{w} > (1+r)w$	>0	>0

Contrary to the previous case, we observe that in a pure Beveridgean system some life-cyclers gain from the the social security scheme: in particular, the poorer among them, i.e. the ones with a wage lower than $\hat{w}/(1+r)$.

Therefore, for a Beveridgean pension scheme to be welfare increasing, we need that the gains obtained by the myopics and the poor can compensate the losses of the rich (either life-cyclers or myopics).

2.3.3. A general model with fixed labor supply. I now turn to the more general case of a mixed pension scheme in which both a Bismarckian and a Beveridgean component coexist. The problem for the individuals is the one that I introduced at the outset of this section. The main difference with the specifications treated so far is that now the amount of savings depends not only on the payroll tax rate, but also on α, the contributory (or Bismarckian) factor: $s^j = s^j(\alpha, \tau)$. Therefore, along with the usual saving response to the tax rate, i.e. $\partial s^j/\partial\tau$, I have also the response to the contributory factor:

$$\frac{\partial s^j}{\partial \alpha} = -\frac{\beta^j u''(c_2^j)\tau(w-\hat{w})}{\beta^j(1+r)^2 u''(c_2^j) + u''(c_1)} \lesseqgtr 0 \qquad \text{if } w \gtreqless \hat{w}$$

which is not necessarily negative. It decreases with productivity and it is greater the higher the degree of myopia.

The problem of the social planner is now:

$$\underset{\alpha,\tau}{max}\ \mathcal{L} = \int_{\underline{w}}^{\overline{w}} \sum_{j=c,m} \pi_j \left\{ u[(1-\tau)w - s^j] + \beta u[(1+r)s^j + \ + \alpha\tau w + (1-\alpha)\tau\hat{w})] \right\} dF(w)$$

which leads to the following FOCs:

$$(2.3.5)\quad \frac{\partial \mathcal{L}}{\partial \tau} = \sum_{j=m,c} \pi_j E\left\{u'(c_2^j)\left[(1+r)\left(\beta-\beta^j\right)\frac{\partial s^j}{\partial \tau}+\left[\beta\alpha-\beta^j(1+r)\right]w\right]+ + u'(c_2^j)\left[(1-\alpha)\beta\hat{w}\right]\right\}=0$$

$$(2.3.6)\quad \frac{\partial \mathcal{L}}{\partial \alpha} = \sum_{j=m,c} \pi_j E\left\{\left[(1+r)\left(\beta-\beta^j\right)\frac{\partial s^j}{\partial \alpha}+\beta\tau(w-\hat{w})\right]u'(c_2^j)\right\}=0$$

From (2.3.6), bearing in mind that β^m can be rewritten as $(1+r^m)^{-1}$, I get an explicit expression for the tax rate

$$(2.3.7)\quad \tau = -\frac{\pi_m \frac{1+r}{1+r^m} r^m E\left\{\frac{\partial s^m}{\partial \alpha}u'(c_2^m)\right\}}{\sum \pi_j cov\left[w, u'(c_2^j)\right]} \geq 0$$

where, as in Cremer et al. (2008a), the covariance term represents the redistributive objective and is generally negative[17].

2.4. A non linear model

I now move to the case in which we want to introduce in the system a non-linear pension scheme. There are basically two ways in which the literature has tried to tackle the issue of myopia under non-linear pension schedules. The first one, which is developed in Diamond (2003) introduces myopia as affecting the incentive compatibility constraint of the worker that mimics other types. Types are heterogeneous only with respect to their productivity: a myopic worker, therefore, "perceives a change in first-period consumption, but not in the second" (Diamond, 2003, p. 35). The second way is developed in Cremer et al. (2008b) and in Tenhunen and Tuomala (2007). I rely on both approaches, giving a different interpretation to the incentive compatibility constraints proposed by Diamond (2003).

We are therefore in a setting with multidimensional asymmetric information, with individuals differing both in productivity and in their degree of myopia. Accordingly, the economy is composed of four types of agents, each of whom represents a fraction of the population in the economy equal to π_i, with *i=1,...,4* (see figure).

[17]An explicit expression for Bismarckian parameter can be found in the appendix.

	Low productivity	High productivity
Myopic	π_1	π_2
Life-cycler	π_3	π_4

While myopia is modeled as in the first part, to keep things simple, I assume productivity to be discrete. Thus, each type has a skill level w such that his earnings are equal to $y_i = w_i l_i$, where w_i is the wage and l_i the labor supply. Note that w_i can now take only two values, high or low, so that $w_1 = w_3 < w_2 = w_4$. Labor supply, however, differs across types because of the cross effect of myopia and productivity, so that each type ends up with different earnings.

Utility functions are similar to the ones we have been dealt with so far, although in this section I slightly modify the notation. Hence, the utility function of a generic type *i* will have the following form, which I write in terms of observable variables:

$$U_i = u(c_i) + \beta_i v(d_i) + z\left(1 - \frac{y_i}{w_i}\right)$$

where c_i is the consumption in the first period, d_i is the consumption in the second and y_i are the earnings. In this simple framework, I assume that the government observes the earnings of the agent and taxes her in period one with a non-linear tax $t_i(y_i)$. In the next period, the government pays the pension, which is partly redistributive:

$$p_i(y_i) = \alpha t_i(y_i) + (1-\alpha)\sum_{j=1}^{4} \pi_j t_j(y_j).$$

The budget constraint for the government is derived from the intertemporal budget constraint for the individuals:

$$\begin{cases} c_i = y_i - t_i(y_i) \\ d_i = p_i(y_i) \end{cases}$$

Hence the budget constraint for the government can be written as:

$$\sum_i \pi_i \left(c_i + d_i - y_i \right) \leq 0.$$

2.4.1. First best. The first best allocation can be derived under the assumption of full information on the behalf of the government.The problem, therefore, writes as follows.

$$\underset{c_i,d_i,l_i \geq 0}{max} \mathcal{L} = \sum_i \pi_i \left[u(c_i) + \beta v(d_i) + z \left(1 - \frac{y_i}{w_i} \right) - \mu \left(c_i + d_i - y_i \right) \right]$$

Note that I keep the assumption of a paternalistic social planner, so that the discount rate is equal to the one of the life-cyclers. The FOCs lead to

$$u'(c_i) = \beta v'(d_i) \tag{2.4.1}$$

with

$$\frac{z' \left(1 - \frac{y_i}{w_i} \right)}{u'(c_i)} = w_i \tag{2.4.2}$$

Now, while (2.4.1) means that the level of consumption is equalized across types, (2.4.2) implies that lower productivity leads to lower labor supply.

2.4.2. Second Best. I assume that individual productivity and the degree of myopia are not observable. Therefore, I have to add to the problem the incentive compatibility constraints, which, since we are dealing with a multidimensional problem, are quite numerous (12) in the case at hand. When writing the constraints, however, I do not consider the second period consumption. This is due to the fact that at the beginning of the second period, i.e. when the government pays the pension, the consumption of the second period is not yet observed and so I have to rely on the observation of the first period consumption and earnings to determine the types. This is a reinterpretation of the model by Diamond (2003) and represents one of the main differences with Cremer et al. (2008b).

Hence, the Lagrangian for the problem at hand can be rewritten as:

$$\begin{aligned}\max_{c_i,d_i,l_i\geq 0} \mathcal{L} &= \sum_i \pi_i \left[u(c_i) + \beta v(d_i) + z\left(1 - \frac{y_i}{w_i}\right) - \mu\left(c_i + d_i - y_i\right)\right] \\ &+ \sum_i \sum_{j\neq i} \lambda_{ij} \left[U_i - \hat{U}_j\right]\end{aligned}$$

where the government maximizes under the true discount rate, and the generic IC $U_i \geq \hat{U}_j$ is:

$$u(c_i) + z\left(1 - \frac{y_i}{w_i}\right) \geq u(c_j) + z\left(1 - \frac{y_j}{w_i}\right)$$

note that an individual can mimic first period consumption and earnings, but not the degree of myopia and productivity, which are idiosyncratic features of each individual.

The FOCs of the above problem are therefore:

$$\frac{\partial \mathcal{L}}{\partial c_i} = u'(c_i)\left[\pi_i + \sum_{j\neq i}\lambda_{ij} - \sum_{j\neq i}\lambda_{ji}\right] = \pi_i \mu \tag{2.4.3}$$

$$\frac{\partial \mathcal{L}}{\partial y_i} = z'\left(1 - \frac{y_i}{w_i}\right)\left[\pi_i + \sum_{j\neq i}\lambda_{ij}\right] - \sum_{j\neq i}\lambda_{ji}\frac{w_i}{w_j}z'\left(1 - \frac{y_i}{w_j}\right) = \pi_i w_i \mu$$

Combining the two equations I get

$$\frac{z'\left(1 - \frac{y_i}{w_i}\right)}{u'(c_i)} = \frac{w_i}{\rho} \tag{2.4.4}$$

where

$$\rho = \frac{\pi_i + \sum_{j\neq i}\lambda_{ij} - \sum_{j\neq i}\lambda_{ji}\frac{w_i}{w_j}\frac{z'\left(1-\frac{y_i}{w_j}\right)}{z'\left(1-\frac{y_i}{w_i}\right)}}{\pi_i + \sum_{j\neq i}\lambda_{ij} - \sum_{j\neq i}\lambda_{ji}} \qquad \text{with } \rho \in [0,1]$$

Note that *a priori* nothing can be said on which constraints are binding, so that I cannot identify in advance who will mimic the behavior of the other agents. However, it is quite reasonable to assume that there will be at least 5 constraints that bite: this condition can be obtained by the hypothesis according to which any life-cycler will try to mimic a myopic individual in order to obtain a higher pension, while any rich individual will try to mimic the poor.

The term denoted by ρ, represents the informational rent, in terms of lower payroll taxes or higher pensions, that the government has to leave to the mimickers in order to make them reveal their type.

Note also that, since we get rid of second period consumption, the discount rate here is not explicitly involved, although it is reflected in the earnings of the individuals.

2.5. A two-period model with time inconsistency

I now want to model a situation in which the agent is time-inconsistent with respect to her choices regarding labor supply, in order to study the impact of time inconsistent choices on the design of optimal pension schemes. I am indeed interested in the behavior of "people who have self-control problems but realize this and behave according to it" (Diamond and Koszegi 2003, p. 1840). This time inconsistent behavior generates an intertemporal conflict among the different selves.

The framework is therefore inspired by Laibson (1997), although the model is restricted to two periods only. The main adjustment consists of adding a compulsory social security scheme. Moreover, instead of dealing with saving behavior, as Laibson does, I look at the effects on labor supply.

The model is as follows. An agent lives for two periods. In the first one she works, in the second she retires and perceives a pension based on her contribution in the first period. The pension is of the general form $p = \alpha\tau w + (1-\alpha)\tau\hat{y}$. There are no private savings and I assume the generosity of the system and the degree of redistribution to be exogenous, with $\tau, \alpha \in (0, 1)$. A main difference with the models seen so far is that now the agent can decide to keep working in the second period, while still receiving her pension. Therefore, in period two her budget constraint will be $c_2 = p + wl_2$. This feature of the model is aimed at capturing the idea that individuals in the second period can found themselves having worked too little in the past and hence they need to work more in order to guarantee themselves an adequate level of consumption.

I assume that the agent is time inconsistent - in the sense that she has self-control problems which are acknowledged in the second period - but sophisticated, meaning that the agent is smart enough to anticipate in period 1 that she is going to regret her choice in the next period. This leads the self in period 1 (self 1) to enter in a game with the self in period 2 (self 2). An alternative formulation of the problem, which I report in the appendix, would be to assume naivete on the behalf of the agent, meaning that in period 1 self 1 naively assumes that self 2 will follow her decisions. The instantaneous utility function is of the CRRA class in consumption, and in particular I assume it to be logarithmic. The disutility from labor instead is linear.

Before dealing with the agent's problem, let's look at how a life-cycler would solve the problem. This is also the best allocation in the economy, and therefore I refer to it as the life-cycler allocation.

2.5.1. Life-cyclers.

A life-cycler discounts the future at the true rate, which I pose for simplicity equal to 1. The problem is therefore:

$$\begin{aligned} V^c(w;\tau) &= \max_{c_1,c_2,l_1,\geq 0,l_2\geq 0} \log(c_1)+\log(c_2)-l_1-l_2 \\ s.t. \quad & c_1=(1-\tau)wl_1 \\ & c_2=p(l_1)+wl_2 \end{aligned}$$

Note that the pension she receives in period two depends exclusively on the amount of labor supplied in the first period. Therefore the optimal quantities of labor in the two periods are

$$l_1^c=\frac{1}{1-\alpha\tau}\geq 0$$

and

$$l_2^c=1-\frac{\alpha\tau}{1-\alpha\tau}-(1-\alpha)\tau\frac{\hat{y}}{w}$$

and the latter is positive iff

$$w\geq k\hat{y}$$

where $k=\frac{1-\alpha\tau}{1-2\alpha\tau}(1-\alpha)\tau\geq 1$.

Note that labour supplies in both periods are negatively related to the degree of redistribution of the system. Moreover, in period two labor supply is strictly positive only for highly productive individuals.

2.5.2. Sophisticated agents. Assume instead that individuals are myopic and ma-ke time inconsistent choices. When the agents are sophisticated, they solve a dynamic game in which the players are the two selves across periods. Since I am looking for a subgame perfect nash equilibrium of the game in pure strategies, I proceed by backward induction looking at the best response of self 2, for a given level of labor supply l_1.

The problem faced in period 2 by self 2 is then:

$$\begin{aligned} \max_{c_2, l_2} \quad & \log(c_2) - l_2 \\ s.t. \quad & c_2 = p(l_1) + wl_2 \end{aligned}$$

from which I obtain self 2's best response to l_1:

$$l_2(l_1) = 1 - \frac{p}{w} = 1 - \alpha\tau l_1 - (1-\alpha)\tau\frac{\hat{y}}{w}$$

Now, moving backward to period 1, given the best response of self 2, self 1 solves

$$\begin{aligned} V^m(w;\tau) \quad = \quad & \max_{c_1, l_1} \log(c_1) - l_1 + \beta\left[\log(c_2) - l_2(l_1)\right] \\ \\ s.t. \qquad & c_1 = (1-\tau)wl_1 \\ & c_2 = p(l_1) + wl_2(l_1) \end{aligned}$$

Computing the FOC

$$\frac{1}{l_1} + \frac{\beta}{p + wl_2}\left[\frac{dp(l_1)}{dl_1} + w\frac{dl_2(l_1)}{dl_1}\right] - 1 - \beta\frac{dl_2(l_1)}{dl_1} = 0$$

we note that substituting for the values of dp/dl_1 and dl_2/dl_1 in the previous expression, the term in square brackets disappears. Therefore we obtain that labor supply in period 1 is:

$$l_1^m = \frac{1}{1 - \beta\alpha\tau} < l_1^c$$

and recursively I can compute the equilibrium choice for self 2:

$$l_2^m = 1 - \frac{\alpha\tau}{1-\beta\alpha\tau} - (1-\alpha)\tau\frac{\hat{y}}{w} > l_2^c$$

Note here that the agent tends to work too little in the first period and too much in the second, compared to the life-cycler. Moreover, an interesting feature of this model lies in the fact that, in contrast with the previous case, a social planner who fixes the values of α and τ at the outset of the game will never succeed in correcting the mistakes of the individual. An important consequence of this is the following proposition:

Proposition 4: *for $\beta < 1$ the life-cycler allocation can be attained only in absence of a social security scheme (i.e. when $\tau = 0$).*

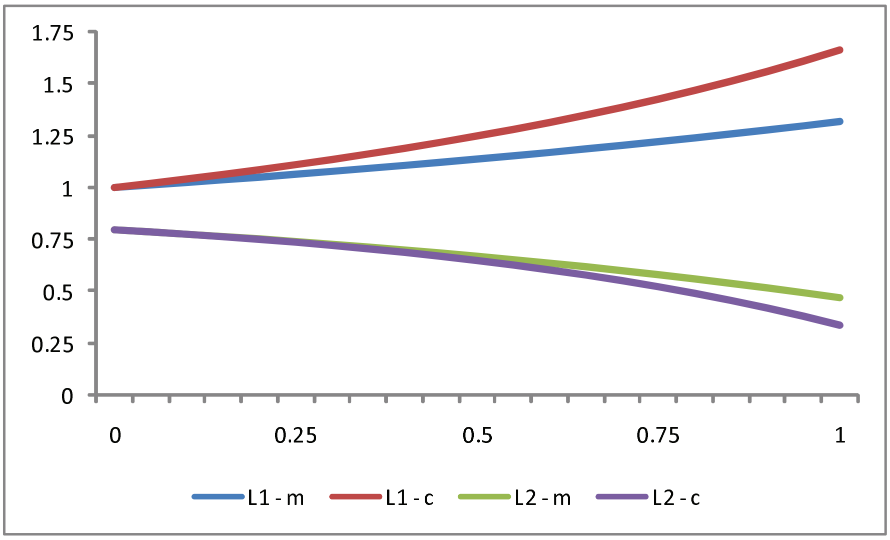
Let us now turn to the two extreme case cases of purely Bismarckian or Beveridgean pension schemes.

