Essays on Trade, Innovation and Finance

University L.Bocconi

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Francesco Bripi

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Contents

Preface

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To my parents,
Antonino and Rosa.

Francesco Bripi

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Introduction

In the last decade there has been a lot of discussion about the reasons of low growth of many European countries with respect to other countries like US and the rising stars of India and China. While the waking up of the Asean giants may be mainly (but not only) attributed to low cost of labour, the growth differential with respect to the US has never reverted against this country (with respect to Europe) since the beginning of the '90s. These considerations have inspired me in studying this problem more deeply under some particular perspectives. While it is widely held that Europe is missing some main institutional factors that have instead allowed the US to be a champion in the last 15 years, I have focused only on few factors, without any pretension to be exhaustive. In particular, I have addressed the research in three directions. First, under an international perspective, the issue of protectionism has been addressed with the idea of letting tradable and nontradables sectors interplay. The main finding is that in the tradable sector protectionism is lower as nontradables productivity increases, because of input mobility across the two sectors.

In the second part of this work I deal with the issues relative to finance, legal system and innovation. First, in the second chapter, the state of technology is considered in terms of distance to the technology frontier. It is shown that for a short distance to the frontier, there is adverse selection in the financing of innovation. Then, some forms of financial development are considered in order to mitigate this adverse result; namely, monitoring by the investor and investment in education by the entrepreneur. This allows to show that financial development is most necessary to productivity growth at late stages of development.

Finally, in the last chapter, I consider what are the main determinants of long run trend of legal investor protection. I use a double sided moral hazard model, in which the entrepreneur and the investor interact according to a level of investor protection which is derived through the imposition of technology constraints. This constraint is in the form of a minimum capital requirement. In this way, the state of technology helps to explain the dispersion of the creditor protection index across countries, even when these belong to the same legal family of origin. Moreover, as the contract is expanded to include equity shares, then also in this case the legal investor protection level is derived through the technology constraints.

Part I

Essays on Trade

Chapter 1

Trade Agreements with Political pressures and labour mobility between the tradables and nontradables sectors

1.1 Introduction

In this paper we provide an explanation of the observed gradual reduction of barriers to trade around the world. The history of trade liberalization of the last fifty years is strongly related with the creation and expansion of the GATT (now WTO), and most of the literature has mainly been focused on explaining why countries sign free trade agreements.[1] Nevertheless, recent empirical studies (see for example Rose (2004) but see also next footnote), using different measures have found that barriers to trade fall gradually over time. At a theoretical level, some recent studies have explained why these barriers emerge in equilibrium as the outcome of non coordination among lobbying groups (Grossman and Helpman, 2005) or as the outcome of a government motivated by problems of commitment and by terms of trade externalities (Maggi Rodriguez-Clare, 2005). While these works have focused mainly on the motivation for protection versus free trade, some more recent contributions explain the persistence and the slow and gradual reduction over time of barriers to trade especially in the most developed countries.[2]

In this paper we argue that governments reduce barriers to trade gradually due to labour mobility between the tradable and the nontradable sector. Labour mobility across the two broad sectors arbitrages away any wage difference that may arise due to technology and sector specific characteristics. The quantity of labour allocated in the tradable sector determines not only output in this sector but also the strength of lobbying activity. In turn, the stronger is lobbying (i.e: the bigger is the amount of contributions collected by the Government) the higher is the level of protection. If labour productivity increases also in the nontradable sector, then labour moves away from the tradable sector. This effect tends to weaken lobbying and so protection. Therefore, the model predicts that countries with a higher level of productivity in the nontradable sector have lower trade protection. Moreover, since labour mobility is only in the long

[1] An early and standard theory has argued that countries sign trade agreements in order to gain from *trade externalities* (Johnson, 1954, Mayer, 1981). According to this theory, terms of trade externalities are the only reason for trade agreements even in presence of domestic agents lobbying against these agreements (Grossman, Helpman, 1995). Other theories have stressed the positive role of the *multilateral approach* that helps governments in their efforts to sign FTAs against internal lobbying forces (Bagwell and Staiger, 1999), and in particular multilateral institutions may provide better communication devices among members in order to avoid problems of enforcement (Maggi, 1999). Finally, another strand of literature has argued that trade agreements allow governments to deal with lack of *commitment* that arise because of economic (Staiger, Tabellini, 1987) or political considerations (Maggi and Rodriguez-Clare, 1998).

[2] We refer in particular to Staiger (1995), Furusawa and Lai (1999), Bond and Park (2004), Conconi and Perroni (2005) and Lockwood and Zissimos (2004).

run, we capture the variation of barriers to trade over a long time horizon.[3]

To better understand the mechanism, consider an increase of nontradables productivity; then, since this sector can offer higher wages, there is an inflow of workers into this sector. Since in equilibrium a lower amount of labour is available in the tradable sector, lobbying for protection is weaker, and then tariffs are lower.[4]

The main results of the model are:

1. *Barriers to trade fall more steadily in the developed countries where nontradables productivity is higher.*

2. *The degree of trade liberalization across sectors depends positively on the degree of intersectoral labour mobility.*

3. *The effect of nontradables productivity over the long run tariff is confirmed when the model is simulated adopting realistic parameter values.*

Indeed, the first two results are derived analytically by imposing a simplifying assumption of workers preferences. When, in the last part of the paper, we relax this assumption, we can solve the model only through simulation, which confirms the main insights of the model.

1.1.1 Related Literature

The paper is related to three strands of the literature. The first is the trade policy literature on the determination of barriers to trade. This literature is very large and we do not aim to give a comprehensive review here,[5] except that the model adopts the "protection for sale" framework (Grossman and Helpman, 1994), which has become a standard in the literature on trade policy.

Moreover, this paper assumes long run labour mobility, and to our knowledge there are no works that include labour mobility between tradables and nontradables. However, an important reference is Maggi and Rodriguez-Clare (1998a; MR henceforth), who provide a different explanation from ours. In fact, MR assume capital mobility (in the

[3] Trefler and Nunn (2006) develop a model where an endogenous lobbying where there are technolgy externalities in the long run. The government is aware that when the economy opens to trade, it acquires and improves the its technolgy level; threfore, anticipating this, the gocernment lowers tariffs in the long run. In their case, acquisition of foreign technology improves also nontradables productivity.

[4] We believe that this model can be adapted to developed countries, where technology differences in the tradables sectors are quite small, but in the nontradables sectors these differences are persisting.

[5] See footnote 1.

long run) between a numeraire and a manufacturing sector. In their model, due to capital mobility capitalists overinvest into the manufacturing sector if this is expected to be protected. Since this overinvestment creates excessive long run distortions, the government cannot trade them off with the short run gains of collected contributions. Then, the outcome of their reasoning is that governments sign free trade agreements. In common with MR we share the assumption of long run input mobility across sectors. Differently from MR, we argue that even if there is input mobility, the long run tariff is positive, and it depends on the final allocation of productivity differentials across tradables and nontradables. Then, taking into account the nontradables helps to explain why countries cannot credibly commit to free trade agreements. Moreover, as mentioned at the beginning of this section, some works have tried to explain the persistence of tariffs. In particular, in Maggi and Rodriguez-Clare (2005), the tariff formation is due not only to government's problems of commitment but also to terms of trade motivations. In MR 2005 the optimal agreement includes a gradual reduction of tariffs. We differentiate from this paper not only because our input mobility assumption is on labour, but also because the long run tariff formation does not depend only on the interaction between the government and the lobby, but it is mainly driven by technology of the two sectors.

The second strand of the literature regards the assumption on the labour market. Our main assumption is that workers move without cost to the sector offering higher wages (competitive assumption). This assumption implies that in the reallocation of resources between the initial and the final equilibrium, not only the sectoral level of employment changes, but also the wage rate varies accordingly. With this regard, the literature on wage dispersion offers mixed results. On the one hand, according to competitive models (Dickens and Katz, 1986) wage differentials stem from a competitive equilibrium reflecting differences in productivity between workers and/or the specific costs borne by employees as regards specific types of jobs. On the other hand, another strand of the literature has focused on cross industry wage persisting differences (Krueger and Summers, 1987; Helwege, 1992; Askenazy, 2005). These differences have been explained by efficiency wage considerations (Krueger and Summers, 1988), or on the basis of bargaining power of the employees (Layard and Nickell, 1999). In this regard, our "competitive" assumption is supported by two observations. First, with this assumption we aim to capture only long run trends of the labour market. Second, while much of the wage persistence can be explained in terms of unobserved workers capacities (e.g.: skilled and unskilled workers), the paper can be easily changed to reflect other distortions from the competitive assumption.

Finally, while in our work labour intersectoral mobility affects the long run tariff, much of the literature has focused on measuring the reverse causation effects: that is, the effects of trade liberalization on labour mobility and changes of the wage rate. The results of this literature are quite mixed. For example, in an early work Grossman (1987) found that job (or earning) losses in nine unskilled labor intensive US manufacturing sectors due to import competition were very small, even if with some exceptions. Instead, Freeman and Katz (1991), Gaston and Trefler (1997) and Revenga (1992) conclude that trade affects the labor market. On the other hand, we are not aware of any literature that has measured directly the causation effect in the direction pointed by our paper. However, some recent contributions have found only indirect evidence of how intersectoral labour mobility affects trade openness, through surveys on people's preferences over trade policy: Mayda and Rodrick (2005) and Scheve and Slaughter (1998). Both these surveys find evidence in favour of the factor-endowments model, which assumes perfect intersectoral mobility of productive factors, and where trade benefits individuals who own the factors with which the economy is relatively well endowed, and hurts the others (Stolper-Samuelson theorem). These results can be interpreted in terms of labour mobility across sectors.