Under a purely Bismarckian scheme ($\alpha = 1$), labor supply reaches the maximum attainable value in the first period. However, the amount of labor supplied in period 2 depends on the productivity of the individual.

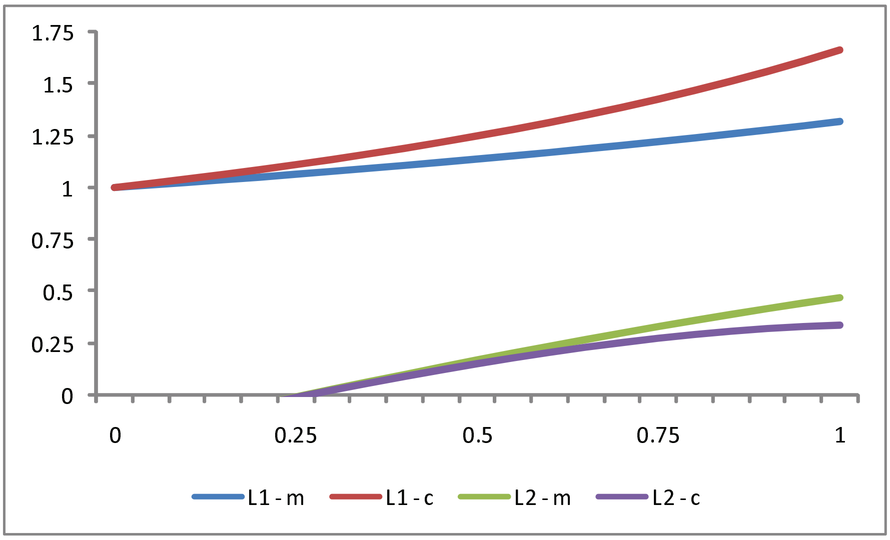
Under a fully Beveridgean scheme ($\alpha = 0$), instead, the life-cycler allocation is attainable (indeed $l_1^m = l_1^c$ and $l_2^m = l_2^c = 1 - \alpha\tau\frac{\hat{y}}{w}$), although the level of labor supply in the first period is minimum.

In order to better clarify the previous statements, I perform a simple calibration exercise, representing in the figures below the labour supply values for different values of α[18]. The first case is one of a relatively rich individual (I set $\hat{y}/w = 0.5$).

[18]The values of the parameters are: $\beta = 0.6$ and $\tau = 0.4$.



In the second figure instead I represent the case of a relatively poor individual ($\hat{y}/w = 3$).



It is worth to note that while labor supply in period one is increasing in the Bismarckian coefficient, labor supply in period 2 can be alternatively increasing or decreasing in α according to the productivity of the individual.

2.6. Myopia as a result of the pension system

The aim of this work was to offer a review on the recent literature on optimal pension schemes under myopia. I showed that under the assumption of a paternalistic social planner, welfare improving PAYG schemes involve redistribution of resources from life-cyclers to myopic agents. In this last section, I suggest that myopia can be seen not only as a psychological bias, but also as a strategic tool.

So far, the "rational prodigality" and myopia arguments have been dealt with separately. However, while in the case of myopia the literature has reached quite well defined conclusions, the literature on rational prodigality is less conspicuous and more ambiguous in its results.

Rational prodigality has been studied in a series of papers which have based their analysis on the existence of some survival wage or mean-tested pensions. In particular, Lindbeck and Weibull (1988) justify the existence of mean-tested pensions in a two periods game with altruistic individuals. Fenge and von Weizsäcker (2001) claim the efficiency of mean-tested linear pension schemes, as a tool for avoiding moral hazard by the individuals with lower productivity. This analysis has been further extended to non-linear pensions in von Weizsäcker (2003).

Homburg (2000, 2006), instead, claims that in many circumstances, the losses created by a pension system are larger than the ones generated by the free-riding behavior of the prodigals in the society and therefore the removal of compulsory savings schemes leads to a welfare improvement.

In my opinion, some future research could aim at reconciling these approaches in a unique framework. More precisely, an attempt could be made to model the concept according to which myopia on the behalf of the individuals can be due to the availability of public resources for the old age. Basically, this approach aims at investigating the causes underlying myopia and in so doing, it relates them to the presence of some resources in the second period which are not related to the contribution in the first period.

Therefore, I support the view according to which myopia is, at least partly, not a psychological bias, but rather a rational response to a generous pension system (Findley and Caliendo, 2008). Indeed, if at the time when people work, they know that, no matter what their current behavior is in terms of savings and labor, they will receive some pension when old, they will discount this in the present not only through a reduction in savings, but also by putting a lower weight on future consumption. Therefore, the social security system, through redistribution, will generate myopia in the system, thus leading to an increase in the dead-weight loss created by the pension system.

To the best of my knowledge, the only paper that tries to develop this approach with a formal model is Pestieau and Possen (2008), which derives an optimal non-linear pension scheme for an economy populated by myopic and prodigal individuals. Their model however takes myopia and prodigality as idiosyncratic features of some individuals. New insights can be derived from the development of a theory of "rational myopia", endogenizing the decision on the rate at which discounting the future.

Appendix

Pension systems in some OECD countries:

Country	Progressivity index	Gross replacement rates by earnings
Australia	73.1	47.9
Austria	30.4	80.1
Belgium	58.8	40.7
Canada	86.6	49.5
Denmark	59.3	83.6
Finland	7.6	63.4
France	24.6	51.2
Germany	26.7	39.9
Greece	2.6	95.7
Ireland	100	38.2
Italy	3.1	67.9
Japan	46.9	36.8
Netherlands	0 .0	81.7
New Zealand	100	46.8
Norway	37.4	60
Spain	18.8	81.2
Sweden	12.9	63.7
United Kingdom	81.1	34.4
United States	40.9	43.6

Source: OECD (2007).

Proof of proposition 1: In this case (2.3.3) can be rewritten as

$$\begin{aligned}\frac{d\mathcal{L}}{d\tau} &= -u'(c_1^c)\left[w+\frac{ds^c(\tau)}{\tau}\right]+\beta u'(c_2^c)\left[(1+r)\frac{ds^c(\tau)}{\tau}+w\right]=0\\ \Longleftrightarrow &\qquad \frac{d\mathcal{L}}{d\tau}=\beta u'(c_2^c)\left\{-(1+r)\left[w+\frac{ds^c(\tau)}{\tau}\right]+(1+r)\frac{ds^c(\tau)}{\tau}+w\right\}=0\\ \Longleftrightarrow &\qquad 1+r=1\end{aligned}$$

which contradicts the assumption that $r > 0$.

Proof of proposition 2: Combining (1.3.1) and (2.3.3) one gets the optimal savings response (Andersen and Bhattacharya, 2008):

$$\frac{ds^m(\tau)}{\tau} = -\frac{\beta-\beta^m(1+r)}{(\beta-\beta^m)(1+r)}w \tag{2.6.1}$$

This expression should be confronted with (2.3.2), which represents the individual private savings response. This ensure that the problems of the myopic individual and of the social planner are compatible. Equalizing (2.3.2) with (2.6.1), one obtains

$$\frac{u''(c_1)+\beta^m u''(c_2)(1+r)}{u''(c_1)+\beta^m u''(c_2)(1+r)} = \frac{\beta-\beta^m(1+r)}{(\beta-\beta^m)(1+r)}.$$

Now, since the expression on the LHS and the denominator of the RHS are both positive, for the equality to hold it must be that $\beta-\beta^m(1+r)=0$. As a consequence, if $\beta^m > \frac{\beta}{1+r}$, the social security program is always welfare decreasing.

Proof of Proposition 3: The formula in the text can be simplified as follows, with $\beta = 1$:

$$-\pi_c u'(c_2^c)rw+\pi_m u'(c_2^m)\left\{(1-\beta^m)(1+r)\frac{ds^m(\tau)}{\tau}+\left[1-\beta^m(1+r)\right]w\right\}$$

in this way we can see that life-cyclers always lose in the presence of a social security program, whereas myopics gain if and only if

$$[1-\beta^m(1+r)]\,w \;\; \geq \;\; -\left[(1-\beta^m)(1+r)\frac{ds^m(\tau)}{\tau}\right]$$

(i.e. if the gains deriving from receiving the pension exceed the reduction on savings). The first step is to show that this condition holds. Indeed, by substituting (2.3.2) into the previous expression one obtains

$$\begin{aligned}
&1-\beta^m(1+r) \geq (1-\beta^m)(1+r)\frac{u''(c_1^m)+(1+r)\beta^m u''(c_2^m)}{u''(c_1^m)+(1+r)^2\beta^m u''(c_2^m)}\\
&\Longleftrightarrow\\
&(1+r)^2\beta^{m^2} \geq \frac{u''(c_1^m)}{u''(c_2^m)}
\end{aligned}$$

if one substitutes $\beta^m = \frac{1}{1+r^m}$ into the previous expression one gets:

$$\left(\frac{1+r}{1+r^m}\right)^2 \geq \frac{u''(c_1^m)}{u''(c_2^m)}$$

we see that for appropriate specifications of the utility function, the condition is always satisfied.

Now we have to compare this net gain with the loss suffered by the life-cyclers:

$$\begin{aligned}
-\pi_c u'(c_2^c)rw+\pi_m u'(c_2^m)\left\{(1-\beta^m)(1+r)\frac{ds^m(\tau)}{\tau}+[1-\beta^m(1+r)]\,w\right\} \;\; &\geq \;\; 0\\
(1-\beta^m)(1+r)\frac{ds^m(\tau)}{\tau}+[1-\beta^m(1+r)]\,w \geq \frac{\pi_c}{\pi_m}\frac{u'(c_2^c)}{u'(c_2^m)}rw&\\
\frac{\pi^m}{\pi^c} \geq \frac{1}{\frac{u'(c_2^m)}{u'(c_2^c)}\left[\left(\frac{1+r}{1+r^m}\right)^2 u''(c_2^m)-u''(c_1^m)\right]} \geq 0&
\end{aligned}$$

and since the term within the square brackets is positive and the ratio $\frac{u'(c_2^m)}{u'(c_2^c)}$ is greater than 1, the previous expression implies that it is sufficient to have a positive proportion of myopics in the population for a welfare improving pension system to arise.

Explicit expression for the Bismarckian parameter for the linear fixed labor supply model: From (2.3.5) I get an explicit expression for the Bismarckian parameter:

$$\alpha = \frac{\left[\pi_c r - \pi_m \frac{1+r}{1+r^m}\right] E\left\{w u'(c_2^c)\right\} + \pi_m \frac{r^m(1+r)}{1+r^m} E\left\{\frac{\partial s^j}{\partial \tau} u'(c_2^j)\right\}}{\sum \pi_j cov\left[w, u'(c_2^j)\right]} + \\ + \frac{\pi_m \hat{w} E\left\{u'(c_2^j)\right\} - \pi_c cov\left[w, u'(c_2^L)\right]}{\sum \pi_j cov\left[w, u'(c_2^j)\right]}$$

Naive agents with commitment: A naive agent with commitment maximizes her intertemporal utility in period 1, knowing that in the next period self 2 will choose the allocation decided by self 1 in period one. Therefore the problem is

$$V^n(w;\tau) = \max_{c_1,c_2,l_1,l_2} \log(c_1) - l_1 + \beta\left[\log(c_2) - l_2\right]$$

$$s.t. \quad c_1 = (1-\tau)wl_1$$

$$c_2 = p(l_1) + wl_2$$

and the solution is:

$$l_1^n = l_1^c = \frac{1}{1-\alpha\tau} \geq 0$$

$$l_2^n = \beta - \frac{\alpha\tau}{1-\alpha\tau} - (1-\alpha)\tau\frac{\hat{y}}{w} \leq l_2^c$$

which is positive iff

$$w \geq k'\hat{y}$$

with $k' = \frac{1-\alpha\tau}{\beta-(1+\beta)\alpha\tau}(1-\alpha)\tau$

In this setting, we observe that the amount of labor supplied in period 1 coincides with the one of the life-cycler, however, because of myopia, now less people work in t=2.

Naive agents without commitment: If there is no way to commit, self 1 will update her choice in period 2. However, this is not anticipated by self 1, so that her problem will be:

$$
\begin{aligned}
V^{nn}(w;\tau) \quad &= \quad \max_{c_1,c_2,l_1,l_2} \; \log(c_1) - l_1 + \beta\left[\log(c_2) - l_2\right] \\
s.t. \qquad & c_1 = (1-\tau)wl_1 \\
& c_2 = p(l_1) + wl_2
\end{aligned}
$$

so that

$$
l_1^{nn} = l_1^c = \frac{1}{1-\alpha\tau} \geq 0
$$

However, in period 2, self 2 plans are updated:

$$
\begin{aligned}
\max_{c_2,l_2} \qquad & \log(c_2) - l_2 \\
s.t. \qquad & c_2 = p(l_1) + wl_2 \\
& l_1 = \frac{1}{1-\alpha\tau}
\end{aligned}
$$

and the amount of labor supplied in both periods will coincide with the one of a life-cycler:

$$
l_2^{nn} = l_2^c = 1 - \frac{\alpha\tau}{1-\alpha\tau} - (1-\alpha)\tau\frac{\hat{y}}{w}.
$$

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CHAPTER 3

Regulation and investment incentives for broadband access networks[1]

ABSTRACT. A fierce debate on how to stimulate investments in the access network is currently taking place in the EU. On one side, it has been argued that the process which has led during the past decades to the opening of the markets to new competitors is now over. Accordingly, no further rules and regulations should be applied to new (private) infrastructures. On the opposite side stand those who fear that a complete deregulation of the industry could lead to a process of consolidation of the markets and in the end to a reduction in the consumer surplus. At the European level, this debate has conflicted with the review of the regulatory framework and has led to new regulatory proposals both from the Commission and from NRAs. In the first part of the work the incentives underlying the adoption of NGANs under different regulatory regimes are investigated. An optimal policy mix is sketched, taking both dynamic and static efficiency concerns into account. In the second part, the paper provides new empirical evidence on the European broadband fixed markets with respect to both broadband adoption and investment choices by the market players, with the aim of assessing the effectiveness of the new EU regulatory framework of 2002 and to draw some lessons for the NGNs context.

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3.1. Introduction

The fixed line telecommunications industry has experienced new challenges in the recent years. The increasing deployment of new technologies and the emergence of new regulatory paradigms are two of the main factors which are currently leading the telecommunications industry towards what has been called an "identity crisis"(OECD, 2006, p.1). Indeed, a trend towards a wider adoption of IP-based technologies and applications has been observed in most of the telecommunications markets during the recent years. Furthermore, this phenomenon has pressed the industry towards a growing convergence with wireless technologies and multimedia.

It is clear that in order to compete in an effective way in the long run, new investments are required for upgrading legacy networks. Indeed, existing public switched telephone networks (PSTNs) cannot support the increasing bandwidth requirements of new IP based applications.

Thus, the main question for policy-makers has become how to stimulate long-term investments, preventing at the same time a re-monopolization of the telecommunications markets from historical operators. A growing debate on this topic has recently spurred, because of the investments announcements made by some operators and also because of the ongoing review of the regulatory framework proposed by the European Commission.

On one side, it has been argued that the process which has led during the past decades to the opening of the markets to new competitors is now over. Accordingly, no further rules and regulations should be applied to new (private) infrastructures. Indeed, keeping regulation still in place – it is argued – would ultimately lead investors to give up plans of upgrading their networks and introducing new services on the market. This is the ratio underlying the US approach, where since 2003 a regulatory forbearance is in place for fibre infrastructures: accordingly, those operators who decide to invest in next-generation access networks (NGANs) are not required to share their networks with competitors anymore. On the opposite side stand those who fear that a complete deregulation of the industry could lead to a process of consolidation of the markets and, in the end, to a reduction in the consumer surplus. A similar outcome would clearly nullify all the progresses achieved during the last decade.

As it has been pointed out by OECD (2008a), within an NGAN framework, government can take several actions in order to promote investments by market players. Indeed, the development of new high-bandwidth infrastructures and technologies is considered beneficial for social welfare, and delays in their deployment can give rise to substantial social costs (Guthrie, 2006). Therefore, it has been acknowledged that the government can enact several measures ranging from facilitating the roll-out of networks through a reduction of the administrative burden, to regulating the market and, in some circumstances, to investing in ventures when the roll-out is not economically feasible for private investors (OECD, 2008a). However, the benefits deriving from the adoption of new technologies can take place only in workable competitive markets (Clark, 1940). Accordingly, in playing its game, the government has to ensure both competition and returns from investments. Hence, this paper investigates the question of how long-run investments in the fixed-line segment can be stimulated keeping a competitive market structure.

The work is made of nine sections. Firstly, an overview on current NGANs implementation is provided. Then, after a review of the reasons underlying public intervention in broadband markets, the problem of underinvestment is outlined. In this section it will be showed that the interaction of many factors – first of all the regulatory variable – affects the incentives to invest, leading to an underinvestment equilibrium. Great attention is also devoted to the analysis of some regulatory options that have been proposed or implemented in the context of NGANs. An optimal policy is then proposed and some preliminary conclusions are sketched. Then empirical evidence is provided: a literature review is performed with the aim of exploring the trends in the empirical literature regarding both broadband penetration and investment behavior. Then an overview of the broadband markets in the European Union is provided, highlighting some stylized facts and trends of the markets. In section 7 I proceed to the estimation of the determinants underlying broadband adoption by sketching and estimating different specifications of a panel-data model with country-level data. In section 8 we refer to a firm-level data-set to explore the investment behavior of both incumbents and competitors in the fixed markets. Section 9 concludes.

3.2. An overview on NGANs implementation

Next generation access networks are an evolution of current copper-based networks. Their main feature relates to the wide adoption of the Internet Protocol (IP) in the transmission of information across the network[2]. NGNs differ from exiting networks in that they exploit a single platform for the transmission of a plurality of services and contents, whereas existing networks have been planned to support specific services (e.g. voice calls). Therefore, NGANs do not discern among different services since information is carried as data packets and accordingly no priority is granted to any kind of services[3].

As demand for new applications and services arises (e.g. IpTV), the upgrading of the networks cannot be delayed any longer. Indeed, a gradual migration towards the deployment of fiber networks can be observed in those countries where broadband penetration rates are higher. The technological frontier is nowadays represented by the Japanese market, where the former monopolist NTT owns the widest FTTH (Fiber-to-the-Home) network in terms of connected households (OECD, 2008a). The complete deployment of this network is expected by 2010 and total investments are estimated at about 37 billion of euros (Ofcom, 2007). In the US, three of the main players in the fixed markets (AT&T, Verizon and Qwest) are deploying proprietary FTTH networks which are expected to reach among 50% and 70% of the population. In Table 1 main investment projects in NGANs at a European level are shown.

3.3. Broadband adoption in the EU: an overview

Broadband adoption within the European Union has followed during the years different growth paths in each country. In 2007, the number of broadband access lines in percentage of the population in the EU 25 was on average around 20%,

[2] The classical definition of an NGN is “a packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users" (ITU, 2005, p. 53).

[3]This claim, however, should not be confused with the concept of “net neutrality”. See *infra.*

TABLE 1

France	In France, three of the main fixed operators (France Télécom, Iliad and Neuf Cegetel) have announced substantial investments in the upgrading of their access networks in the main French cities. Moreover, Numericable, the leading cable operator in France, has already started some projects based on FTTLA(Fiber to the last amplifier) technology in some of the main cities. The French government has declared that the policy goal is to connect through FTTH four million of households by 2012.
Germany	Deutsche Telekom is currently upgrading its access network with a mix of FTTC (Fibre-to-the-Curb) and VDSL technologies. The goal is to connect 17 million of users in 800 cities. After some criticism on the behalf of the European Commission, DT has announced that part of the network will be realized in co-operation with some competitors.
Italy	In March 2007, Telecom Italia has announced a plan for the upgrading of its access network, using a mix of FTTC and FTTB (Fibre-to-the-Building) technologies, according to geographical and economic characteristics of the areas that have to be reached. These new technologies will reach 8% of the population by 2010.
The Netherlands	In July 2007, KPN has reached an agreement with its competitors on the interconnection to its new fibre network. Accordingly, KPN has already started a migration process towards an NGAN which will cover the whole population by 2009. Total investments are around 1 billion of euro.
Spain	Telefónica has announced a project for the deployment of an “All-IP” network which will combine both VDSL and FTTx technologies.
United Kingdom	The former incumbent BT has announced in 2004 the creation of a NGAN, named 21st Century Network), and in 2008 has unveiled a super-fast broadband plan in order to roll out a new UK fixed-line network offering broadband speeds five times quicker than those currently available. Total investments are around £1.5 billion.

essentially in line with the OECD average (19,96%). If one restricts attention to the group of countries belonging to the EU 15, the broadband penetration rate is even higher (23,6%), reaching a level of broadband adoption comparable with the US (23,3%)[4].

However, the current situation in each member state shows some peculiarities that can be traced back to the economic and regulatory features that were already in place in each market before the adoption of a common regulatory framework. Therefore, within the EU 15, it is possible to identify a leading group of countries where broadband adoption rates are higher than 25% (Belgium, Denmark, Finland, Luxembourg, Netherlands, Sweden and United Kingdom), and another group of countries (Italy, Ireland, Greece, Portugal and Spain) which is currently lagging behind, with adoption rates rather below the EU average.

The reasons behind the different shapes of the broadband adoption curves can be traced back to several factors, such as population density (which is directly linked with the possibility of exploiting economies of scale from the producers side) or GDP growth rate, but also to the regulatory and legal features of the fixed markets. More in detail, the possibility of quickly reaching substantial economies of scale (on the producers side) as well as the impact of network effects (on the consumers side) seem to play a significant role. It is indeed worth remarking that higher levels of broadband penetration can be observed in those countries where cable-based technologies have been more widely developed.

Furthermore, many legal and regulatory variables seem to equally play a role in spur-ring broadband adoption and therefore in stimulating new investments. Indeed, the process which should lead to a common regulatory framework has not yet been completed. Although a minimum level of regulatory harmonization has already been reached, many different policies on the same issues are currently endorsed by different NRAs. Indeed, looking at the growth rates both before (2000 -2003) and after (2003 – 2007) the implementation of the regulatory package of 2002, it can be observed that the adoption of the new regulatory provisions has not led to a full convergence towards a uniform growth path within the European Union. However, no policy conclusions can be directly derived from the raw data reported in these tables. Indeed, these figures are the result of the interaction of several economic and legal variables that need to be carefully treated through

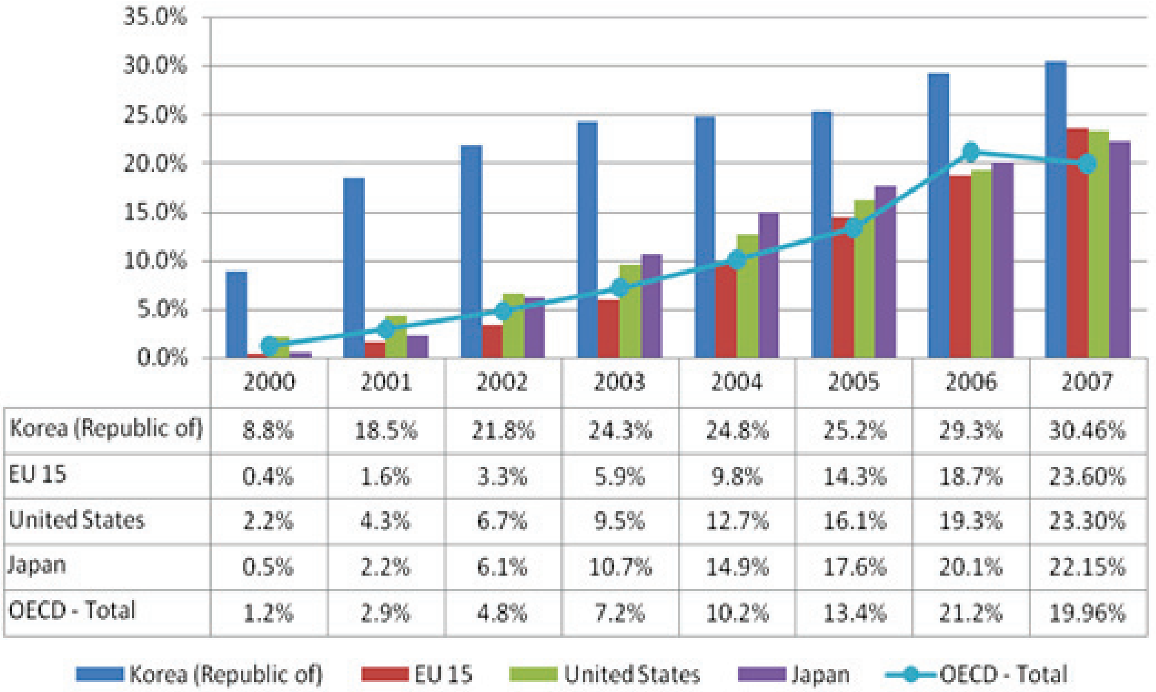
[4]However, it should be mentioned that recently, data on broadband penetration in the US have been criticized by some scholars on methodological grounds, see Wallsten (2006).

TABLE 2. Total Broadband penetration rate in some OECD Countries, 2000 – 2007

Year	2000	2001	2002	2003	2004	2005	2006	2007
Austria	1.72%	3.63%	5.57%	7.60%	10.55%	14.43%	17.40%	19.59%
Belgium	1.42%	4.35%	8.65%	11.67%	15.50%	18.10%	22.55%	25.74%
Czech Republic	0.10%	0.12%	0.17%	0.48%	2.50%	6.36%	10.64%	14.62%
Denmark	1.26%	4.44%	8.25%	13.08%	18.93%	24.87%	31.73%	35.07%
Finland	0.58%	1.31%	5.44%	9.47%	14.95%	22.37%	27.14%	30.71%
France	0.32%	1.05%	2.84%	6.10%	10.81%	15.65%	20.91%	24.61%
Germany	0.25%	2.30%	3.90%	5.47%	8.37%	12.95%	17.03%	23.77%
Greece	0.00%	0.00%	0.02%	0.09%	0.46%	1.41%	4.60%	9.15%
Hungary	0.02%	0.26%	0.65%	2.00%	3.57%	6.33%	11.90%	13.56%
Ireland	0.01%	0.01%	0.27%	0.83%	3.34%	6.53%	12.29%	18.05%
Italy	0.20%	0.72%	1.73%	4.15%	8.11%	11.87%	14.86%	17.20%
Japan	0.50%	2.23%	6.13%	10.69%	14.94%	17.58%	20.09%	22.15%
Korea (Republic of)	8.84%	18.47%	21.84%	24.26%	24.79%	25.24%	29.27%	30.46%
Luxembourg	0.00%	0.28%	1.54%	3.45%	9.62%	14.49%	19.80%	26.73%
Netherlands	1.63%	3.80%	7.02%	11.81%	18.98%	25.23%	31.79%	34.78%
Norway	0.40%	1.86%	4.19%	7.96%	14.79%	21.79%	27.54%	31.22%
Poland	0.00%	0.06%	0.30%	0.77%	2.12%	2.39%	6.86%	8.76%
Portugal	0.25%	0.96%	2.53%	4.80%	8.15%	11.55%	13.85%	14.41%
Slovak Republic	0.00%	0.01%	0.01%	0.35%	0.96%	2.48%	5.08%	7.64%
Spain	0.14%	1.15%	2.94%	5.17%	7.97%	11.70%	15.34%	18.04%
Sweden	1.70%	5.20%	8.14%	10.93%	14.73%	20.17%	25.87%	30.34%
United Kingdom	0.10%	0.58%	2.32%	5.38%	10.36%	16.47%	21.71%	25.78%

Source: OECD, ITU, EC Implementation Reports

FIGURE 3.3.1. Comparison of total broadband penetration rate in some OECD countries, 2000 - 2007



	2000	2001	2002	2003	2004	2005	2006	2007
Korea (Republic of)	8.8%	18.5%	21.8%	24.3%	24.8%	25.2%	29.3%	30.46%
EU 15	0.4%	1.6%	3.3%	5.9%	9.8%	14.3%	18.7%	23.60%
United States	2.2%	4.3%	6.7%	9.5%	12.7%	16.1%	19.3%	23.30%
Japan	0.5%	2.2%	6.1%	10.7%	14.9%	17.6%	20.1%	22.15%
OECD - Total	1.2%	2.9%	4.8%	7.2%	10.2%	13.4%	21.2%	19.96%

Source: OECD, ITU

appropriate econometric models, in order to isolate the impact of each of them before one can proceed to some policy evaluations. However, at a first inspection, some interesting trends are revealed by the data. In particular, it can be observed that those countries which started from lower adoption rates have shown in the last eight years higher growth rates, thus apparently adhering to the tenets of the standard economic models of growth in innovative industries. Indeed, the existence of spillovers in the form of economies of scale and network effects in broadband adoption seem to play a significant role in the evolution of the telecommunications industry.

This trend is more evident if one compares the broadband adoption path in South Korea, and the average OECD broadband penetration rate (Figure 3.3.1.). The Korean growth rate has continuously declined over time because of both the marginal diminishing impact of scale economies and the (partial) saturation of the market. At this stage of the analysis, then, one could ask whether a new rise in the broadband adoption rate could be expected from a new investment wave in NGNs and if its impact can be predicted from the observation of past and current data. In order to answer this question, the factors that determine broadband adoption have to be identified.

TABLE 3. Compound annual growth rate in Broadband uptake in some OECD Countries, 2000-2007

	2000 - 2003	2003- 2007	2000 - 2007
Austria	65%	27%	42%
Belgium	103%	22%	52%
Czech Republic	69%	136%	105%
Denmark	119%	28%	61%
Finland	154%	34%	77%
France	168%	44%	88%
Germany	180%	44%	92%
Greece	426%	214%	292%
Hungary	344%	61%	149%
Ireland	379%	120%	207%
Italy	175%	43%	90%
Japan	178%	20%	72%
Korea (Republic of)	42%	6%	20%
Luxembourg	-	69%	-
Netherlands	95%	31%	55%
Norway	173%	41%	88%
Poland	-	83%	-
Portugal	171%	32%	80%
Slovak Republic	-	117%	-
Spain	236%	38%	102%
Sweden	86%	29%	51%
United Kingdom	281%	49%	123%
United States	65%	26%	41%

Source: OECD, EC Implementation Reports

It is quite evident that an increase in broadband penetration can be reached only through new investments in the network infrastructure. From the supply side, however, market players will embark in new investments only if a) new demand for broadband services can be reasonably expected to rise in the next future, b) financial resources are available to be channeled into new investments and c) a stable regulatory environment can be expected after the investments are made. For the purposes of the essay, I will focus on the expected level of demand and regulatory intervention on the markets, taking these two as the main variables that directly affect investment choices, although, in the light of the current financial crisis, the issue of finding new sources for financing investments can be significant as well.