The paper is structured as follows. In section 2 we outline the main model, where short run tariff formation is derived. Section 3 contains the long run equilibrium solution. In section 4, we study the value of commitment to free trade agreements and in section 5 the model is simulated under a more general setting where some of the simplifying assumption of the main model are relaxed. Finally, section 7 concludes.

1.2 The Model

Consider a small open economy where two goods are consumed: a numeraire nontradable good (henceforth good N), a single tradable good (henceforth T).

1.2.1 Preferences

Preferences are described by a quasi-linear utility function, as follows:

$$U = Q_N + u_T(Q_T) \text{ with } u_T' > 0,\ u_T'' < 0$$

where Q_T is the aggregate quantity of the T good (Q_T); Q_N is the numeraire good and also the aggregate quantity of the nontradable good. The traded good has the following utility function: $u_T(Q_T) = DQ_T - \frac{Q_T^2}{2}$ (where D is a positive constant). Under this type of preferences, we have the following demand function: $d(p_T) = D - p_T$ for the T good and $Q_N = Y - p_T Q_T$ for the N good (where Y is total income of the economy). Prices p_T are expressed in relative terms with respect to the numeraire price: $p_N = 1$.

Maximization of U subject to the budget constraint gives the following indirect utility:

$$V(p_T) = Y + S(p_T) \tag{1.1}$$

where $S(p_T) = u(d(p_T)) - p_T d(p_T) = \frac{(D-p_T)^2}{2}$.

1.2.2 Production

The N and the T goods use only one input: labour. The total labour endowment is given by L, and it is fixed. Total labour allocated to the T sector is l, while in the N sector it is $L-l$. The N good is produced competitively with the following production function:

$$Q_N = F(L-l)$$

where $F(L-l)$ has a quasi linear form: $F(L-l) = b(L-l) - \frac{(L-l)^2}{2}$, and b is an index of productivity in the N sector. Because of perfect competition in N, wage in this sector is given by

$$W_N = b - (L-l) \tag{1.2}$$

The T good is also produced competitively, such that under free trade the world price p_T^{ω} is efficient. In this sense, any price different from the world price is only due to lobbying. In this sector there are I firms (to be determined in equilibrium in the long run), and for each firm i $(i = 1, 2, ...I)$ the production function is given by

$$q_{T,i} = \varphi_i l_i = \varphi_i \bar{l}$$

where l_i is the amount of labour per firm; the second equality follows from imposing input symmetry, that is every firm employs the same amount of labour: $l_i = \bar{l}$ $\forall i$. In this sense $\bar{l}$ is a measure of firm size. Moreover, φ_i is the firm specific productivity parameter.

Aggregating over all I firms (I is the total number of firms in the T sector), total output in the T sector is given by $Q_T = \sum_{i=1}^{I} \varphi_i l_i \ \forall i$. Since we let firms be homogeneous with respect to productivity, each firm has the same average productivity given by $\bar{\varphi}$. Therefore total output in T can also be rewritten as $Q_T = I\bar{\varphi}\bar{l} = \bar{\varphi}l$.[6]

1.2.3 The model under Free Trade

Before proceeding with the description of the model with lobbying, in this section we solve the model under free trade (that is in absence of lobbying in the T sector). Note that we assumed above a linear production function of sector T, and given that the competitive price is exogenously given by p_T^{ω} (normalized to 1), we have that the wage in T is given by

$$W_T = \bar{\varphi} \tag{1.3}$$

As expected, wages in T increase with productivity ($\bar{\varphi}$). In the short run the allocation of labour between T and N is completely random. Long run labour mobility implies wage equalization across sectors, since workers move to the sector offering the highest wage. But note that both W_T and W_N depend on different exogenous variables $(\bar{\varphi}, b)$ and employment, and from (1.2) and (1.3) we have

$$l_{FT} = \bar{\varphi} - b + L \tag{1.4}$$

which is the long run level of employment under free trade.[7]

1.2.4 Lobbying

In the N sector, we assume there is no lobbying activity, while this takes place in the T sector, where firms are able to solve the free-rider problem[8] and can organize as a lobby.

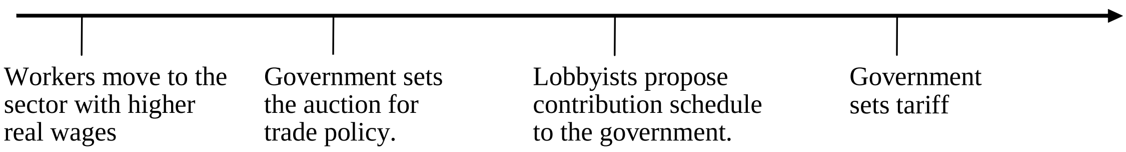
[6]Note that $Q_T = \sum_{i=1}^{I} \bar{\varphi} l_i = \bar{l} I \bar{\varphi}$, where we impose simmetry cost assumption: $l_i = \bar{l}$. Moreover, aggregate labour in the T sector is $l = \sum_{i=1}^{I} l_i = I\bar{l}$.

[7]For the non-negativity of l_{FT} we need that $b < \bar{\varphi} + L$. However, since productivity in nontradables is usually lower than in tradables, and since $L > 0$, it is sufficient to have $b < \bar{\varphi}$.

[8]The way the free riding problem is solved is discussed below.

We design the lobbying game as a collective menu auction, as described by Bernheim and Whinston (1986, BH henceforth) and adopted by GH (1994), with several principals and one agent. Every lobbying firm is a principal and the government is the agent. Lobbying takes place in four stages, as shown in the following figure:

Figure 1



At the beginning, there are workers who are allocated between the two sectors. Since they anticipate the tariff at the last stage, they will accordingly move to the sector that offers highest wages. At the second stage the government sets the auction for trade policy. At the third stage the lobby presents the government a contribution schedule such that every price corresponds to a different contribution level. When proposing this schedule to the government, the lobby knows government preferences. In the fourth stage, the government takes the contribution levels designed by the lobby as given, and it sets policy such that its utility function is maximized.

The model develops in the short run from the second to the fourth stage, while the allocation of workers between the two sectors happens in the long run. Workers care of the tariff set by the government because this affects their wage (as it is shown below). Indeed, since all variables are fully observable by all agents, workers can anticipate the tariff and their wage, so by backward induction at the beginning of the time line, they will not be allocated randomly across sectors, but they will move ex ante to the sector offering higher wage; this implies wage equalization in the long run.

Since this is a sequential game, it can be solved backward. We analyze the government preferences first and then we will consider how the lobby designs the contribution schedule.

Government preferences are given by a weighted average between consumers welfare and contributions it receives from the lobbies:

$$\Omega(p_T, l) = aV\left(p_T, l\right) + I\bar{c}\,\bar{l} \tag{1.5}$$

where $\bar{c}$ is the amount of contribution per firm expressed in terms of contributions per unit of firm labour $\bar{l}$, so that total amount of contributions collected by the government is and $C = I\bar{c}\,\bar{l}$. p_T is the tradables price vector.

We assume that the contribution schedule is differentiable with respect to prices: $\bar{c}(p_T)$. a is the weight of welfare relative to contributions. In accordance to these types of models,[9] we impose no restriction on the size of the parameter: $a > 0$. When using this function we also assume, following GH (1994), that the politician cares in part of the social welfare and in another part of contributions, where the relative weight of importance is given by the parameter a. The incumbent politician can use contributions for any purpose, like campaign financing for re-election, private use or other. Moreover, aggregate welfare is given by $V(p_T, l)$ and it is defined as total income received plus consumers' surplus:

$$V(p_T, l) = b(L-l) - \tfrac{(L-l)^2}{2} + p_T I\bar{\varphi}\,\bar{l} + r(p_T, l) + S(p_T)$$

where the first two components are the aggregate income from the N sector. The third component is aggregate income of the T sector gross of contributions (as it is explained below) and $r(p_T, l)$ is the amount of tariff revenues that the government collects from foreign firms[10] and it is completely rebated to citizens. In formulas, $r(p_T, l) = \tau m = \tau\,[d(p_T) - Q_T]$, so that $m(= d(p_T) - Q_T)$ represents imports[11] and τ represents the applied tariff: $\tau = p_T - 1$. $S(p_T)$ represents the surplus in the T sector as defined above.

In the T sector, since the only input is labour, then all the income generated by the economic "equilibrium" (i.e.: free trade) and all of the extra-rents generated by protection in the political game increase the return to labour. Letting $W_i(p_T, l)$ be firm i gross of contributions welfare, we have:

$$W_i\left(p_T, \bar{l}\right) = W_T\bar{l} + \alpha_i\left[r(p_T, l) + S(p_T)\right] = p_T\bar{\varphi}\,\bar{l} + \alpha_i\left[r(p_T, l) + S(p_T)\right] \qquad (1.6)$$

[9] We refer to the "Protection for Sale" models whose set up derives from Grossman and Helpman (1994). Grossman and Helpman (1995b) have shown that this reduced form is the outcome of a more microfounded structure where the incumbent politician is mainly concerned for re-election.

[10] We are implicitly assuming that the government's policy options are limited to trade taxes and subsidies.

[11] Protection may occur in the form of import tariff or export subsidy. We will refer to tariffs over imports for simplicity. For a similar approach, see Grossman and Helpman (2005b), Krishna (1998) and Ornelas (2004).

where α_i is firm i workers share over population; since we set $l_i = \bar{l}$, we have that $\alpha_i = \alpha$ for any i.[12] From this consideration we can write $\alpha = \frac{\bar{l}}{L}$, that is also a measure of the relative firm size (in the tradable sector) relative to the total working population.

Considering a contributing firm i, its net payoff is then

$$NW_i\left(p_T, \bar{l}\right) = W_T \bar{l} - \bar{c}\,\bar{l}$$

or also

$$NW_i\left(p_T, \bar{l}\right) = p_T \varphi_i \bar{l} + \alpha_i \left[r(p_T, l) + S(p_T)\right] - \bar{c}\,\bar{l}$$

where in the second equality we have used the result that $c_i = \bar{c}$ for every firm i in T, due to the assumption of firms homogeneity.

We will proceed backward by first analyzing the short run equilibrium where firms and the government bargain over the trade policy, and then we will move to determine the long run equilibrium tariff.

1.2.5 Short Run Equilibrium Prices

A short run equilibrium is characterized by a pair $\left\{\bar{c}^*, p_T^*\right\}$ such that the following properties are satisfied.

1. $\bar{c}^*$ is feasible for any $i \in I$;
2. $p_T^* \in \arg\max\, \Omega(p_T, l)$
3. $p_T^* \in \arg\max\, NW_i\left(p_T, \bar{l}\right)$
4. $\sum_{i=1}^{I} c_i^*\left(p_T^*, l\right) \bar{l} = a\left[V\left(1, l\right) - V\left(p_T^*, l\right)\right]$

Condition 2 states that the equilibrium price must be in the set of prices that maximize the government utility function. Condition 3 derives directly from imposing that the equilibrium price p_T^* belongs to the set of prices maximizing firms net pay-off: $p_T^* \in \arg\max\, NW_i\left(p_T\right) \Longrightarrow p_T^* \in \arg\max\, W_T \bar{l} - \bar{c}\,\bar{l}$. It can be shown that from conditions 2 and condition 3 the short run equilibrium price is given by the following:

$$p_T^* \in \arg\max\, J\left(p_T, l\right)$$

where $J(p_T, l)$ is given by summing the welfare of the lobby and the utility of the government (Ω):

[12] Note that W_T is the individual wage of every worker employed in T, while W_i is the payoff of firm i, that is the sum of all individual wages over all workers employed in firm i: $W_i = W_T \bar{l}$.

$$J(p_T,l) = \Omega(p_T,l) + \sum_{i=1}^{I} NW_i(p_T,l)$$

Since in this expression contributions cancel out (indeed, they are a relocation of resources between the lobby and the government), it can be rewritten as:[13]

$$J(p_T,l) = aV(p_T,l) + \sum_{i=1}^{I} W_i\left(p_T,\bar{l}\right) \tag{1.7}$$

where the summation of the second component is over the set of lobbying firms I (since firms are all of the same size, all firms participate to the lobby).[14]

Conditions 4 states that each contribution level is just sufficient to leave the government indifferent between adopting protection or not (we assume in this case that the government gives protection):[15] this corresponds to assuming that firms have all the bargaining power with respect to the government. The expression in condition 4 can be derived considering that $\Delta\Omega = \Omega(p_T^*,l) - \Omega(p_T^\omega,l) = 0$. Substituting the values for the utility function in both cases, we have: $\Omega(p_T^*,l) = aV(p_T^*,l) + \sum_{i=1}^{I} c_i\bar{l}$ and $\Omega(1,l) = V(1,l)$. So, we have that:

$$aV(1,l) + \textstyle\sum_{i=1}^{I_0} c_i^*(1,l)\,\bar{l} - aV(1,l) = 0$$

and so finally:

$$\textstyle\sum_{i=1}^{I} c_i^*(p_T^*,l)\,\bar{l} = a\left[V(1,l) - V(p_T^*,l)\right]$$

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[13]Indeed: $J(p_T,l) = \Omega(p_T,l) + \sum_{i=1}^{I} NW_i\left(p_T,\bar{l}\right) \Longrightarrow$

$J(p_T,l) = aV(p_T,l) + I\bar{c}\,\bar{l} + \sum_{i=1}^{I}\left(p_T\bar{\varphi}\bar{l} - \bar{c}\,\bar{l}\right) \Longrightarrow J(p_T,l) = aV(p_T,l) + I\bar{c}\,\bar{l} + \sum_{i=1}^{I} p_T\bar{\varphi}\bar{l} - I\bar{c}\,\bar{l}.$

from which we finally have $J(p_T,l) = aV(p_T,l) + \sum_{i=1}^{I} W_i\left(p_T,\bar{l}\right)$.

Moreover, note that lobby's income is weighted $(1+a)$, while income's weight of the N sector is only a, as explained by the expansion of the expression above:

$J(p_T,l) = a\left[b(L-l) - \frac{(L-l)^2}{2} + p_T\bar{\varphi}l + r(p_T,l) + S(p_T)\right] + \sum_{i=1}^{I} W_i$

$J(p_T,l) = aB_N + a\sum_{i=1}^{I} W_i\left(p_T,\bar{l}\right) + \sum_{i=1}^{I} W_i\left(p_T,\bar{l}\right) = aB_N + (1+a)\sum_{i=1}^{I} W_i\left(p_T,\bar{l}\right)$

where B_N is the welfare of the N sector. As expected, the lobbying sector receives a higher weight in the joint utility function.

[14]The conditions of existence of a lobby are discussed in sections 4 and 5.

[15]Under this assumption, the government is indifferent between receiving addtional contributions and not receiving them. In fact, if it receives contributions and applies a higher tariff, it incurs a welfare loss, while if it does not receive contributions it maximizes social welfare.

We can find a value for $\bar{c}^*$ by solving we this expression. Moreover, following GH (1994), we restrict our attention to Truthful Nash Equilibria (TNE,see BW(1986) for more details). TNE are Nash equilibria supported by truthful contribution schedules. In order to explain truthfulness of the contribution schedule, rewrite joint welfare

$$J = \Omega(p_T, l) + \sum_{i=1}^{I} NW_i \left(p_T, \bar{l}\right) = aV\left(p_T, l\right) + \bar{c}l + \sum_{i=1}^{I} W_i \left(p_T, \bar{l}\right) - \bar{c}l$$

and differentiate this with respect to prices:

$$a\frac{\partial V(p_T,l)}{\partial p_T} + \frac{\partial C(p_T)}{\partial p_T} + \sum_{i=1}^{I} \frac{\partial W_i\left(p_T,\bar{l}\right)}{\partial p_T} - \frac{\partial C(p_T)}{\partial p_T} = 0$$

Since from condition 2 above, we have that the first order condition is

$$a\frac{\partial V\left(p_T,\bar{l}\right)}{\partial p_T} + \frac{\partial C(p_T)}{\partial p_T} = 0$$

Plugging this result into the previous expression we have:

$$\sum_{i=1}^{I} \frac{\partial W_i\left(p_T,\bar{l}\right)}{\partial p_T} = \frac{\partial C(p_T)}{\partial p_T} \tag{1.8}$$

A contribution scheme satisfying (1.8) is known as locally truthful, because the marginal change in contribution is equal to the marginal benefit deriving from the change of policy around the equilibrium point. These schedules can also be represented by a contribution function that is truthful *for every price*, and it corresponds to the difference between the lobby gross welfare and a base level of welfare B:

$$c^*\left(p_T^*, l\right) = \max\left[0, W\left(p_T, l\right) - B\right] \Longrightarrow \max\left[W\left(p_T, l\right) - B\right] \tag{1.9}$$

where $W(p_T, l)$ is the lobby gross of contributions welfare: $W\left(p_T, l\right) = \sum_{i=1}^{I} W_i\left(p_T, \bar{l}\right)$ and the second expression follows considering that as in GH (94) we focus on equilibria where lobbies make positive contributions. According to (1.9), the contribution schedule is characterized by different contribution levels at all tariff values (recall that we assume continuity), and it reflects the willingness of the lobby to pay to the government for the excess of lobby's gross welfare ($W(p_T, l)$) relative to some fixed base level of welfare to be determined in equilibrium (B).[16]

Moreover, BW (1986) show that TNE and truthful contribution schedules may be focal: a) no firm has incentive to deviate in equilibrium; b) the equilibrium is robust to non-binding pre-play talk. Point a) means that firms' best-response sets always include a truthful strategy so firms cannot lose from choosing a truthful contribution schedule. Point b) is because TNE are Pareto optimal, robust to communication among players and therefore they are coalition-proof.

It will be useful in the ensuing analysis to set the value of $\alpha = 0$, that is lobby members care only about the welfare coming from their labour income and not about rebated taxes and consumers surplus.[17] While this assumption is just for simplifying the analysis, a more complete version of the model (where this assumption is relaxed) is in section 5. For the moment, consider that this assumption looks less restrictive for two reasons. First, since α is the size of firm i with respect to the total population, firm i workers have a relatively little concern for the loss of consumer surplus due to protection. Second, it is widely known that in the developed economies income from trade taxes is quite low, so that consumers do not care about it.