I assume, therefore, that expected demand for new services and products in the broadband markets is affected by three macro-categories of variables:

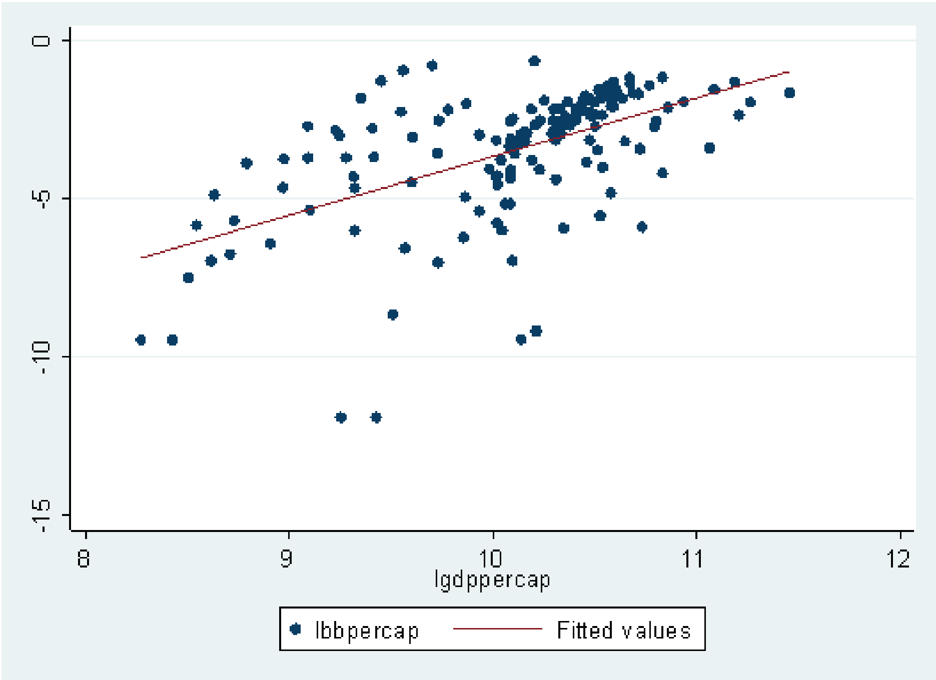
- General macroeconomic factors;
- Industry specific features;
- Market specific features.

General macroeconomic factors are related to the fundamentals of the economy, i.e. GDP growth, inflation growth and so on. These factors have a significant impact on broadband penetration rates. In Figure 3.3.2. the correlation among broadband penetration and GDP is shown for some OECD countries. The correlation coefficient for the years 2000-2006 is around 0.5561[5]. This correlation is not surprising since it can be expected that more resources available to the representative agent in the economy (the GDP per capita) lead to higher levels of consumption.

Among macroeconomic factors, a prominent role is played by access to lending in capital markets. Indeed, especially in times of financial turmoil, it could happen that investment opportunities are not fully caught because of credit rationing on the markets[6]. In this periods, even firms with rather stable cash flows such as telecom firms could find difficult to find new source of financing.

[5]In order to have a linear relationship, in Figure 3.3.2. (and in all the following figures) the correlation coefficient has been computed on the logs of the variables. The correlation coefficient tends to show a weaker impact on larger samples, however the correlation still holds.
[6]See Tirole (2006).

FIGURE 3.3.2. Correlation among broadband penetration and GDP per capita in some OECD countries, 2000 - 2006

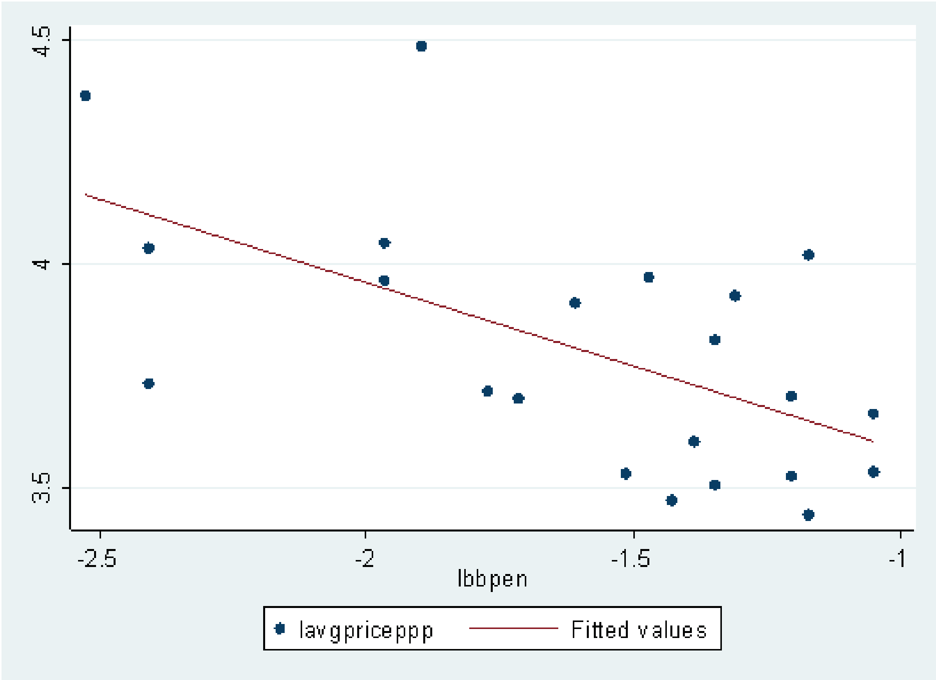


Finally, the broadband adoption rate in a given country is directly linked with the average retail price of broadband services. Although country-level data on broadband retail prices are quite incomplete and lack of a significant time series, even in this small sample for the year 2007, a negative relationship among these two variables can be observed (Figure 3.3.3.). In Figure 3.3.3., a correlation of -0.5874 among broadband penetration rate and average subscription prices (in US dollars, PPP adjusted) for the year 2007 in some OECD countries can be observed. As one would expect, the correlation is negative (-0.5119), meaning that higher broadband subscription prices lead to lower adoption rates.

Running the risk of oversimplifying a bit, from a microeconomic point of view, one could see the penetration rate as the quantity of broadband demanded by the representative consumer, whereas the GDP and the average prices are respectively his income and the relative prices of the broadband good. This perspective is backed by Figure 3.3.3., where broadband penetration and average subscription prices show a negative correlation.

3.3.1. Market conditions and regulation impact in broadband adoption. Expectations over the future levels of demand are influenced by industry related factors, such as the possibility for players of exploiting market power in order to

FIGURE 3.3.3. Correlation among broadband penetration and average subscription prices (in USD, PPP) in some OECD countries, 2007



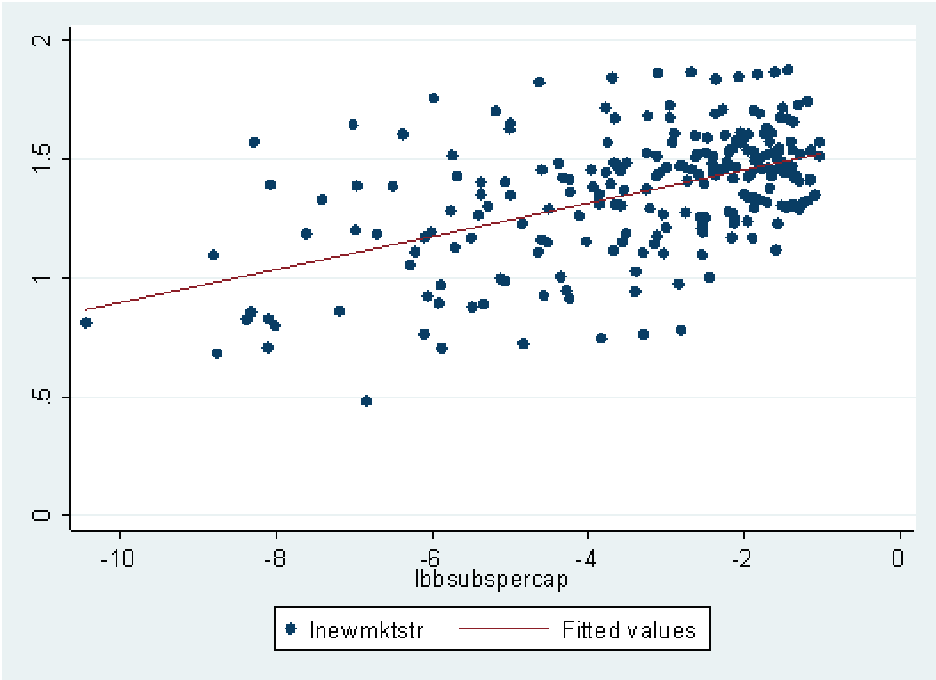
extract oligopolistic rents[7], or potential expansion in adjacent markets through strategies aimed at offering services in bundles. Finally, within the fixed broadband markets themselves, expectations on the level of demand are given by the possibility of customers migration towards alternative operators or technologies. In this respect, broadband adoption seems to show a positive correlation with competitive market structures. In particular, in Figure 3.3.4. the relationship is shown among the level of per capita broadband adoption, and the concentration in the fixed markets, as measured by the OECD regulatory index. The variable on the horizontal axis is a transformation of the OECD index on market structure. In particular, since the latter index has a range of values between 0 (maximum level of competition in the market) and 6 (maximum level of concentration) the variable has been transformed as follows:

$$lnewmktstr = \log\left(7 - OECD\, market\, structure\, index\right)$$

In this way I simply invert the ranking of the index to make results more intuitive. Now the index (before applying the logarithmic transformation) goes from 1 (monopoly) to 7 (highly competitive market). Figure 3.3.4. then shows a positive

[7]Assuming that firms compete à la Cournot, which is not always the case, especially if high fixed costs are involved.

FIGURE 3.3.4. Correlation among per capita broadband subscribers and market structure in some OECD countries, 1997 - 2007



correlation between the broadband adoption rate and the degree of competition in the market.

A useful source for measuring the general impact of regulation on the telecommunications markets are the OECD Regulatory Reform Indexes (RRIs). These indexes are available for regulated industries and for the telecommunications sector they are based on three main variables (Conway and Nicoletti, 2006)[8]:

- Entry regulation: this variable looks at the legal limitations on the number of competitors in the communications markets;
- Public ownership: indicates the extent of direct governmental control in one or more firms;
- Market structure: this is an index of the market shares of new entrants in the telecommunications markets.

These indexes provide an easy way to compare the effectiveness of regulatory intervention in several countries, and they can be used as an approximation for measuring the impact of regulation and market conditions on broadband adoption.

[8]See the appendix for details.

TABLE 4. OECD Telecom Regulatory Reform Indexes (RRIs) in some OECD countries, 2000 – 2003

Regulatory index	2000	2001	2002	2003	Cagr 2000 - 2003
Telecoms					
US	0.216	0.184	0.160	0.214	-0.38
EU 15	1.849	1.674	1.540	1.382	-9.24
Japan	1.945	1.972	1.722	1.675372	-4.85
Korea (Republic of)	2.331	1.655	1.109	2.675372	4.69
Entry					
US	0.000	0.000	0.160	0.000	-
EU 15	2.215	0.294	1.540	0.000	-100.00
Japan	0.000	0.000	0.000	0.000	-
Korea (Republic of)	0.000	0.000	0.000	0.000	-
Public ownership					
US	0.000	0.000	0.000	0.000	-
EU 15	2.215	2.086	1.977	1.674	-8.92
Japan	3.900	3.330	2.760	2.766	-10.82
Korea (Republic of)	3.534	1.767	0.000	0.000	-100.00
Market structure					
US	0.649	0.553	0.481	0.642	-0.38
EU 15	3.351	2.991	2.931	2.881	-4.91
Japan	1.935	2.587	2.405	2.260	5.31
Korea (Republic of)	3.460	3.199	3.326	3.348	-1.09

Source: OECD

The Market Structure index: some remarks. Since competition in the telecommunication sector can take many forms, a few words on how the market structure index is constructed and what it actually measures are needed. The index covers telecom firms operating in each country (both fixed and mobile) and it is a weighted average of three sub-indexes which measure the aggregate market share of new entrants (i.e. other licensed operators - OLO) in the three main markets: trunk, international and mobile markets. Therefore, this index is just a proxy for the overall degree of competition in the communications sector. Moreover, it does not discriminate among the various forms of competition (intra- vs. inter-platform). However, for the purposes of the present paper, I believe that this index provides enough information on the competitive climate in the markets.

3.4. Literature review

Recent literature on telecommunications regulation has mainly focused on the impact of unbundling policies on investments and broadband penetration. Indeed, this strand of literature has its roots in the liberalization process which has been observed during the 1990s in many developed countries.

Several empirical works have investigated the impact of regulation on telecommunication operators' choices. At a general level, two main lines can be envisaged in this literature. On the one side stand those works that investigate the factors underlying the adoption of new telecommunication services. On the other side, a more recent literature has spurred, aiming at finding the variables that affect the level of investments in the telecommunications industry and the impact of different regulatory measures on the investment choices of the agents in the market.

3.4.1. The empirical literature on broadband penetration. The drivers underlying broadband adoption have been recently studied in several empirical papers. However, the evidence is quite contrastive among the different studies, and therefore no conclusive policy recommendations can be drawn.

Garcia-Murillo and Gabel (2003) analyze the role of regulation in stimulating fixed telecommunications penetration. The data-set refers to a cross-section over 135 countries in the year 2001. The authors find no evidence of correlation among unbundling policies and broadband penetration, whereas a positive relationship is found with respect to the level of competition in the markets.

In the same vein, Burnstein and Aron (2003) regress the number of broadband subscribers over a set of regulatory variables, including ULL prices. Their data refer to a US cross-section for the year 2000. They find that inter-platform competition significantly affects broadband penetration: "after controlling for the demand and cost influences on adoption, intermodal competition drives increased penetration in a state" (*ibidem*, p. 7). Accordingly, the authors come to the policy conclusion that policies that encourage facilities-based competition are to be preferred to ubiquitous access.

Kim, Bauer and Wildman (2003) estimate the impact of broadband penetration on a cross-section of 30 OECD countries in 2001. They perform a OLS regression on prices of broadband and dial-up connections and several other variables, finding that most of the independent variables are not statistically significant; only preparedness of a nation (i.e. diffusion of computers in the households) and the cost conditions of deploying advanced networks are consistent in explaining broadband uptake. However their results are not very robust and their analysis can suffer of biases because of the lack of a time series.

Ford and Spiwak (2004) study the impact of prices and costs of unbundled loops on availability of broadband services on a US panel with semi-annual observations for the period 2002-2003. The authors regress a set of regulatory and socio-economic variables on universality of access (i.e. availability of at least one broadband provider) and competitive broadband access (i.e. availability of at least four broadband pro-viders), finding that lower unbundled loop prices are associated with an increase both in universality of access and competitive access.

Denni and Gruber (2005) study the role of intra- and inter-platform competition on the diffusion of broadband infrastructure. The authors analyze a panel of semi-annual observations from 2000 to 2004 across the US states, showing that both types of competition significantly affect the rate of broadband penetration. More precisely, inter-platform competition seems to have a higher impact on the rate of diffusion than intra-platform competition.

Similarly, Distaso, Lupi and Manenti (2005) develop a model of intra-platform *versus* inter-platform competition and then test it on a panel of 14 European countries with quarterly observations from 2001 to 2004. They regress broadband penetration on the level of market concentration, the price of unbundled local loops and leased lines and some other regulatory variables. Their results show that lower unbundling prices stimulate broadband uptake.

Flamm (2005) examines the evolution of broadband in the US from 2000 to 2003 at zip-codes level. The paper finds that geography, income and population density are among the main determinants of broadband penetration, whereas most of the regulatory variables (such as the eRate program and the rural health care grants) appear ineffective in stimulating broadband availability.

Wallsten (2006) evaluates the impact of unbundling regulations on broadband adoption over a data-set of 30 OECD Countries during the period 1999-2003. The author takes into account several kinds of unbundling (full unbundling, bitstream and sublo-op unbundling) as well as interconnection (collocation) regulations (co-mingling and virtual). He finds that unbundling policies do not promote broadband adoption; however, interconnection may play a significant role in stimulating new entry, even though entry by itself does not necessarily stimulates investment.