We can focus on the Nash equilibria where there are not conflicting interests among lobbies. In order to find the short run equilibrium tariff we maximize the joint welfare in (1.7):[18]

$$J = a\left[b(L-l) - \tfrac{(L-l)^2}{2} + p_T\bar{\varphi}l + r(p_T, l) + S(p_T)\right] + p_T\bar{\varphi}l$$

The optimum implies the following first order condition:

$$a\left[l\bar{\varphi} + m + m'(p_T - 1) - d(p_T)\right] + \bar{\varphi}l = 0$$

Considering that the demand function is $d(p_T) = D - p_T$, we have that $m\prime = -1$; then:

[16] Formally, B is the maximum value that satisfies the constraint that the joint value (1.7) at the equilibrium price is greater than under any alternative price. That is:
$\max B(p_T^*) = B$
$s.t.\ c(p_T^*, B) + aV(p_T^*) \geq W_i(p_T) - B + aV(p_T) \quad \forall p_T \neq p_T^*$.
Since the lobby contributions function is truthful and the nonnegativity contraint in (1.8) is not binding, then the eqilibrium price p_T^* is given by:
$p_T^* = \arg\max\left[c(p_T, B) + aV(p_T)\right] \Longrightarrow p_T^* = \arg\max\left[W_i(p_T) - B(p_T^*) + aV(p_T)\right] \Longrightarrow$
$\Longrightarrow p_T^* = \arg\max\left[W_i(p_T) + aV(p_T)\right] - B(p_T^*)$. Since $B(p_T^*)$ is a constant, then it does not affect the maximization process, and therefore the first order conditions are to be computed over (1.7).

[17] For a similar approach see Maggi and Rodriguez-Clare (1998a).

[18] See footnote 13 for details.

$$am\prime(p_T - 1) + \bar{\varphi}l = 0$$

and solving for the price:

$$p_T^* = 1 + \frac{I\,\bar{l}\,\bar{\varphi}}{a} \tag{1.10}$$

Rewriting (1.10) in terms of tariffs, we have:

$$\frac{\tau}{1+\tau} = \frac{1}{a}\frac{z}{e} \tag{1.11}$$

where z $(= Q_T/m)$ is the inverse of the import penetration ratio, e is the elasticity of imports to price $[e = m'/\,(m/p_T)]$ which is negative and τ is the tariff: $\tau = (p_T^* - 1)$.

Moreover, since $Q_T = I\,\bar{l}\,\bar{\varphi}$, the short run price can also be rewritten as

$$p_T^*(l, \bar{\varphi}) = 1 + \tfrac{Q_T}{a}$$

Put in this way, (1.10) highlights a main property of the model that will be useful in the later text: the tariff depends positively on the level of output of the lobbying sector.

It is useful to compare this expression with the more general expression of GH (94) of prices

$$p_T^* = 1 + \frac{\delta - \alpha}{a + \alpha}\frac{l\bar{\varphi}}{a} \tag{1.12}$$

and tariffs:

$$\frac{\tau}{1+\tau} = \frac{\delta - \alpha}{a + \alpha}\frac{z}{e} \tag{1.13}$$

where δ is a dummy variable that takes the value 1 if the sector is organized as a lobby and 0 if it is unorganized. We see that the only differences with respect to GH(94) is that we assume that the sector is always organized and we have set $\alpha = 0$.

1.2.6 Short Run Equilibrium Contributions

We now proceed to compute contributions by firms. Recall that firms have all the bargaining power, that is, following condition 4:

$$\bar{l}\sum_{i=1}^{I_0} c_i = a\left[V(1, l) - V(p_T^*, l)\right]$$

Since $V(1,l) = l\bar{\varphi} + B_N + \frac{(D-1)^2}{2}$[19] and $V(p_T{}^*, l) = p_T^* l\bar{\varphi} + B_N + (p_T^* - 1)\left(D - p_T^* - l\bar{\varphi}\right) + \frac{\left(D - p_T^*\right)^2}{2}$, we have that

$$[V(1,l) - V(p_T{}^*, l)] = \frac{[p_T^* - 1]^2}{2} \tag{1.14}$$

Imposing condition 4 and using (1.10), we find the average equilibrium value of contributions:

$$\bar{c}^* = \frac{l\bar{\varphi}^2}{2a} \tag{1.15}$$

while total contributions are given by $C^* = \bar{c}^* I \bar{l}$:

$$C^* = \frac{l^2\bar{\varphi}^2}{2a}$$

From these results, we can derive the following proposition.

Proposition 1 *The total level of contributions increases with the average productivity of the T sector ($\bar{\varphi}$) and with the amount of labour employed by the sector (l). It decreases with the weight on social welfare in government utility function (a).*

Contributions increase with productivity and labour input. Indeed, these two components increase prices and consequently also profits (where profits are convex in prices).[20] Since they both increase protection, they also increase contributions. More intuitively, as lobbying firms have more output either in terms of quantity of the input (l) and in terms of level of productivity ($\bar{\varphi}$), they can lobby more aggressively, and this explains why they increase contributions. Moreover, the more the government is concerned with social welfare (higher a), the less firms are willing to contribute. In fact, when the government cares more about social welfare, for any level of contributions it will apply a lower degree of protection; by backward induction, the lobby contributes less.

[19] Note the particularity in this case is that: $r(p_T^{\omega}, l) = r(1, l) = 0$.

[20] The fact that higher productivity sectors receive higher protection may look counterintuitive. For a modelling of declining sectors with an endougenous lobbying model see Baldwin and Nicoud (2002) and Cadot, De Melo, Olarreaga (2003). This charachteristic of the orginal "protection for sale" model" is strictly connected to the role that the import penetration ratio has on the endogenous tariff: see Maggi and Rodriguez-Clare (1998b).

1.2.7 Short Run Equilibrium Wages

Proceeding another step backward, wages in T are determined before lobbying takes place and they are actually dependent on the outcome of the lobbying activity. Recall that since we set $\alpha = 0$, workers utility is composed only of their labour income, which we have termed as wage for simplicity. Under this specification, wages are composed of the reward that labour would obtain under the competitive free trade equilibrium plus all extra rents deriving from lobbying. In this subsection we determine the wage level in the short run, while in the next section we will determine the long run level of wages and employment.

We have already derived wages in the N sector from (1.2) $W_N = b - (L - l)$: where the wage rate decreases with quantity of labour in the N sector $(L - l)$ and increases with the productivity parameter b.

With regard to sector T, consider that in the short run wages between the two sectors may be different because the allocation of labour between sectors is random, therefore we can derive only labour demand in T. To this end, recall that firm i's welfare net of contributions are given by $NW_i\left(p_T^*, \bar{l}\right) = W_i\left(p_T^*, \bar{l}\right) - \bar{c}^*\bar{l}$. Plugging the value of p_T^* from (1.10) and of $\bar{c}^*$ from (1.15), we have that net welfare of firm i becomes:

$$NW_i\left(p_T^*, \bar{l}\right) = \left(1 + \tfrac{\bar{\varphi}l}{a}\right)\bar{\varphi}\bar{l} - \tfrac{l\bar{\varphi}^2}{2a}\bar{l}$$

from which we derive the nominal net wage in the T sector W_T':[21]

$$W_T' = \bar{\varphi} + \frac{I\bar{\varphi}^2}{2a}\bar{l} = \bar{\varphi} + \frac{\bar{\varphi}^2}{2a}l \tag{1.16}$$

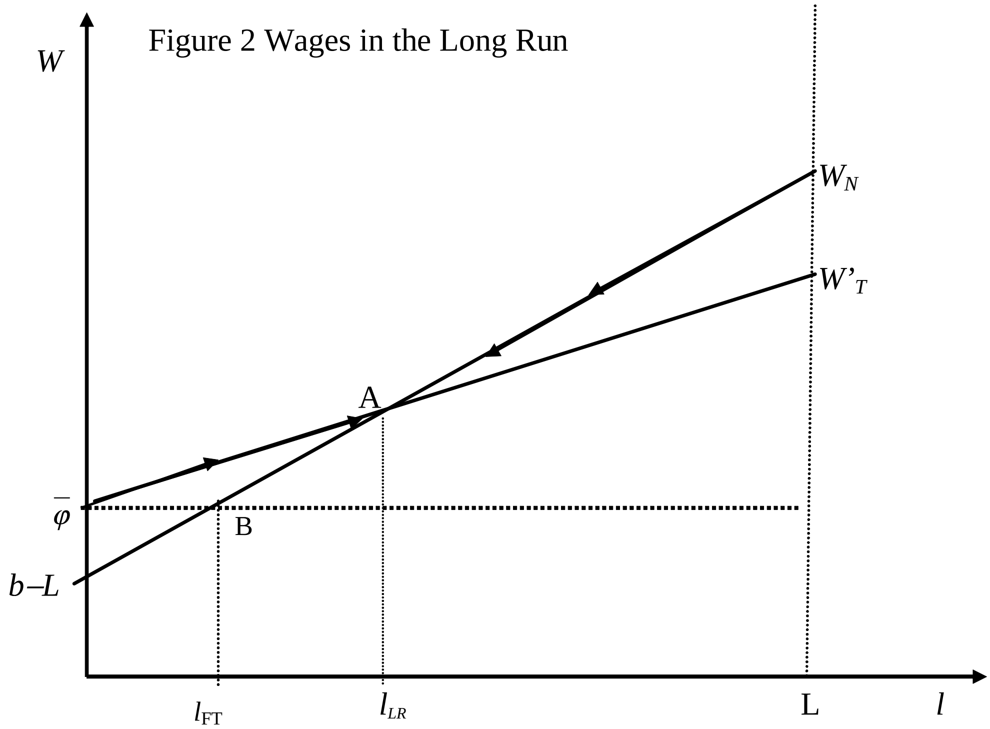
Note that in absence of lobbying, the wage would be set at the free trade level $\bar{\varphi}$, as from (1.3); with lobbying, W_T changes according to the strength of the lobbying activity . In particular, as stated in proposition 1 the larger is the T sector (either in terms of productivity $(\bar{\varphi})$ and in terms of employment $(\bar{l})$, and in the number of firms (I)), the stronger is lobbying; finally also the wage rate will be higher because the marginal net value of labour has increased.