Finally, Wallsten and Hausladen (2009) analyze the impact of diverse regulatory tools, such as net neutrality regulations and unbundling on the penetration rate of fiber connections (NGNs) in the EU27 with semi-annual observations over six years (2002-2007). The authors find a significant negative correlation between the number of unbundled DSL connections per capita and the number of fiber connections, bringing thus further evidence in support of the intra- vs. inter-platform competition view.

The picture emerging from the reviewed literature suggests that the determinants of broadband adoption are still a question open to debate. Moreover, many of the above studies tend to focus on the US broadband market, whereas a sound economic assessment of the European regulatory provisions seem to be lacking. This may be mainly due to lack of data on the European markets, heterogeneity among data sour-ces and to some difficulties in constructing time series for European countries. Furthermore, as a general remark, many of these empirical studies do not properly investigate the impact of regulatory provisions on long-run welfare. Indeed, although regulation can be beneficial in the short term, it can fail in giving proper investment incentives to market players, thus leading to a gradual decrease in the deployment of new infrastructures. Empirical literature focusing on investment is reviewed below.

3.4.2. The empirical literature on investments. The study performed by Greenstein, McMaster and Spiller (1995) is one of the first attempts to capture the impact of regulation on investments at a firm-level. The authors analyze a panel of 101 Local Exchange Companies from 1986 to 1991. Even though the study is quite dated, their methodological intuitions are still very useful. Indeed, the partial adjustment model for investments in tangible assets developed in the paper has been used in further empirical works. Their main finding is that price regulation schemes (price caps) can affect the deployment of digital equipment at the local exchange level. However, "more liberal regulatory environments lead to greater incentives to deploy modem equipment, and [...] LECs respond to those incentives" (*ibidem*, p.189). Furthermore, price caps regulations seem to be more effective in stimulating investment than earnings sharing provisions.

In an important paper, Röller and Waverman (2001) provide a model for telecommunications investment with the aim of investigating the relationship among economic growth and telecommunication infrastructures development. The authors develop and estimate a system of equations, in order to avoid reverse causality among investments and growth. More in detail, the investment (supply) equation is obtained by regressing investment in telecom infrastructure on prices of telephone services, geographic area, government surplus and waiting list for main lines per capita. The authors find evidence of a significant positive causal link among economic growth and telecom infrastructure. Because of the presence of network externalities in telecommunications networks, this trend is strengthened when a critical mass of telecommunications infrastructure is reached.

Ai and Sappington (2002), examine the behaviour of the Regional Bell Operating Companies from 1986 to 1999 in terms of revenues, investment and profit. The authors compare the level of these variables under incentive regulation and rate-of-return regulation, finding that higher values of investment are associated with incentive regulation provisions. However, the authors acknowledge the risk of endogeneity of regulatory variables and accordingly some instruments are added to their regressions in order to mitigate the problem.

Li and Xu (2004) focus on the role of market privatization and liberalization on investment. They analyze a large data-set of 166 countries over nearly twenty years, finding a positive complementarity between privatization and competition in facilitating investment.

Chang, Koski and Majumdar (2003) tackle instead two distinct aspect of regulation: the impact of access prices on incumbents' investment and the relationship among competition and entry in the market. The authors address the two problems by looking at two distinct data-sets. For the purposes of the current work, only the first part is reviewed here. The authors look at the deployment of fiber-based technologies on the incumbents' networks, finding that lower access prices tend to promote greater deployment of digital technologies among ILECs. According to the empirical results, this apparently odd phenomenon can be explained through the fact that lower prices boost the demand for new services and technologies and consequently give incentives to incumbents to invest in order to meet the demand.

Ingraham and Sidak (2003) provide empirical evidence in support of the Jorde-Sidak-Teece hypothesis, which states that mandatory unbundling at TELRIC prices harms incumbent's investment because it increases the incumbent's cost of equity: indeed, since "TELRIC prices are not compensatory in economic terms, ILEC returns will suffer in times of recession and improve during an expansion" (*ibidem*, p. 2). According to the authors, empirical analysis of daily market data seems to confirm this hypothesis. However, their results are significant only for two over four of the ILEC considered. Moreover, the Jorde-Sidak-Teece hypothesis focuses only on incumbents' behaviour, whereas nothing is said about investment incentives on the behalf of competitive carriers.

Garrone (2004) provides a first attempt concerning the analysis of the investment behaviour of 23 European fixed incumbents among 1995 and 2002. Investments are regressed over a set of financial variables, corporate restructuring variables (eg. State's control) and regulatory variables. The value added of this work is the inclusion of financial and corporate governance aspects within the modeling of the investment behaviour. The main regulatory findings of the paper are that privatization does not significantly affect the investment behaviour, whereas liberalization, competition and unbundling obligations depress incumbents' incentives to invest. Although very valuable, this study suffers from some shortcomings. In particular, the data-set is quite small and unbalanced and the analysis is performed with exclusive focus on incumbents' behaviour.

Hausman and Sidak (2005) discuss four rationales for mandatory unbundling (retail competition, entry barriers, "stepping stone" hypothesis and wholesale competition) and test them on five representative countries. The authors test the effectiveness of mandatory unbundling as enabling future facilities-based investment ("stepping stone" theory). Even though the authors acknowledge theoretical soundness to the theory, they do not find empirical evidence in support of the hypothesis. The authors claim that this failure can be due to the fact that "regulators have been remarkably unconditional in developing access regulations that would support the transition to facilities-based competition. In particular, regulators have failed to impose obligations to ensure that promises to evolve from UNE-based to facilities-based competitor are subsequently realized"(*ibidem*, p. 224). Moreover, mandatory unbundling may have attracted firms interested in short term profits ("hit and run" strategies) to the detriment of long-run competition.

The "stepping stone theory" is at the core of Hazlett (2005), which investigates the investment path of the US telecommunications industry from 2000 onwards. An analysis of the investment behaviour of the main US telecom firms is performed and the findings are that mandatory unbundling has not proven effective in spurring new investments neither from incumbents nor from new entrants. Moreover, resale competition, where achieved through regulation, has not led to additional facilities-based entry; on the contrary, it has generally displaced such activity. Therefore, according to the author, the stepping stone theory has not shown a significant predictive power.

In the last few years, a growing debate on telecommunications investment in the EU has spurred, mainly because of the i2010 initiative launched in the framework of the Lisbon strategy. Accordingly, some econometric studies have been performed by economic consultancies. London Economics and PricewaterHouseCooper (2006), in a study commissioned by the DG InfoSoc of the European Commission, analyze the investment behaviour of firms operating within the perimeter of the markets for electronic communications between 2001 and 2004. In this study a data-set is collected at firm level for the main firms in the 25 European Countries. A regression is performed in order to check the impact of regulation of investments. Gross investment in tangible assets is employed as dependent variable, whereas, among the regressors, the OECD Regulatory Index[9] is used as a measure of regulatory effectiveness. The main finding of this study is that "a better performing regulatory regime does contribute to higher levels of investment" (*ibidem*, p. 50). This study however suffers from some inaccuracies in data gathering, since investment figures have been processes quite arbitrarily.

After this study, and partly in response to it, two more studies have been performed, one commissioned by the ETNO (European Telecommunications Network Operators' Association) and the other by the ECTA (European Competitive Telecoms Association). The first study (LECG, 2007) analyzes firms in 12 European Countries, regressing broadband penetration over a set of variables, including the wholesale prices of ULL and Bitstream. The main finding is a negative correlation among broadband penetration and tight access policies. Furthermore, the

[9]See Cowley and Nicoletti (2006).

authors stress that increased intra-platform competition, achieved through regulation, might be achieved at the expense of longer-term interplatform competition and investment in alternative infrastructure. The authors postulate that there is a positive link between end-user demand and network investment: "[s]ince a reduction in the LLU price reduces the (relative) demand for broadband offered over alternative infrastructures such as cable, it affects both the probability that large-scale lumpy investments (such as network upgrades or footprint expansions) are undertaken at all, and it reduces the magnitude of these investments" (*ibidem*, p. 56). The second study, commissioned by the ECTA, has been performed by Cadman (2007). The author investigates the relationship among investments in telecommunications and the level of regulatory effectiveness, over a set of 16 European Countries in 2003 and 2005. The author performs two distinct regressions using the OECD Regulatory Reform Index and the ECTA Regulatory Scorecard as a proxy of regulatory effectiveness. In both cases a positive relationship among regulatory effectiveness and investments is found. However, the critique made for the use of regulatory indexes also applies for this study. Moreover, the data-set is very small and the estimates could be biased. Friederiszick, Grajek and Roeller (2008), perform an econometric investigation on telecom investments on a data-set with firm-level data over 25 European Countries from 1997 to 2006. Two main features distinguish this study from the previous ones. First of all, the problem of endogeneity of regulatory policy is tacked with instrumental variables techniques. This solution is derived from Greenstein, McMaster and Spiller (1995) and makes estimates unbiased. Secondly, availability of data at firm-level make the sample statistically significant, with more than 1000 observations. The authors come to the conclusion that unbundling provisions in the fixed markets tend to discourage infrastructure investments by new entrants, but apparently no effects are detected on incumbents behaviour.

The reviewed literature on investment is very wide-ranging both with regard to the features of the studies and the conclusions they reach. However, these study as a whole do not provide conclusive evidence of the impact of regulatory policies on investment behaviour.

3.5. Why public intervention in broadband access?

Recent theoretical literature on telecommunications regulation has mainly focused on the impact of unbundling policies on investments and broadband penetration.

Indeed, this strand of literature has its roots in the liberalization process which has been observed during the 1990s in most of the developed countries.

The theoretical underpinnings for public intervention in the broadband markets lie in the economic features of the markets themselves. As pointed out by Picot and Wernick (2007), there are at least two main arguments in support of governmental intervention in the industry.

The first argument relates to the need of universality of broadband access: this is a common feature of network industries and can involve direct governmental intervention in broadband provision in those geographic areas where private firms do not find profitable to fully roll-out broadband networks. Public intervention could be justified by the fact that the benefits of universal broadband access can significantly exceed the deployment costs of the network. The second feature involves competition law issues. Indeed, the local loop has a bottleneck nature that constantly puts the industry at risk of being monopolized; from this point of view, regulatory-driven competition is intended to increase broadband availability at lower prices, with a significant increase in the consumer surplus. However, if the impact of regulation on short term consumer surplus is almost unanimously considered beneficial, it is doubtful whether regulation can increase total welfare in the long run. To be more precise, it is not clear whether regulation gives the right incentives to market players to properly invest in new infrastructures.

A modern approach to the relationship among investments and regulation can be traced back to the work of Dixit and Pyndick (1994), where investment choices are treated as real options. According to this view, each investment decision is equivalent to the exercise of an option; therefore, this implies that one can also decide not to exercise it (i.e. delay the investment) if the latter alternative is more profitable.
In the light of this framework, one can see regulation as one of the variables affecting the decision whether to exercise the option or not. Gavosto et al. (2007) apply the real options approach to investments in next generation networks. The authors construct a model in order to investigate investment decisions of telecommunications operators under regulation. Their analysis suggests that regulation affects the investment decision only in the initial period when uncertainty is very high, whereas in the long run investments do not seem to be significantly affected. The theoretical literature on investment decisions under regulatory uncertainty is more extensively discussed in the next section.

3.6. The underinvestment problem and the role of regulation

In view of the above explanations, it becomes very important to understand the role for public policies, which have historically played a huge part in shaping the evolutionary dynamics of the telecommunication sector. Indeed, public intervention can sometimes determine the success or the failure of a technology and therefore can alter the structure of the markets themselves. More specifically, public policies are subject to the risk of failure, since the shape of the industry is continuously evolving. Furthermore, information asymmetries among public bodies and market players make possible for the latter to exploit regulatory gaps in their favor. Thus, regulators, while required to intervene and settle market failures, face the risk of slowing down the pace of investments in the industry through a misplaced intervention.

In order to understand the link between regulation and investments, I refer to Goldberg's (1976) firm-regulator model. Within this model, each regulatory regime can be viewed as a contract among the regulator, which acts as the principal, and the regulated firm (the agent). It is worth remarking that regulators act at the same time both as principals towards regulated firms and as agents towards consumers. This leads to a double agency relationship, with all the problems related to it in terms of opportunistic behaviour and asymmetric information. More specifically, one of the main risks faced by regulated firms relates to moral hazard strategies on the behalf of the regulator (Lyon and Mayo, 2005). As a matter of fact, the latter could have ex post incentives to deviate from its previous commitments, given its double-folded agency relationship. Indeed, "from a contractual perspective [...] the highly incomplete nature of the regulatory framework means that opportunistic behavior - e.g., inappropriate investment practices by the firm or abuse of pricing discretion by the regulator- has always been a nagging possibility" (*ibid.*, p. 629). Indeed, since regulators tend to weight consumer surplus more than producer surplus (Bower, 1981), once new investments have been made, operators face the risk that the regulator unexpectedly lowers access tariffs, in order to increase consumer surplus. This means that ex post regulators could be tempted to transfer wealth from producers to consumers, through severe price constraints. Therefore, regulatory opportunism could lead to the truncation of the probability distribution of the investment returns. Accordingly, "anyone contemplating such investment will anticipate that the high-end of the distribution of possible returns may be truncated by access regulation, reducing their expected returns and hence,

FIGURE 3.6.1

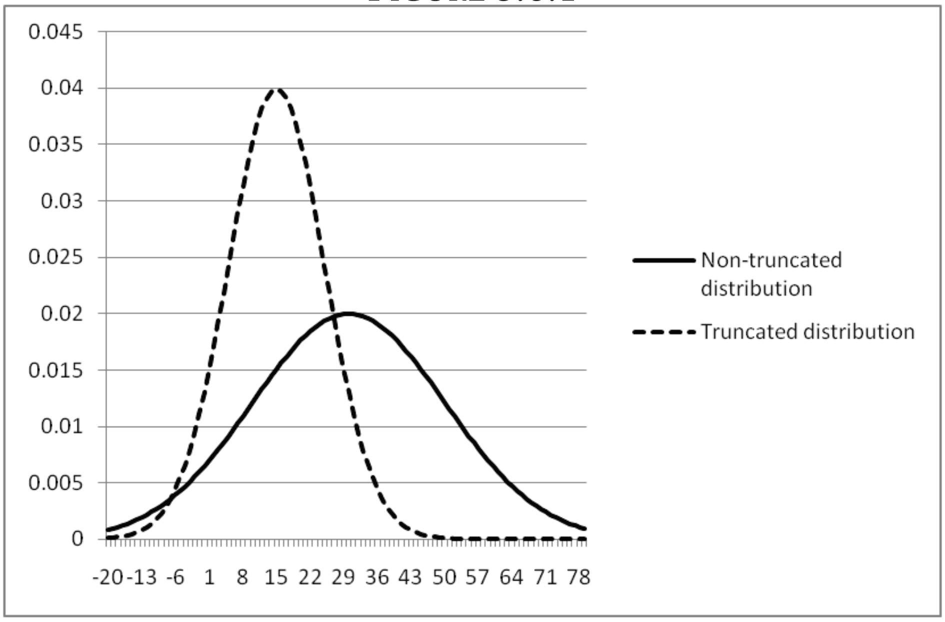
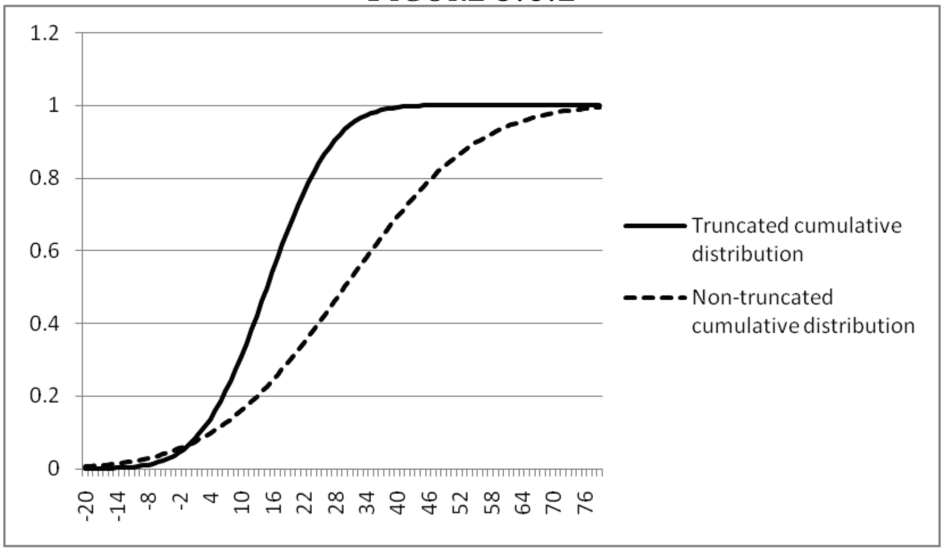


FIGURE 3.6.2



their incentives to invest" (Gans and King, 2004, p. 90). An example of truncation is represented in Figures 1 and 2, where two distributions of an hypothetical investment project are sketched. The effect on returns of regulatory opportunism is twofold: on the one side, it induces firms to choose investment projects with lower volatility, but on the other side, firms tend to pick those investment projects with lower expected values.

Indeed, anticipating the possibility of regulatory opportunism, at the beginning of the regulatory process a regulated firm will tend to enact several defensive strategies. The most frequently observed strategies in the literature are:

- delay in investment decisions;
- under-investment;
- preference towards less volatile investment projects;
- preference towards external debt financing.

Teisberg (1993) shows that firms facing regulatory uncertainty tend to delay their investment projects and to prefer smaller investment alternatives. Spiegel and Spulber (1994) study the effect of regulatory opportunism from a financial point of view. They show that a significant exposure to debt is correlated with less severe access tariffs, and therefore they argue that external debt acts as a shield from excessive regulatory intervention[10]. Indeed, this is what it can be currently observed in the industry, where most of the incumbents tend to have a debt-oriented financial structure. This has a clear impact on the investment choices of the firms. Indeed, heavily indebted firms tend to prefer projects with less volatile cash flows. This is due to the need to match inflows and outflows in order to reduce the risk of financial distress. Therefore, a first policy recommendation can be derived. Since investing in NGANs involves both operative and financial risk, a regulatory policy aimed at increasing broadband penetration should point at minimizing the riskiness of the investments' cash flows.

In the context of NGANs development, some more features make investments less attractive. First of all, investment decisions in NGANs are irreversible[11]: consequently, while irreversibility adds great value to the investment choice itself, at the same time, this feature increases the riskiness of the project. Furthermore, technologies underlying the telecommunications industry are characterized by huge fixed costs and tiny variable costs. As a consequence, short run marginal costs are very close to zero for each firm in the industry, whereas long run marginal costs

[10] Empirical evidence can be found in Bortolotti et al. (2007).

[11] See Dixit and Pyndick (1994). According to the authors "an irreversible investment opportunity is much like a financial call option" (p. 9).

can be significantly higher. Thus, the risk of not recovering fixed costs is high, especially in highly competitive markets.

Finally, the current financial structure of many incumbents can act as a constraint to new investment opportunities. This has been explained in both theoretical (Spiegel e Spulber, 1994) and empirical literature (Bortolotti et al., 2007), as a defensive strategy enacted by firms in order to protect themselves from regulatory opportunism. Indeed, debt-financed investments tend to shift the risk of regulatory opportunism from shareholders to debt-holders, thus creating an unfavorable climate towards the imposition of tight access tariffs.

Therefore, the interaction among the financial constraint, the irreversibility constraint (Caggese, 2006) and the regulatory opportunism risk, leads the industry towards a stable underinvestment equilibrium.

Up to now the contractual relationship among the regulator and one single firm has been considered. From now on I take a broader perspective on the industry as a whole. Indeed, form this perspective, I see that the regulatory dilemma relates not only to spurring investments but also to keeping a competitive market structure. The-refore, regulators face a trade-off among what has been labeled "dynamic efficiency", which relates to the optimal level of investments, and "static efficiency", which involves the maximization of short-run total surplus. This trade-off has been studied both in theory and empirically, and it is often at the centre of debates on regulatory options in an NGAN context. Keeping in mind this trade-off, in the rest of the chapter some of the main regulatory policies are explored.

3.6.1. A theoretical framework for an optimal policy mix. Within the NGANs debate, several regulatory options have been proposed in order to stimulate broadband provision. In the light of the European context, the following options will be analyzed:

- local loop unbundling (LLU);
- sunset clauses;
- structural/functional separation;
- risk sharing clauses.

However, in approaching these options, one has to bear in mind that they are not mutually excluding. On the contrary, it can easily happen that some of the above policies are part of a single policy mix. Moreover, it has to be stressed that none of the above policy options can lead by itself to a first best outcome. There is indeed a trade-off among investment incentives and the degree of competition in the markets. Therefore, second best solutions should be sought, bearing in mind that "there is no single combination of regulatory settings that is best in all situations and that the various components of a regulatory scheme are interrelated" (Guthrie, 2006, p. 996).

Local Loop Unbundling (LLU). Local Loop Unbundling has been one of the most popular regulatory tools in the last decade. It has been widely adopted within the liberalization process in the European Union and has significantly impacted on the degree of competition in the fixed markets, where a general decrease in retail prices has been observed. Nonetheless, LLU does not seem to give the proper incentives neither to incumbents nor to new entrants to invest in new infrastructures. As a matter of fact, many empirical studies have been carried out on infrastructures development under LLU obligations, but none of them leads to conclusive evidence. Indeed, a vast majority of scholars and practitioners nowadays acknowledge that inter-platform competition is not yet fully asserted in Europe, whereas intra-platform competition seems to be far more widespread among new comers. Among the factors that could have affected incentives to invest in the industry, a study by LECG (2007) points at tight access obligations as a main cause of low levels of investment: according to this study, EU access policies have made new investments unattractive both for incumbents – which have been reluctant to share their networks with alternative operators – and for new entrants – which have preferred to resell rather than fiercely compete through developing alternative platforms. However, it should be mentioned that these conclusions are at odds with several other studies claiming the existence of a "ladder of investments" (see, *ex multis*, London Economics e PWC, 2006). Therefore, a strict LLU regime could cause operators to delay investments and instead prefer cheaper and less volatile alternatives such as reselling. This view has been embraced by the FCC in 2003, when LLU obligations have been totally removed for investments in fibre technologies (FCC, 2003).

Sunset Clauses. Through sunset clauses, regulators impose unbundling obligations for a given time span. The regulator then commits to remove these obligations at a future time, ex ante set. This policy option has been designed with the aim of inducing new entrants not to rely for long on the incumbent's infrastructures, but to develop instead their own infrastructures. From one side it can be argued that this policy gives incentives at least to the incumbent to invest, since at the expiration of the clause it will fully take possession of the infrastructure. However, it could also happen that at the time of expiration of the clause alternative operators haven't carried out their investments yet. If this were the case, the regulator would face a dilemma: it could either 1) abide its commitments and accordingly remove the obligations or 2) keep the obligations in place. In the former case, the effect would be a re-monopolization of the market, while in the latter, the newcomers would take a free ride on incumbent's investments, thus lowering the incentives of the incumbent to invest in the first place.

Structural/Functional Separation. Separation of the access network is one of the most intrusive regulatory remedies. This option has been adopted by Ofcom, spurring an international debate on its effectiveness. The impact of this policy on social welfare is still debated and typically depends on the technological and economic features of the industry. OECD has recently expressed concerns regarding the adoption of this policy, pointing out that "[t]he results of functional separation, particularly on investment, are still far from certain and warrant significant research. Regulators should actively consider other policy options at the same time, which may provide similar outcomes – such as requiring operators to share internal wiring in buildings". (OECD, 2008b, p. 11).

A structural/functional separation regime can indeed give incentives both to incumbents and newcomers to under-invest for two main reasons: first of all, the economic contract which gives rise to the separated entity does not give any incentive to the managers to reach dynamic efficiency; on the contrary, their performance increases proportionally with the degree of network openness[12]. Secondly, since alternative operators under a separation regime can easily access to a

[12]Indeed, if we assume that the mission of the separated entity is to guarantee equal access and that the managers of the separated entity are paid on performance, their wages will be positively related with the number of connected players, whereas the level of investments will not directly affect them.

shared infrastructure, they could find not profitable to give birth to a riskier inter-platform competition.

Hence, even though structural separation is a tool that guarantees a minimum level of competition in the markets, its potential downsides lie in the wrong set of incentives to pursue dynamic efficiency. Therefore within the spectrum of regulatory options, structural separation is one of the options that can better achieve static efficiency, and accordingly, it seems to better fit full-grown industries with constant investment rates, rather than industries in the midst of a technological revolution.

Risk sharing. The amount of investments undertaken by a firm is clearly affected by volatility in returns. Volatility is the expression of both an operative risk and a regulatory risk in the investment project, which tend to interact among them. Within the context of NGANs, a regulator can affect both risks through risk sharing policies. These policies have the great advantage of reducing volatility and accordingly increase the NPV of the investment projects.

In order to better clarify this claim, we can depict investment choices as follows[13]. Let M be an incumbent who decides to invest in period t_0 and assume that after the investment is made a new entrant enters the market and starts competing with M. Two forms of competition are then available to the new comer: 1) reselling (service-based competition) and 2) inter-platform competition, which obtains when the new entrant decides to invest in the development of its own infrastructure. Reselling takes place at time t_s(where $t_s \geq t_0$). Furthermore, service-based competition needs specific investments on the behalf of the new comer equal to I_s and generates cash flows in each period equal to X_S^E.

Inter-platform competition requires an initial investment by the side of the new comer equal to I_I, where $I_I \geq I_S$, and it generates cash flows equal to X_M^I.

Similarly, M will invest an amount equal to I_M in t_0 and will obtain cash flows equal to:

- X_0^M when the competitor is not competing in the market (thus this cash flows are monopolistic rents);
- X_S^M in all the periods in which reselling is in place, and

[13]The following expressions are an adaptation from Guthrie (2006)

- X_I^M in all the periods of infrastructural competition.

Finally, I assume that both investments and cash flows are random variables normally distributed with given means and variances. In the light of the above assumptions, the NPV of the investment project for the incumbent will be:

$$NPV_I = E\left[-\frac{I_M}{(1+r)^{t_0}} + \sum_{t=t_0+1}^{t_S}\frac{X_0^M}{(1+r)^t} + \sum_{t=t_S+1}^{t_I}\frac{X_s^M}{(1+r)^t} + \sum_{t=t_I+1}^{\infty}\frac{X_I^M}{(1+r)^t}\right] \tag{3.6.1}$$

Whereas for a new comer, the NPV will be:

$$NPV_C = E\left[-\frac{I_S}{(1+r)^{t_S}} + \sum_{t=t_S+1}^{t_I}\frac{X_S^E}{(1+r)^t} - \frac{I_I}{(1+r)^{t_I}} + \sum_{t=t_I+1}^{\infty}\frac{X_I^E}{(1+r)^t}\right] \tag{3.6.2}$$

Although not explicitly introduced in the above expressions, regulation directly affects both the cash flows (i.e. the *Xs*) and the investments (i.e. the *Is*). Notably, regulatory opportunism negatively affects the incumbent's NPV, whereas the impact on new comers' NPV will be positive. However, not only the cash flows are affected by regulation. Indeed, regulator's choices can alter both the amount of investments that will be carried out and the timing of the investment choices. In the light of the option theory by Dixit and Pyndick (1994), in each period the incumbent faces the possibility of exercising a real option: indeed he can either invest or delay the decision to the next period. Therefore, in the model above, t_0 is the period in which the incumbent exercises the investment option. Regulation can clearly affect this choice. In particularly, regulatory uncertainty tends to make more profitable for the incumbent to delay the exercise of the option. In the same vein, regulation can give incentives to the new comer to prolong the service-based competition periods and delay the investments needed for infrastructure competition. This happens when the marginal value of the reselling in (2) is greater that the marginal value of the discounted net cash flows gathered in the periods of infrastructure competition. This could be due to the fact that the risk of the reselling is significantly lower than the risk of infrastructure competition. Therefore, in order to increase expected NPVs, risk sharing is needed. Indeed, if risk were allocated only on the incumbent, the new comer could have a free ride on the incumbent investments through a "wait and see" strategy.

Passive Infrastructure sharing. A prompt example of risk sharing involves the sharing of passive (i.e. physical) infrastructures. This is a possibility first advocated within the European context by the French NRA, Arcep. Among the advantages underlying the adoption of this policy one can include the abatement of fixed costs and the decrease in the operational risk, which is proportionately shared among the operators. Among the disadvantages, there is (at least in theory) the risk of setting up a collusive oligopoly among the firms who share the infrastructures. Moreover, potential free riding on network maintenance could also lead to a gradual reduction in the Quality of Service (QoS).

3.6.2. Regulation of Contents. The problem of regulatory opportunism in the markets for digital goods can have an impact not only at the physical layer of the infrastructure, but also at the higher layers of applications and content. Indeed, the adoption of NGANs is expected to lead to a huge increase in content consumption[14]. Truncation of incoming cash flows could take place also in the case of "net neutrality" policies, i.e. in the case in which telecom operators were prevented from gathering revenues from applications and content delivered on their networks. Some recent regulatory policies in the US telecommunications industry can be better understood in the light of this framework: indeed, recent "net neutrality" provisions have been recently enacted in order to balance the effect of the fibre investments regulatory forbearance and therefore to prevent the creation of "walled gardens" on the behalf of bigger players in the market.

Therefore, although aimed at preventing monopolies at the higher layers of the network, net neutrality policies could be redundant if the physical layer is quite competitive. Accordingly, uncertainty over expected returns could be significantly lowered if applications and content policies where specified together with regulatory policies for the physical layer of the NGAN infrastructure.

3.6.3. Platform Substitutability and the Demand for New Services. As previously seen, two main sources of volatility for expected returns in NGAN investments are public intervention and market risk. In other words, apart from regulatory intervention, investment choices are determined by the expected level of demand for new services. This is a problem that affects all kinds of investments in

[14]A strong positive correlation among broadband adoption and content consumption is found in a recent empirical work by Hitt and Tambe (2008).

which irreversibility plays a significant role. Several factors can have an influence on the demand for new communications services. These can be classified as:

- macroeconomic factors such as GDP growth, inflation growth etc.;
- industry specific characteristics;
- market specific characteristics.

Industry and market specific factors relate to technological convergence and technological evolution processes. These two factors increase the risk of customers shifting from one technology to others and accordingly increase demand volatility.

3.6.4. Towards an Optimal Policy Mix. Regulatory policies discussed so far cannot achieve first best solutions. Therefore, in order to identify an optimal NGAN regulatory framework, regulatory goals should be narrowed down. For the rest of the paper, it will be assumed that the main regulatory goal in the NGAN development phase will be to give incentives to current and potential market players in order to reach an optimal level of NGAN investments, under the constraint of a workable competitive market. Indeed, in a phase of substantial technological evolution, regulatory goals differ from the goals of the liberalization phase, when a former public monopoly needed to be opened up to competition. In the current phase new private investments need to be implemented and therefore returns on investments should be granted. However, this does not mean that investments should be only pursued by incumbents. On the contrary, investments should be carried out by as many players as possible, depending on the economic features of the markets. Analyzing the various features of the above regulatory options, it appears that regulatory holidays give best *ex ante* incentives to incumbents in performing the investments. Indeed, through regulatory holidays, a full appropriability of cash flows is granted to the incumbent, but at the same time, similar provisions could lead to a concentrated market structure, with a generalized price increase and a reduction in consumer surplus.