1.3 Long Run Equilibrium

In this section we introduce the main novel ingredient of the model. The long run is characterized by labour mobility between the T and N sectors. This implies that labour

[21] We define the net wage as the firm income (net of contributions) per worker: $W_T' = \frac{NW_i}{\bar{l}}$.

moves across sectors so that the two marginal returns (wages in the model) are equalized. In figure 2, it shown that the equilibrium is at point A.



In order to assess the stability of the equilibrium at point A of figure 2, consider that starting from $l = 0$, workers prefer to be allocated in T. Any increase of labour in T increases the sizes of the sector and so also wages, through lobbying. In turn this increases the quantity of labour in T and so on.[22] At point A, the two marginal returns are equalized. Any further increase of workers beyond l_{LR} would increase wages in both sectors, but wages in N rise more quickly. But in sector N, for a greater quantity of labour, wages decrease, and this ensures convergence to the equilibrium.[23] At this point, given by equalization of wages, we have:

$$l_{LR} = \frac{2a\left(\bar{\varphi} - b + L\right)}{2a - \bar{\varphi}^2} \tag{1.17}$$

which is the unique long run equilibrium of the model.[24] At l_{LR} there is a subgame-perfect Nash equilibrium (where the short and long run equilibrium values of the mar-

[22] Recalling that $l = I\bar{l}$, note that since we have set labour firm size to $\bar{l}$, we have that labour mobility implies a change of the number of firms I.

[23] The same reasoning applies if we start from $l = L$.

[24] For the non-negativity of l_{LR} we need to impose the following condition: $2a > \bar{\varphi}^2$.

ginal returns to labour are equalized).[25] Note that l_{LR} depends on productivity levels of the T and N sectors, and on the a parameter. Adopting the long run level of labour as the subgame-perfect Nash Equilibrium, we have the following proposition:

Proposition 2 *The long run tariff depends on the productivity levels of the N and T sectors (b, $\bar{\varphi}$) and on the weight of social welfare of the government utility function (a).*

In fact, plugging (1.17) into (1.10), we have that the long run level of employment is given by:

$$p_{T,LR} = 1 + \frac{2\bar{\varphi}\left(\bar{\varphi} - b + L\right)}{2a - \bar{\varphi}^2} \tag{1.18}$$

where it is immediate to see that given labour mobility across sectors, the long run price depends on relative technologies of the T and N sectors. The resulting tariff (in terms of coverage ratio) is:

$$\frac{\tau}{1+\tau} = \frac{1}{1 + \frac{2a - \bar{\varphi}^2}{\bar{\varphi} - b + L}} \tag{1.19}$$

It is clear, that when productivity $\bar{\varphi}$ increases lobbying is stronger and then higher protection is granted. On the other hand, productivity in N decreases the tariff; indeed, for a higher productivity of the nontradable sector (increase of b), W_N increases; since this effect tends to attract workers from the T sector, there will be a lower amount of labour in T, implying a lower final tariff. Therefore the effect of this variable on the tariff is confirmed also in the long run. Finally, as for the short run, the long run equilibrium tariff depends negatively on a.[26]

These findings suggest that countries with a higher productivity in nontradables have lower tariffs. Therefore, given that this productivity is higher in more advanced economies, we have a rationale for these countries have lower barriers to trade.

[25] In appendix A a similar graphic version of the long run solution is drawn.

[26] There has been a wide debate over the estimated value of the parameter a. In fact, while from casual observation we have that lobbying for trade protection is pervasive, the empirical estimates have found very high values for this parameter. Since the puzzling estimates of Goldberg and Maggi (1999), who obtained large values of this parameter ($\hat{a} = 53$), there have been various attempts to reconcile the protection for sale framework with the more realistic values of a.For a preliminary discussion about this puzzling problem see Feenstra (2004), while for more recent contributions on this topic see Gawande and Krishna (2003).

1.3.1 Imperfect Labour Mobility

As stated in the introduction, labour mobility can be imperfect. Indeed, some literature has pointed out that wage inequality may persist for long periods (Krueger and Summers, 1987; Helwege, 1992; Askenazy, 2005). It turns out that the model can be easily extended to include imperfect labor mobility. We model this case by introducing a wage gap between T and N, as follows:

$$W_T = W_N - \psi$$

where ψ is an arbitrary positive wage premium in the N sector.

In this case, substituting from (1.2) and from (1.16), the long run employment is:

$$l_{LR,\psi} = \frac{2a\left(\bar{\varphi} - b + L + \psi\right)}{2a - \bar{\varphi}^2} \tag{1.20}$$

Since wages will always be lower in T than in N, then the equilibrium level of employment in T is higher (for a positive value of ψ).[27] This is because workers in T have to lobby more aggressively than if labour were perfectly mobile. From (1.20), we can state the following proposition:

Proposition 3 *The degree of capital mobility reduces the long run tariff.*

In fact, with imperfect mobility, the long run price is:

$$p_{T,LR,\psi} = 1 + \frac{2\bar{\varphi}\left(\bar{\varphi} - b + L + \psi\right)}{2a - \bar{\varphi}^2} \tag{1.21}$$

The long price also is higher than in perfect mobility, because as it is clear from (1.20), the long run employment in T level in this case is higher, and so also protection has increased. The result on labour mobility is in line with some recent literature on factor mobility (MR, 2005).[28]

1.4 The Value of Commitment

In this section we study the value of government's commitment to free trade because of two reasons. First, the long run tariff value derived in the previous section may not

[27] In terms of figures 1 and 2, this is equivalent to a downward shift of the W_T' curve.

[28] MR (2005) find that "trade liberalization is deeper when capital is more mobile across sectors." (page 3). Moreover, note that these results hold for a positive wage premium to the N sector, while if we were to allocate a positive premium to the T sector, the results would be simply reversed.

be applied if the government is not sufficiently compensated of the losses due to: a) the welfare reduction caused by protectionism; b) the re-allocation of resources towards the protected sector. Second, we verify the existence of the lobby; indeed, so far the analysis has been conducted assuming implicitly that all firms in T are lobbying. However consider that this may not be automatic. In fact, if the government accords protection in the long run, then more and more firms are set in the sector that is to be protected. This creates a reallocation of resources, which is distortionary with respect to the efficient allocation under free trade; then, if the government considers such distortions excessive and such that protection cannot be granted, by backward induction the lobby is not formed ex-ante.

In more general terms, while the model is built with a simple description of the T sector as producing a unique final good, it turns out, however, that not all the industrial sectors may be lobbying, due to sector specific charachteristics. While the decision whether to lobby or not is completely exogenous in GH (1994), other works have taken different approaches to endogenize this decision.[29]

We can determine whether the tradable sector will lobby or not by checking whether condition 4 is respected in the long run; in this way, we verify whether the government is (in the long run equilibrium) willing to give protection instead of allowing free trade.

In order to establish the government value of commitment to free trade in the long run, the policymaker compares its own utility under free trade and under protection. Government utility under free trade is given by $\Omega(1, l_{FT}) = aV(1, l_{FT})$, or also

$$\Omega(1, l_{FT}) = a\left[b(L - l_{FT}) - \frac{(L - l_{FT})^2}{2} + \bar{\varphi} l_{FT} + S(1)\right] \tag{1.22}$$

On the other hand, the government utility under protection is given by:

$$\Omega(p_{T,LR}, l_{LR}) = a\left[b(L - l_{FT}) - \frac{(L - l_{FT})^2}{2} + p_{T,LR}\bar{\varphi} l_{LR} + r(p_{T,LR}, l_{LR}) + S(p_{T,LR})\right] + l_{LR}\bar{c}^* \tag{1.23}$$

The utility variation is

$$\triangle\Omega_{LR} = \Omega(p_{T,LR}, l_{LR}) - \Omega(1, l_{FT})$$

For $\triangle\Omega_{LR} > 0$ the government may not credibly commit to free trade, but it grants protection. In the appendix we show that $\triangle\Omega_{LR}$ is positive for $2a > \bar{\varphi}^2$(as already

[29] For example, Mitra (1999) links the existence of a lobby to the degree of capital concentration. For a more general review, see the review by Gawande and Krishna (2003).

assumed above: see footnote 25). Therefore, in the long run the government finds convenient to grant protection to the tradable sector.

This result is interesting with respect to the recent literature on the value of commitment to free trade agreements. In fact, while this model shares with MR (1998) the assumption that lobbying is made only after workers have been allocated between sectors (and not also before the allocation),[30] it differs from MR (1998) because it predicts that the government implements a protectionist trade policy when the lobby has all the bargaining power.

1.5 Extension of the model

In this part of the paper we extend the model to the case in which $\alpha_i > 0$. We will not be able to derive a solution analytically, but through a simulation where we let three out of six parameters vary. The simulated model confirms our predictions as derived in sections 2 or 3 as it is explained below. In particular, we let the parameters vary in ranges whose values are taken in part from the empirical literature, where this is available (e.g.: the parameter a), otherwise we make a reasonable guess about the values while respecting constraints that come from well known facts (e.g.: productivity of nontradables is always lower than in the tradables). The purpose of the simulations is not to derive values that are directly comparable with actual data on firms, but more simply to verify that the main properties of the model hold under different parameters changes.