At the opposite end of the spectrum lies structural separation, which guarantees the highest degree of regulatory commitment and can significantly lower the risk of regulatory opportunism. At the same time, structural separation guarantees equality of access to the infrastructure, thus lowering cash flows volatility. Finally, among the advantages of such a provision stands the preservation of a competitive market structure. However, potential disadvantages of structural separation lie in the lack of incentives to invest in new networks and this in turn could lead to a lessening in infrastructural competition and to equilibria of under-investment. This disadvantage could be overcome through a system of incentives that could lead market players to share the risk and consequently to invest more.

3.6.5. A Proposal for an Optimal Policy Mix. In this paragraph an incentive mechanism for risk-sharing is proposed. As we have seen, risk sharing is generally desirable in an NGN environment, since it leads to a general increase in the level of investments. In many circumstances, however, the risk of free-riding could prevent the attainment of this virtuous circle. Therefore, risk-sharing clauses can prove effective only at some stages of development of the infrastructure and only if combined with other policy tools. Accordingly, what I propose in the following is a set of policy tools that can guarantee the achievement of an optimal level of investments through the sharing of both operative and regulatory risk among market players. It is assumed that before fibre investments have been carried out, a structural separation of the access network has been already realized. This ensures "Equality of Access" among players and therefore a minimum competitive threshold in the market[15]. Once the competitive constraint is satisfied, one has to look at the best mechanism for reaching an optimal level of investments. In my opinion, this mechanism consists of an auction among market players for wholesale interconnection. Essentially, the access division could auction physical and logical interconnection rights for different levels of the network and then set the initial price accordingly to the proximity of the interconnection point with the final customer, thus reflecting the costs of deploying the infrastructure up to the interconnection. Therefore, the closer to the customer the interconnection point auctioned by the alternative operator, the higher should be the price, since the investments needed on the behalf of the alternative operator to reach the final customer are lower[16].

[15]Remember that at § 4.4 I imposed a competitive landscape as a constraint on regulatory goals.
[16]On the other side of the coin, the price should be higher because the investments on the behalf of the access division are higher.

The most attractive feature of an auction mechanism like this one relates to the creation of a risk-sharing device: indeed, if a competitor opts for a high level of interconnection, the latter will have to invest significantly to reach the final customer, but the auction price will be lower. From the market players point of view, an auction mechanism like this is equivalent to an auction for options whose exercise price is the price paid by the winner. Therefore, each player, once given the interconnection right, faces the option among investing (not exercising the option) or delaying the investment (thus exercising the option).

Then, once the auction is performed, in order to ensure that the investments are really carried out, the regulator should constrain the access division to employ the auction revenues for realizing the infrastructure up to the interconnection point. In this way, part of the network will be realized in any case, notwithstanding the investment choices of the alternative operators, i.e. even if after winning the auction the alternative operator finds more profitable a delay in the investment.

In sum, the key phases of the mechanism are:

- Structural separation: to ensure a certain degree of competition in the markets;
- Auction for interconnection rights: creation of a risk-sharing device among the incumbent and the alternative player;
- Constraint for the access division to spend the auction revenues for the roll out of the infrastructure up to the interconnection point.

Finally, it is worth remarking that this mechanism, although imposing strong regulatory intervention in setting up the policies, leaves in the end the choice among service based and infrastructure based competition directly to the market[17].

3.7. The empirical evidence on Broadband adoption

3.7.1. The Data-set. Data have been gathered form several sources with the aim of investigating the investment dynamics underlying broadband development with a focus on the European and OECD markets. The panel therefore covers a

[17]However, it should be also pointed out that one of the disadvantages underlying the adoption of this mechanism is the risk of an increase in retail prices.

time span of ten years (1997 – 2007) and 28 countries, mainly belonging to the European Union. To the best of my knowledge, this is the first study on broadband adoption that deals with such a recent data-set on the European markets.

First of all, general economic and geographical data on the European markets have been gathered. Main sources have been the OECD Database, as well as World Bank and Eurostat. Furthermore, Eurostat, OECD and ITU databases have been employed for gathering some industry related variables as well, such as subscribers to telecom services, aggregate investment etc. However, Eurostat and ITU provided a quite unbalanced dataset. The OECD database has been proven useful also for several variables related to the fixed markets. It is a balanced and rich dataset which includes telecommunications regulatory indexes (see Appendix), ranking countries according to 1) the presence of entry barriers in the sector, 2) the percentage of State ownership of telecom firms and 3) the degree of competition in the markets.

3.7.2. Econometric specifications and results. In order to investigate the impact of some relevant economic and regulatory variables on broadband penetration, I proceed by a process of subsequent econometric specifications and regressions, starting with few significant variables, analyzing their behaviour and then accordingly modifying the specification of the model. Therefore, I start with a baseline model, adopting the following specification, in order to focus on the effect of the degree of market openness:

$$\log\left(\frac{BBsubs_{it}}{Pop_{it}}\right) = \alpha + \beta_1 \log\left(\frac{Gdp_{it}}{Pop_{it}}\right) + \beta_2 \log\left(mkt.structure_{it}\right) + \beta_3\left(\frac{Bandwidth_{it}}{Pop_{it}}\right) + \beta_4 \log\left(agric.land_{it}\right) + \eta_i + \varepsilon_{it} \tag{3.7.1}$$

where:

- BBsubs/Pop = number of broadband subscribers on total population;
- Gdp/Pop = Gross Domestic Product per capita (in US $);
- agric.land = percentage of agricultural land in each country observed;
- Bandwidth/Pop = international internet bandwidth per inhabitant (bit/s);
- mkt.structure= market structure in the fixed telecom industry.

TABLE 5. Descriptive statistics with means and standard deviations

Variable	Obs	Mean	Std. Dev.	Min	Max
lbbsubspercap	228	-3.36487	1.936024	-10.4419	-1.02184
lmobsubs	308	3.946678	0.80928	0.598977	5.031212
lbandwidthpercap	235	6.854053	2.430271	0.779295	15.83065
lpercagrland	246	3.684722	0.681303	1.985395	4.286153
lgdpcap	306	9.894446	0.744567	7.947815	11.45877
lmktstr	308	1.221821	0.389246	0	1.879825
lprice3minfix	259	-2.03197	0.519077	-3.4996	0.134919
lentry	302	0.364428	0.651693	0	1.94591

This baseline model is aimed at capturing the effect of competition in the fixed industry. The other variables are needed to control for the size of the market both from a financial (GDP per capita) and geographic point of view (agricultural land) and for the quality of the service provided (bandwidth per capita). The market structure variable is the same transformation of the OECD index on market structure discussed above.

I make use of a fixed effects (FE) estimator. Therefore, the general form of the models I am going to estimate will be:

$$Y_{it} = X'_{it}\beta + P'_{it}\gamma + \eta_i + \varepsilon_{it}$$

where Y is the broadband penetration rate, X_{it} contains variables which control for the size of the market and the quality of the broadband connection, P_{it} contains the set of variables that we are more interested in, such prices and market structure. The η_i are the fixed effects reflecting unobservable country-specific characteristics that may be correlated with (X_{it}, P_{it}). The ε_{it} are the usual zero-mean error terms, assumed to be i.i.d. and with variance σ^2.

Some descriptive statistics are shown in Table 5.

The results of the first specification are shown in the table below.

BBsubs/pop	Coef.	Std. Err.	t
Gdp/pop	2.190583	0.3476891	6.3
mkt.structure	1.544182	0.5751426	2.68
agric.land	-10.2478	2.651565	-3.86
Bandwidth/Pop	0.8199407	0.0701299	11.69
constant	3.644239	10.45827	0.35***
	F(27, 127)= 18.62		Prob>F=0.00
	overall R-squared=0.2782		

*Note: *** not significant.*

We first observe that in both the above regressions, almost all coefficients are significant at 5% (apart from the percentage of agricultural land in RE and the constant in FE). Moreover, we observe that the sign of the coefficients is the same in both estimations. This is fully coherent with the theory. In particular, we observe that broadband adoption is positively related to an increase in (i) the GDP per capita, (ii) the competitive structure of the market, and (iii) the average quality of the service. Moreover, the coefficients for the market structure and the bandwidth per capita are very close in both estimations.

The relationship among the level of per capita GDP and broadband penetration has a plain economic justification: indeed, from a microeconomic perspective, the GDP level can be viewed as a proxy for the income of the representative consumer, and therefore, a positive link between the two variables is due to the fact that an increase in income means an increase in the demand for broadband.

Market structure, instead, is one of the most significant variables of the model. Basically, the positive impact of this variable on broadband penetration suggests that, *ceteris paribus*, broadband adoption is doomed to be higher in those countries with lower concentration ratios in the fixed communication industry. This positive relationship however is valid only for the countries observed and on the time span considered. This is because during the observed years, the telecommunications industry has undergone a deep transformation both in the technologies and in the business models. This technological evolution towards the adoption of broadband technologies was happening during a regulatory phase which has gradually led to the opening of the markets and, as a consequence, it cannot be excluded that this causal relationship is only temporary.

Further specifications of this model are basically extensions of equation (3.7.1). The variables that will be added are aimed at capturing price effects and the impact of the existence of barriers to entry in the fixed market. The latter variable is given by the OECD regulatory index.

In order to measure the impact of the first variable, I look for proxies of an index of the general level of prices at the retail level for a given country in a given year. For this purpose, I make use of the price of a 3 minutes national call during peak hours (measured in US $) as a proxy for the general prices level in the fixed markets. As showed in Figure 3, we should expect a negative impact of the level of prices on broadband adoption, and this is indeed the case for all the specifications provided.

Finally, I add the number of mobile subscribers per capita. This variable is aimed at capturing the relationship with the mobile markets and the sign of its coefficient will give us some information on the complementarity/substitutability among the fixed and mobile technologies. For this specification, I restrict attention to the years 2003-2007.

BBsubs/pop	Coef.	Std. Err.	t
Gdp/pop	3.025188	0.4932386	6.13
mkt.structure	1.314779	0.709687	1.85*
Price 3 min fix	-0.2167309	0.1065206	-2.03
Mob.subs	1.565792	0.5009599	3.13
constant	-42.35065	2.975216	-14.23
	F(24, 86)= 17.69		Prob>F=0.00
	overall R-squared=0.4874		

*Note: * significant at 5%.*

In the above regression, although the coefficient of the market structure becomes less significant, I observe that the level of prices in the fixed markets has a negative impact of broadband adoption. Moreover, we see that broadband adoption tends to increase with the number of mobile subscribers. This indeed could be interpreted as a tendency to consume digital goods on more than one device.

Finally, I add to the last specification the impact of barriers to entry in the fixed markets.

BBsubs/pop	Coef.	Std. Err.	t
Gdp/pop	3.034561	0.493703	6.15*
mkt.structure	1.287965	0.710787	1.81
Price 3 min fix	-0.21764	0.106603	-2.04
Mob.subs	1.624285	0.505218	3.22
Entry	0.275118	0.294317	0.93***
constant	-42.7042	3.001327	-14.23
	F(24,85)=26.97		Prob>F=0.00
	overall R-squared=0.487		

*Note: * significant at 5%; *** not significant.*

Here we first note that the coefficient of this new variable is not statistically significant in the fixed effects regression, whereas it is in the random effects. In the RE estimation, this variable has a positive impact, meaning that lower entry barriers to the markets lead to and increase in the rate of broadband subscription.

3.7.3. Comments. The results of the estimation exercises are consistent both with the theory and with the stylized facts pointed out in the previous section. From a regulatory point of view, the take-home lesson is that a more competitive environment leads to higher adoption rates.

In my opinion, however, this rather intuitive conclusion depicts only a part of the story. Indeed, in network industries what is beneficial in the short-term could lead to undesirable side effects in the long run. To be more precise, I examine how the incentives to invest are affected by the legal and economic conditions of the markets.

3.8. Firm-level analysis of the investment behavior

I now turn to the analysis of the investment decisions at a firm level. The aim of this section is to investigate the dynamics underlying the decision of a telecommunication firm regarding how much to invest in the development of the fixed infrastructure. This choice is clearly affected by several variables, which range from macroeconomic conditions to the level of competition in the markets and the regulatory environment. The topic has been heavily debated across Europe, especially with respect to the impact of regulatory provisions on the incentives to invest. As already mentioned, the debate has been polarized on two opposite views: the ladder of investment theory on one side and the theory which sees provisions such as the unbundling of the local loop as chilling for investment decisions.

If, at least in theory, both views sound plausible, their applicability to European markets is closely related to the incentives and the economic conditions the players face on the markets. Therefore, the aim of this part of the study is to extract some trends and stylized facts that could be useful to shed new light to the debate and to improve the theoretical models on this topic. Hence the aim of the following empirical investigation is to better understand the impact of regulatory provisions, mainly related to the opening of the markets to new competitors and the role played directly in the market by the public sector, on the investment dynamics.

Before proceeding, a caveat is needed. Data on investments are, in general, difficult to retrieve. In the telecommunications sector, the problem is exacerbated, since data on annual reports comprise both the fixed line segment and the mobile[18]. The crucial task faced during the data gathering activity has been the identification of the amount of fixed tangible investments exclusively related to the domestic fixed line segment, thus excluding financial investments and investments related to other business lines (mobile and international activities). This task has involved therefore a careful investigation of the supplementary information included in the documents accompanying the annual reports. However, in few cases it has been impossible to exactly identify the contribution to the fixed line: I decided however to keep these observations rather than dropping them.

3.8.1. The Dataset. The dataset is composed of 37 European firms, analyzed over a time span of five years (2003-2007). The firms are 24 incumbents and 13 leading competitors[19]. The data collected refer mainly to tangible fixed assets and turnover. Tangible fixed assets (TFA), which is an item in the assets side of the balance sheet, includes properties, plants and equipments and all the physical network infrastructure equipment.

In most of the firms observed this item has been taken with respect only to the fixed line segment. However, there are cases in which splitting the two business

[18]The point is highlighted also in OECD (2009), where a significant attempt in the analysis of investment behavior in the European broadband markets is performed. The study however is at a country level and the time span covered is up to 2005.
[19]See the appendix for details.

TABLE 6

	Incumbents+ Competitors	Competitors	Incumbents
2003	-1.42%	2.85%	-3.75%
2004	8.20%	21.84%	1.08%
2005	3.45%	24.82%	-7.23%
2006	-0.92%	9.31%	-6.71%
2007	0.26%	5.18%	-2.65%

segments has not been possible. In those cases, I collected aggregate data including both fixed and mobile segments.

The key variable of the dataset, net investments, has been computed as the difference in TFA from one fiscal year to the next one. In my opinion, this is the closest available proxy for capturing the investment decision by the management of the firm. In few cases, the data on tangible assets were not available and thus I have been referring to the CAPEX as indicated in the cash flow statement.

Moreover, I collected data on fixed line turnover and then constructed the following variable, which can be expressed in percentage terms:

$$\frac{Net\,Investments_t}{Turnover_t} = \frac{TFA_t - TFA_{t-1}}{Turnover_t} * 100$$

The measure obtained can then be used for comparisons across firms of different size.

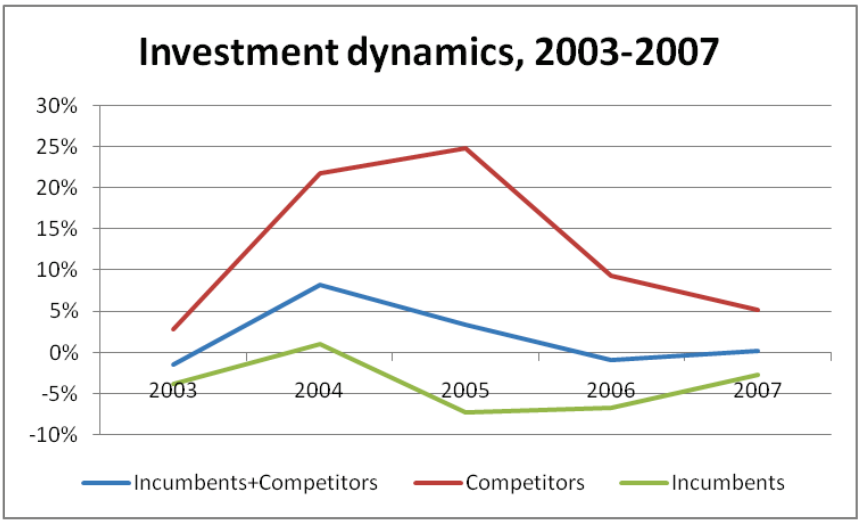
Moreover, I employ some of the variables already used for the econometric part of this paper such as broadband growth, GDP growth and the OECD Regulatory indexes. The value-added of this dataset lies in the fact that it is the first attempt to explore investment behavior at a firm level in the European markets under the new regulatory framework adopted in 2002.

3.8.2. Analysis of the investment dynamics. In the Table 6 the global dynamics of investments during the time span 2003-2007 are reported. The first striking feature is that, apart from 2004, when investments have been growing by 8.2%, the global growth rate is generally flat. However, at a closer look, this performance is the result of the opposite behaviors of the two kinds of market players: the competitors, on one side, which have been growing at a fast pace, and the incumbents, on the other, which instead show, on average, negative rates of growth.

The main reason for the divergent behavior of the incumbents and the competitors may lie in the fact that incumbents have already at their disposal a network and so they just need to perform small investments aimed at fixing and upgrading the network: as a consequence, depreciation and amortization of the assets tend to prevail over new investments.

Competitors instead need to build their own and therefore they need to embark on a relatively higher level of investment. These figures are however ambiguous and cannot be used in support of none of the above theories on investment dynamics. Indeed, if one could argue that the figures on the investments performed by competitors prove the effectiveness of the investment ladder, on the other side, the chilling effect on the incumbents can be also claimed. Therefore, further analysis is required before reaching any conclusion. Moreover, it is important to bear in mind that investments are one of the most volatile macroeconomic variables and therefore it is very difficult to reach any conclusion concerning their long-run trend with a short time series like the one at hand.

FIGURE 3.8.1. Average investments as % of turnover



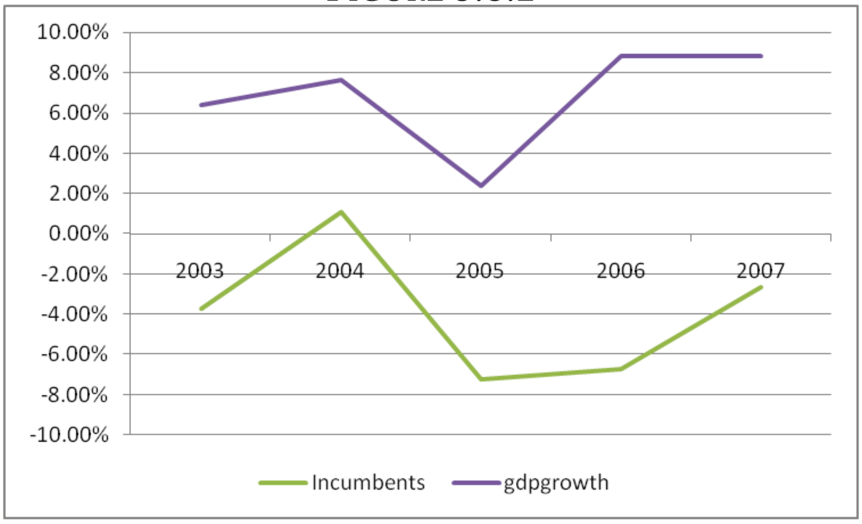
3.8.2.1. *Investments and GDP growth.* Comparing these data with the rate of growth of the economies, another interesting feature can be highlighted. Indeed, in the following figures, we observe a pro-cyclical behavior for the incumbents, while the behavior of the competitors is much less related to the growth of the economy.

This comparison highlights a much more conservative approach towards new investments from the incumbents compared to the competitors.

TABLE 7

	Competitors	Incumbents	Gdp growth
2003	2.85%	-3.75%	6.40%
2004	21.84%	1.08%	7.62%
2005	24.82%	-7.23%	2.38%
2006	9.31%	-6.71%	8.78%
2007	5.18%	-2.65%	8.81%

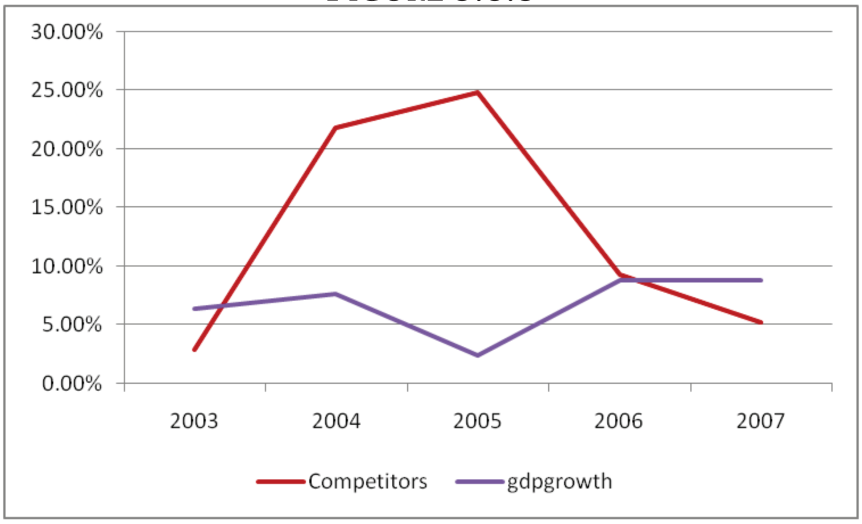
FIGURE 3.8.2



The reason for this lies in the fact that incumbents start from a higher level of assets and therefore they need to invest less to grow. On the contrary, many competitors started with tiny levels of stock and therefore they need to invest more. Note, in passing, that this fact has a very deep impact on the pricing strategies of the two kinds of players: indeed, the need to invest more for the competitors acts as a constraint on their pricing plans.

3.8.2.2. *Investments and Broadband growth.* At a market level, I now investigate the relationship between investments and the rate of growth of broadband subscriptions. At an aggregate level, the correlation coefficient is positive and equal to 12.84%. However, as one could expect, there is a significant difference among the incumbents and the competitors. Indeed, the correlation coefficient for the competitors is much higher (27.62%), whereas for the incumbents is negative (-13,02%). This implies that as the number of broadband subscribers increase, the incentives to invest tend to decrease for the incumbents and decrease for competitors. Indeed, the behavior of these two players when facing a growing market

FIGURE 3.8.3



is deeply different. Incumbents tend to exploit economies of scale, whereas the new comers have more incentives to invest in a growing market.

3.8.2.3. *Investments and Market Structure.* An important factor that drives investment decisions is the degree of competition in the final markets (see, *ex multis*, Athey and Schmutzler, 2001). In my dataset, the relationship among the degree of competition in the final markets and the level of investments is negative, both at an aggregate level (-16.63%) and in the two subgroups of incumbents (-12.42%) and competitors (-23.53%). The fundamental reason behind this evidence lies in the fact that more competitive markets lead to a decrease in the extra-rents for the players, thus making it less appealing for new players. Moreover, in cases in which the competition is fierce, few resources can be devoted to investments. Therefore, firms face the classical trade-off among short term and long-run gains.

3.8.2.4. *Investments and Public Ownership.* The European debate on NGANs is also a debate on the role of governments in the development of the networks. If indeed under many respects the development of NGANs is in the public interest (think for example about the digital inclusion problem), the impact of a direct intervention in the markets is still highly debatable, because of the side effects and the deadweight losses involved. Therefore, I take now the OECD public ownership index and make a correlation with the level of investments in the market. The correlation is negative and equal to -26.22%. Interestingly enough, the correlation is very low and close to zero for the incumbents (-6.85%), whereas is much higher for the leading competitors (-46.36%). These figures are significant under many respects. First of all, the behavior of the incumbents is almost unaffected by

FIGURE 3.8.4

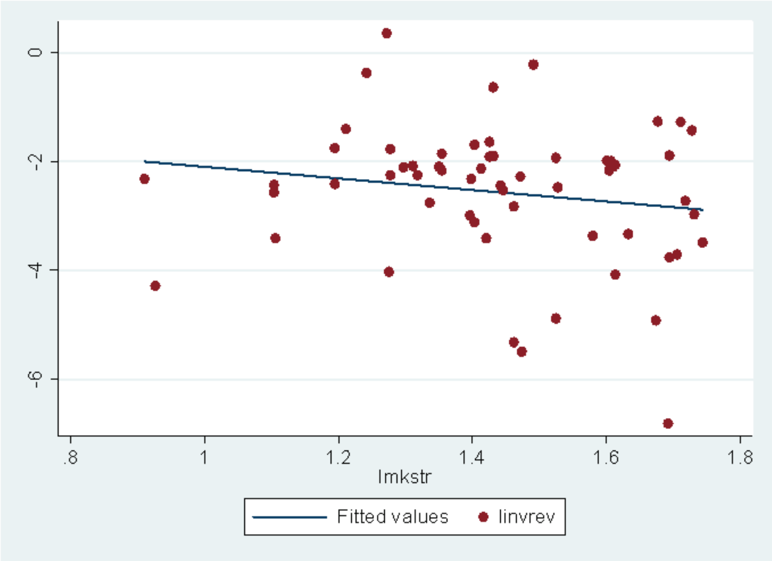
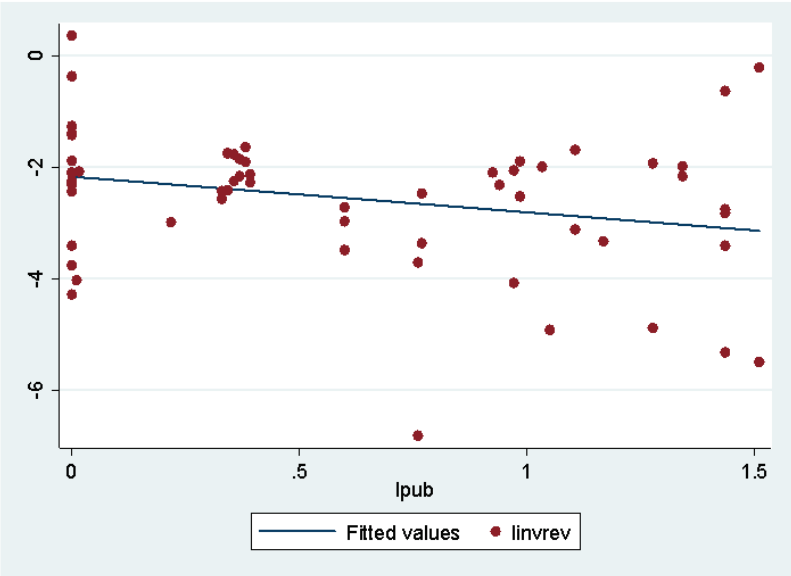


FIGURE 3.8.5



public ownership. These results are quite at the odds with the standard economic theory of incentives under imperfect information. The data on the competitors instead has not a clear cut interpretation and can be read in both ways: it could indeed suggest that the presence of the government in the market tends to create a unfavorable climate for the newcomers, or alternatively that the presence in the market of solid competitors makes it unnecessary for the government to directly intervene, so that we can observe a reduction in the scope of intervention for the government.

TABLE 8

	Investments/ Turnover	Market Structure	Public Ownership	Fixed line staff	Broadband growth
Investments/ Turnover	100.0%				
Market Structure	-16.6%	100.0%			
Public Ownership	-26.2%	17.4%	100.0%		
Fixed line staff	-21.03%	8.6%	19.1%	100.0%	
Broadband growth	12.84%	-29.4%	4.9%	25.7%	100.0%

3.8.2.5. *Other factors affecting the Investment Behavior.* The variables analyzed so far, however, are not the only ones that affect investment decisions. Indeed, many other factors play a role in shaping the investment strategy. First of all, the level of debt of the firm and the cost of debt is undoubtedly a constraint on the investment strategies at a firm level. Indeed, as pointed out by Spiegel and Spulber (1994), a high level of debt could be desirable for a regulated firm since it could act as a shield against excessive regulatory intervention. However, the other side of the coin is that a high debt to equity ratio puts a constraint on the strategic decisions of the firm itself. Moreover, input costs can be a burden that reduces the possibilities to invest. Indeed, if we analyze the relationship between investments and the number of employees in the fixed market, we observe a negative correlation, equal to -21.03%. As one could expect, for the group of the incumbents this index is even higher (-34.44%), whereas is smaller for the competitors (-10.83).

3.9. Conclusions

The empirical investigation pursued in this paper basically confirms the existence of a trade-off among the goal of competitive markets in the short-run and the need to ensure the long-run growth of the sector. Indeed, a service-based oriented form of regulatory intervention (like the one currently in place in the European Union) can well serve its liberalization goal. However, the main side effect lies in the reduction in the incentives to invest. Moreover, this chilling effect is stronger for the newcomers, mostly because of the possibility to rely on the investments made by the owner of the network.

On the other side, when the regulatory intervention, as it is currently happening with respect to the regulatory approach to the NGNs, tends to focus more on the goal of spurring new investments, a negative impact on the rates of adoption by the final users should be expected.

Moreover, governmental intervention that takes the form of ownership of shares of the incumbent firms, tends to chill significantly the incentives of the competitors to invest.

These results are relevant for the next generation networks environment, where the adoption of ad hoc regulatory provisions is currently debated. Indeed, in order to reach at the same time an adequate level of investments without slowing down the pace of broadband penetration, mild forms of regulation should be looked for, keeping however in mind that the best regulatory solutions (i.e. those that guarantee a “workable” competition) can differ according to the economic and legal characteristics of each market.

Appendix

The OECD Regulatory Reform Index.

	Question weights	Coding of data		
Entry regulations				
		Free entry	Franchised to two or more operators	Franchised to 1 firm
What are the legal conditions of entry into the trunk telephony market?	$\frac{1}{4} w^t (1 - w^m)$	0	3	6
What are the legal conditions of entry into the international market?	$\frac{1}{4} (1 - w^t)(1 - w^m)$	0	3	6
What are the legal conditions of entry into the mobile market?	$\frac{1}{2} w^m$	0	3	6
Public Ownership				
What percentage of shares in the PTO are owned by the government?	$1 - w^m$	% government ownership / 100 * 6		
What percentage of shares in the largest firm in the mobile telecoms sector are owned by the government?	W*	% government ownership / 100 * 6		
Market Structure				
What is the market share of new entrants in the trunk telephony market?	$\frac{1}{4} w^t (1 - w^m)$	6 – normalised market share		
What is the market share of new entrants in the international telephony market?	$\frac{1}{4} (1 - w^t)(1 - w^m)$	6 – normalised market share		
What is the market share of new entrants in the mobile market?	$\frac{1}{2} w^m$	6 – normalised market share		

List of Companies.

Country	Company	
Austria	Telekom Austria[2]	Incumbent
	Tele2UTA	Competitor
Belgium	Belgacom[1]	Incumbent
	Telenet	Competitor
Bulgaria	BTK	Incumbent
Czech Republic	Telefonica 02	Incumbent
Denmark	TDC	Incumbent
Estonia	Elion	Incumbent
	Starman	Competitor
Finland	Teliasonera[1]	Incumbent
	Elisa[1]	Competitor
France	FT[1]	Incumbent
	Neuf	Competitor
Germany	DT	Incumbent
	Arcor	Competitor
Greece	OTE	Incumbent
	Tellas	Competitor
Hungary	Magyar Telekom[1]	Incumbent
Ireland	Eircom	Incumbent
	BT Ireland	Competitor
Italy	TI[1]	Incumbent
	Wind[1]	Competitor
Latvia	Lattelecom	Incumbent
Lithuania	TeoLT	Incumbent
Malta	GO	Incumbent
Netherlands	KPN[2]	Incumbent
Poland	Telekomunikacja Polska	Incumbent
Portugal	PT[2]	Incumbent
	Sonaecom	Competitor
Romania	ROMTELECOM	Incumbent
	RCS & RDS	Competitor
Slovak Republic	Slovak Telecom	Incumbent
Slovenia	Telekom Slovenije	Incumbent
Spain	Telefonica	Incumbent
	ONO	Competitor
United Kingdom	BT[1]	Incumbent
	Virgin media	Competitor

Notes: 1) Data fixed-mobile, 2) Data on capital expenditures from cash flow statements.

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