The assumption of $\alpha_i > 0$ represents the case in which workers have a concern for consumer surplus and of the income from rebated trade taxes, as from (1.6). In particular, we set $\alpha_i = \alpha = \bar{l}/L$ as a fixed positive parameter. In this case, from (1.10) we rewrite the short run equilibrium price as:

$$\widetilde{p}_T = 1 + \sigma\left(a, \alpha\right) \frac{I\bar{l}\bar{\varphi}}{a} \tag{1.24}$$

where $\sigma\left(\bar{a}, \bar{\alpha}\right) = \frac{1-\alpha}{a+\alpha}$, and the short run equilibrium contribution level is:

[30] We do not need to introduce ex ante lobbying in order to have the government to grant protection, as MR (2005) do. Indeed, we may distinguish between *"ex-ante lobbying," which influences the selection of the trade agreement, and "ex-post lobbying", which influuences the choice of trade policies subject to the constraints set by the agreement* [MR (2005), pag. 2]. In the first case, lobbying is before the allocation of resources between the sectors, while the second case considers lobbying after resources have been allocated.

$$\widetilde{c} = \frac{\widetilde{\tau}^2}{2} = \frac{\sigma^2 \overline{\varphi}^2 l^2}{2} \tag{1.25}$$

From these expressions we obtain the wage rate in T:

$$W_T' = \left(1 + \sigma \frac{\overline{\varphi} I \overline{l}}{a}\right) \overline{\varphi} \overline{l} + \left[S\left(\widetilde{p}_T\right) + r\left(\widetilde{p}_T\right)\right] \tag{1.26}$$

In turn in non tradables, the wage rate is given by:

$$W_N = b - (L - \overline{l} I) + S\left(\widetilde{p}_T\right) + r\left(\widetilde{p}_T\right) \tag{1.27}$$

In the long run, wage equalization implies that from (1.27) and (1.26) we obtain the long run level of employment $\widetilde{l}_{LR} = \widetilde{I}_{LR} \overline{l}$. $\widetilde{l}_{LR}$is a non linear function of the explanatory variables b, a, and $\bar{\varphi}$. Since we are not able to solve for $\widetilde{I}_{LR}$ analytically, we proceed by simulation, according the following method. The prediction is that $\widetilde{I}_{LR}$increases with $\bar{\varphi}$, while it decreases with respect to a and b. We let three parameters above vary in pairs: 1) a and b; 2) a and $\bar{\varphi}$; 3) $\bar{\varphi}$ and b.

1.5.1 Simulation 1

The basic values for the fixed parameters are $D = 100$, $\overline{l} = 1$, $L = 100$. Despite the value of D is arbitrary, it is chosen so as to obtain reasonable values of the demand function of tradables; $\overline{l}$ represents firm size and we set $l = 1$, where 1 is the minimum size of a firm, corresponding to the case of an individual entrepreneur (firm size is counted with the number of workers). $L = 100$ for simplicity;[31] $\bar{\varphi}$ is fixed at a baseline level of 40. With regard to b, since productivity in tradables is usually higher than in nontradables, we proceed by letting b vary in the positive interval $[0.1, 40.1]$, where the upper bound is chosen to be an epsilon greater than the value of $\bar{\varphi}$, just to analyze the case of reverse magnitude of the two productivities (the choice of the productivities values is arbitrary). a varies in the range $[1, 70]$, because as discussed in section 3 (footnote 27), the estimated values of this parameter are usually very high. Indeed, the first estimates of the model (Maggi and Goldberg (1999)) found $\hat{a} = 53$. Successive

[31] L measures the total labour force. We set $L = 100$, in order to obtain simple comparable values of I. It can be shown that increasing L *ceteris paribus*, implies only a proportional increase of I, without affecting the properties of the model: see later in the text.

estimates[32] produced much higher values. Only some more recent papers obtained lower values of this parameter.[33] Therefore, we let the a parameter change in a wide range of positive integers, so embracing also the initial estimates of Goldberg and Maggi (1999).

The results are shown in figure 3.a, where the tridimensional values of the number of firms (I) are plotted versus the two parameters a and b. It is evident that I is monotonically downward sloped with respect to b. Instead, with respect to a, the number of firms in T does not depend on the "democracy" parameter. This implies that the tariff is still negatively dependent on a, but not through the size effect of the number of firms I. This constant pattern of I with respect to a confirms the shortcomings of the protection for sale model with respect to the estimates of this parameter (see discussion above). The values of I with respect to the two parameters are also displayed in Table 1.

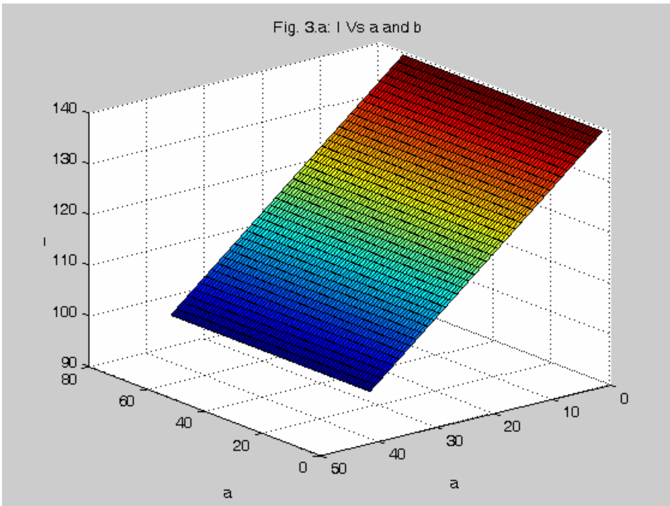


Figure 3.a: plot of I versus a and b.

We proceed further, by checking whether with these parameters, the government value of commitment is higher for free trade or for protection. That is to say that we check whether $\triangle\Omega_{LR} = \Omega(\widetilde{p}_T, \widetilde{I}_{LR}) - \Omega(1, l_{FT})$ is positive; as in the analytic section, if it is positive the government grants protection, otherwise it implements free trade. The results are shown in figure 3.b and 3.c, where $\triangle\Omega_{LR}$ is always positive, so confirming the prediction of the analytic part, that the government adopts protection in the long run. Moreover, the value of protection is rapidly decreasing in both a and b: when

[32] For a review see Feenstra (2004) and Krishna and Gawande (2003).

[33] Krishna and Gawande (2005).

b increases, as more workers move to the N sector, the value of protection decreases because the government collects less contributions; differently, an increase of a implies an immediate sharp fall of the relative value of contributions (to the government); then, for further increases of a, $\triangle\Omega_{LR}$ remains stable at low but positive level (see table 2 for details).

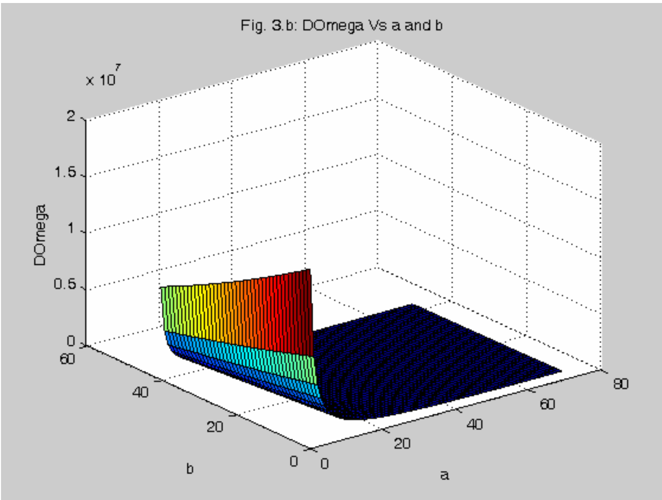


Figure 3.b: plot of $\Delta\Omega$ versus a and b.

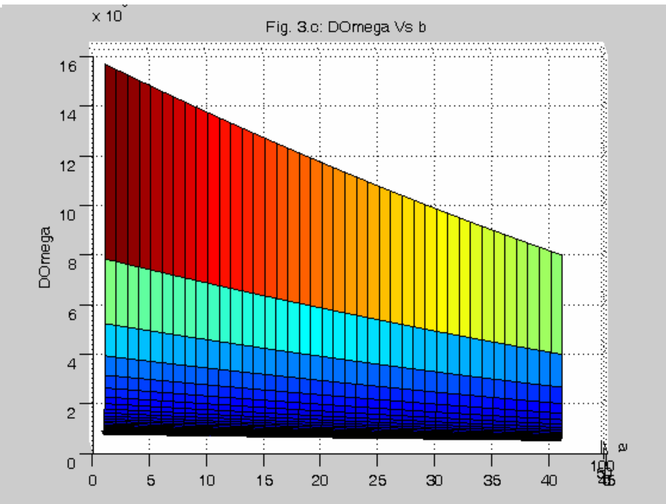


Figure 3.c: plot of $\Delta\Omega$ versus b.

1.5.2 Simulation 2

In this simulation we keep the same values for the parameters D, L and $\bar{l}$ and fix productivity in nontradables: b. We let $\bar{\varphi}$ vary in the range $[20, 40]$ and a, as before, in the range $[1, 70]$. Since we want b to be not greater than $\bar{\varphi}$, it is fixed at 20.1.[34] The results for the variable I are shown in figures 4.a and 4.b, where it is confirmed that I does not change with respect to a, while it increases monotonically with respect to $\bar{\varphi}$, as expected; this last effect depends on the characteristic of the protection for sale models, that is, as seen in (1.11), the tariff is decreasing in the import penetration ratio, so it is increasing in the output components of the T sector: labour and productivity; indeed, when productivity increases the interest group has more output and so it can lobby more aggressively; since this increases wages in T, it also attracts more workers in T: I increases.

[34] As before, for the lowest values of $\bar{\varphi}$, we want to check the effects of reverse magnitude of productivities.

When the model is simulated for the value of commitment (see figures 4.b and 4.c), we find again that the value of protection is always positive. In particular, it decreases rapidly with respect to a, as shown also in the previous subsection, and it increases with an exponential trend when related to $\bar{\varphi}$. The same reasonings of apply also in this case: an increase of a decreases the relative value of contributions, and so also of the value of protection, while an increase of productivity in tradables increases the strength of lobbying (i.e.: contributions), and so also the value of protection relatively to that of free trade level. The results of this simulation are shown also in the tables 3 and 4.

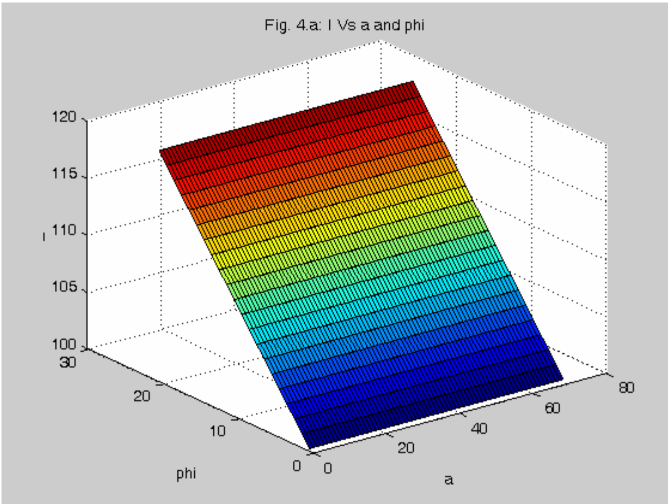


Figure 4.a: I versus a and $\bar{\varphi}$.

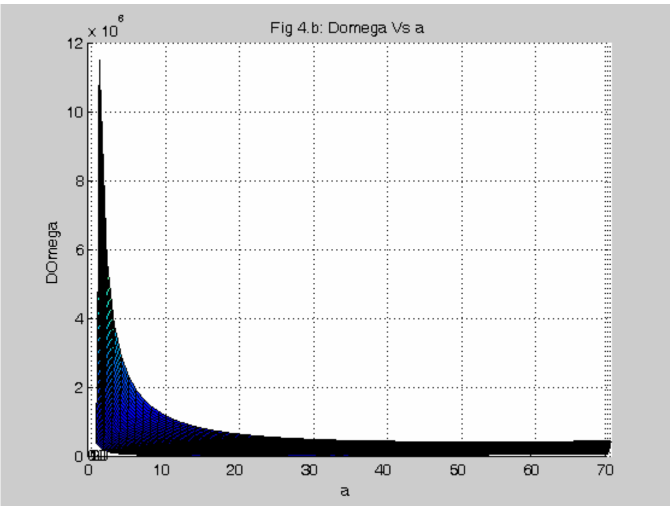


Figure 4.b: $\Delta\Omega$ versus a.

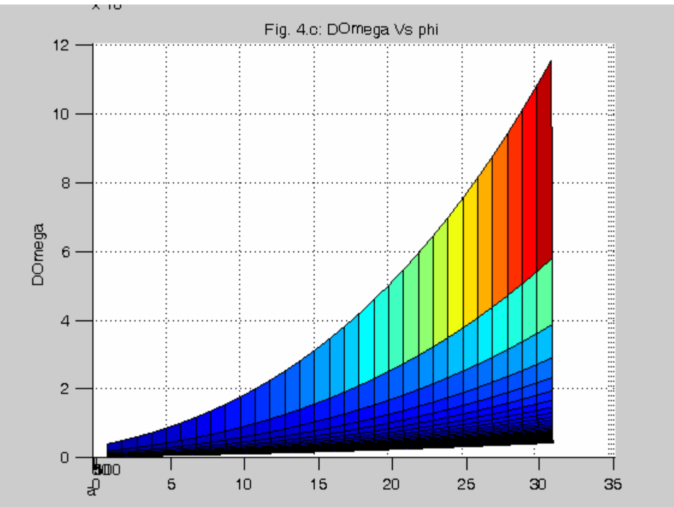


Figure 4.c: $\Delta\Omega$ versus $\bar{\varphi}$.

1.5.3 Simulation 3

In this last simulation we fix the government preference parameter a and let the productivity of the two sectors (b and $\bar{\varphi}$) vary (D and $\bar{l}$ are unchanged). We fix a at 53, which is the reference value taken from Goldberg and Maggi (1999). Moreover, productivity of tradables varies in the same range as before: $\bar{\varphi} \in [20, 40]$, while we let productivity in nontradables vary in the range with the upper limit of $\bar{\varphi}$; therefore, $b \in [0.1, 20.1]$. The results are shown in figure 5.a. Also in this case, I decreases monotonically and linearly with respect to b, while it increases (also in this case monotonically) with respect to $\bar{\varphi}$ (see Table 2). Therefore, the model confirms that one of the main effects of the model holds: higher productivity of nontradables decreases the strength of the lobby by reducing the number of firms it lowers the level of trade protection.

The value of commitment (see figure 5.b and 5.c) is always positive and the slopes also confirm the reasoning of the previous simulations: the value of protection decreases with b while it increases with $\bar{\varphi}$ (the values of this simulation are in tables 5 and 6). While this finding further confirms the prediction of the model regarding the role of nontradables productivity on the trade tariff, it also reproduces a scenario which might depend deeply on the value of the parameter a. Therefore, in the following subsections we produce the simulation results of this same simulation, but only changing the value of a.

Simulation 3.a

Indeed, since there is a lot of uncertainty in the empirical literature about the true value of a (as discussed above), we repeat the previous simulation by setting $a = 1$ and $a = 1000$. $a = 1$ corresponds to the case when the government attaches the same weight to one dollar of contributions and one unit of welfare in its utility function. Instead, $a = 1000$ is an extreme case of over-estimation of the parameter a. The results are shown in figures 5.a and 5.b respectively for $a = 1$, and in figures 6.a and 6.b for $a = 1000$.

When $a = 1$ (see figure 6.a), I is still negatively sloped with b and increasing with respect $\bar{\varphi}$. Moreover, as a stress test, we have repeated the same simulation with the values of the parameter b and $\bar{\varphi}$ multiplied by a factor of 100.[35] Also in this case, the model shows the same properties: b and $\bar{\varphi}$ have the same opposing effects on I. Moreover, with regard to the value of commitment (figure 6.b), as expected, the value

[35] These results are not reported here for seke of brevity, but they are available upon request to the author: francesco.bripi@uni-bocconi.it.

of protection decreases with b and increases with $\bar{\varphi}$, but this is always positive in the range considered. The values of these simulation are in table 7 and 8.

Simulation 3.b

Finally, we repeat the same exercise of simulation 3, setting $a = 1000$. Again, the results of the baseline simulation are confirmed (I increases with $\bar{\varphi}$ while it decreases with b: see figure 7.a). More interestingly, by comparing the values of tables 5, 7, and 9, we see that the values of I are identical. This means that the strength of the lobby does not depend on the parameter a, as already noted in the simulation 1 and 2.

With regard to the value of commitment (fig. 7.b), the results are mainly unchanged: it is increasing with respect to $\bar{\varphi}$ and decreasing with respect to b. This value is always positive and comparing the values from tables 8 and 10 we note that in this last case the value of protection is lower; in fact, since a has increased, for the same value of the two productivities we have the same amount of contributions to the government are valued less positively by the government.

Overall, these simulations confirm the good fit of the model also in the more general case in which workers care also about of consumers' surplus. The role of nontradables productivity is confirmed to affect negatively the amount of firms in T, while the reverse for tradables productivity. From these simulations, the role of a seems to be null. This result is not driven by the particular choice of the productivities values, as the stress tests have confirmed: increasing the values of b and $\bar{\varphi}$ upward, the same results are obtained: a does not affect the number of firms.[36] A solution to this problem is probably to be found in the more recent approaches dealing with the role of this parameter in the protection for sale models (see footnotes 33 and 34 for the most recent references).

[36] These tests are not shown here. They are built on the idea of repeating the same exercises of the simulations by increasing the magnitude of the parameters b and $\bar{\varphi}$, and in another case increasing the value of L. It is shown that the main ptoperties of the model hold in all of the cases, where the only effects consist of an increase of I.

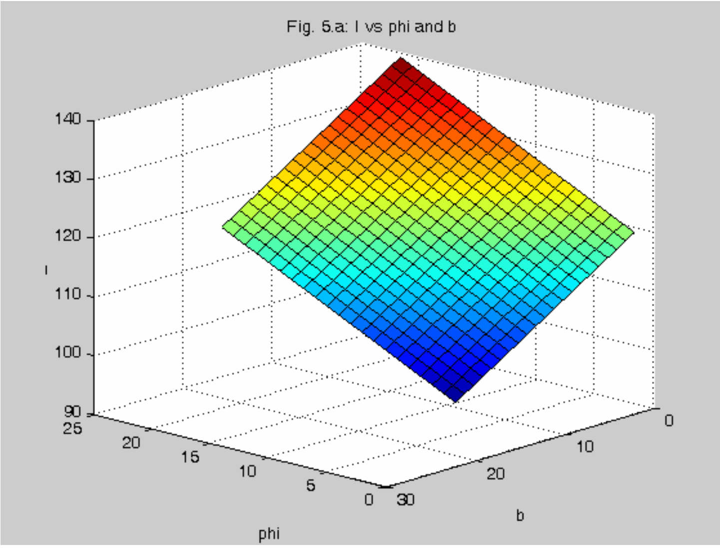


Figure 5.a: I versus $\bar{\varphi}$ *and b, with* $a = 53$.

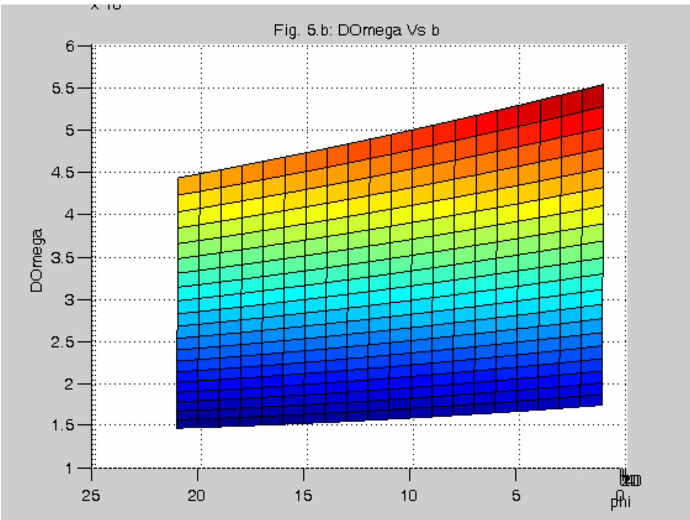


Figure 5.b: $\Delta\Omega$ *versus b.*

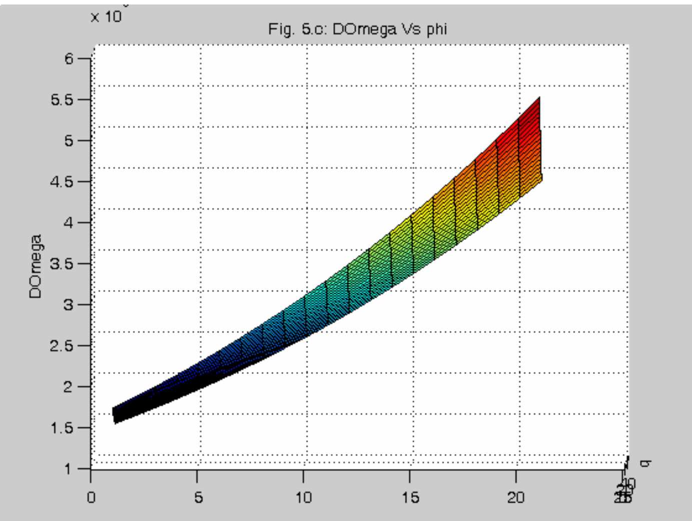


Figure 5.c: $\Delta\Omega$ *versus* $\bar{\varphi}$.

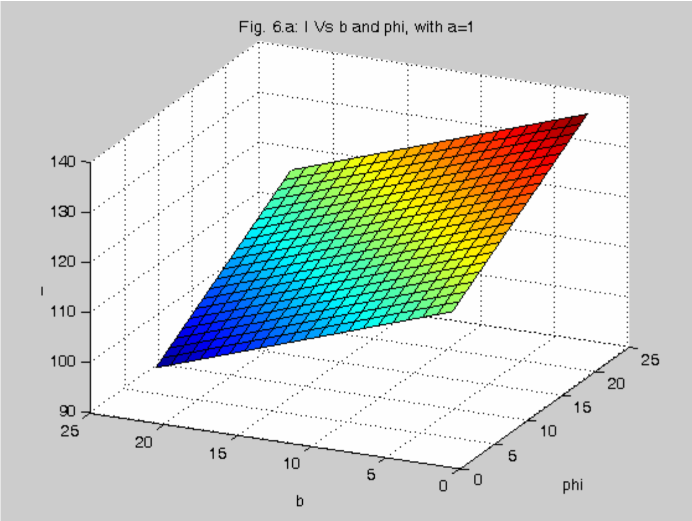


Figure 6.a: I versus $\bar{\varphi}$ *and b, with* $a = 1$.

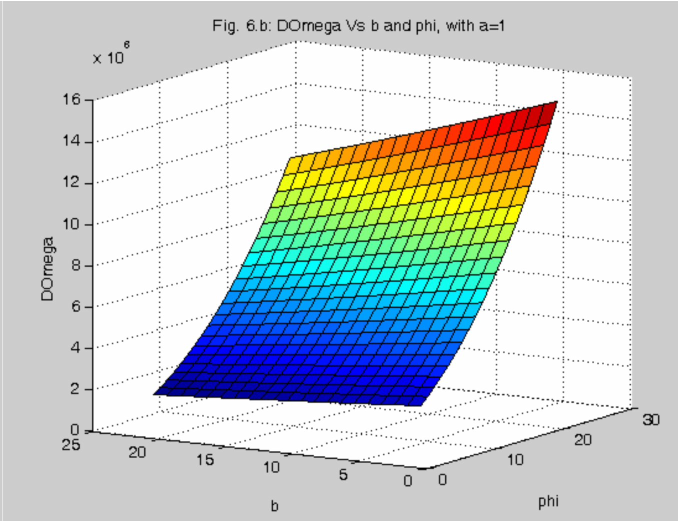


Figure 6.b: $\Delta\Omega$ *versus* $\bar{\varphi}$ and *b, when* $a = 1$.

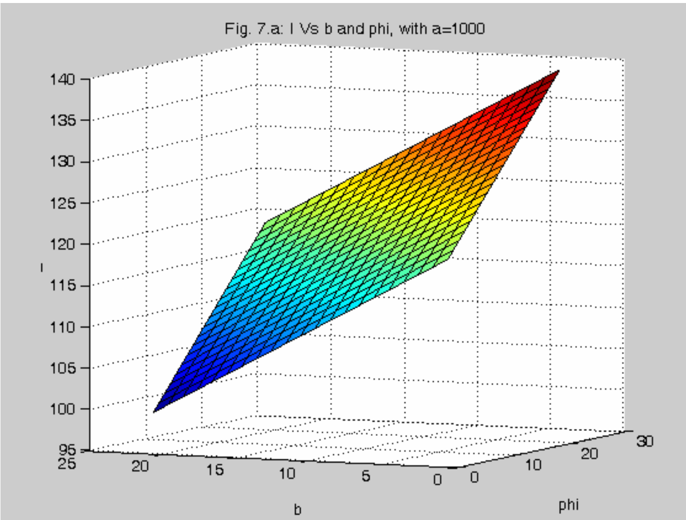


Figure 7.a: I versus $\bar{\varphi}$ and *b, when* $a = 1000$.

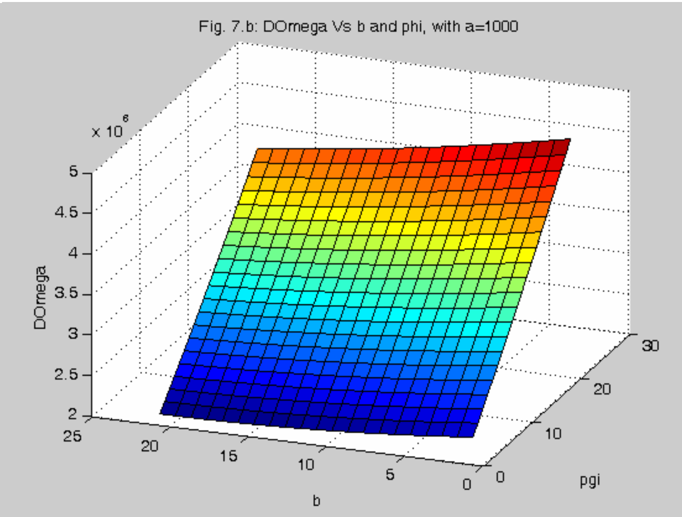


Figure 7.b: $\Delta\Omega$ *versus* $\bar{\varphi}$ and *b, when* $a = 1000$.

1.6 Conclusions

In this paper we have tried to explain how tariffs move in the long run due to the effects that labour mobility has on firms lobbying for protection. We have started from a simple protection for sale framework augmented for a nontradables sector, to describe tariff formation in the short run. Then, we have added a long run condition (equalization of wages due to labour mobility of workers) in order to derive the long run value of the tariff. We find that the long run tariff level depends on the relative productivity of the N sector with respect to that of the T sector.

In particular, as firms become more productive in the N sector, trade barriers fall in the long run. Differently from the original approach of Grossman and Helpman (1994), the equilibrium tariff (in the long run) in this model depends also on characteristics of other sectors considered (in this model the N sector). This approach helps to explain why: a) barriers to trade still exist among many open economies; b) they tend to fall gradually over time; c) they fall more steadily in the countries where the productivity gap of the nontradables sector (with respect to the tradable) is greater. The mechanism outlined in this paper is based on the assumption of competitive forces in the labour market that induce workers to move to the sector that offers highest wages. This assumption may be criticized on the ground of an empirical literature which has at times found that persistence of wages across sectors. However, much of this persistence can be explained in terms of observed and unobserved workers capacities (e.g.: skilled and unskilled workers). Even correcting for imperfect labour mobility, the main results hold. Moreover, in this paper the economy is modeled as composed of two aggregate sectors (T and N); therefore, we believe that in the long run wages differences can be reasonably be arbitraged away. Secondly, when we extend the model to the case where workers care also of surplus and rebated taxes, we find, through simulation, that the long run level of protection still depends negatively on nontradables productivity.

Finally, we believe that a further extension of this work might go in the direction of introducing lobbying in the nontradables sector, as much of the industries that are naturally protected from international competition are also protected domestically by regulatory intervention. In this sense, a deeper understanding of protection against competition in nontradables sectors could provide a further insight on the mechanisms at work, but we leave the study of these topics to future research.

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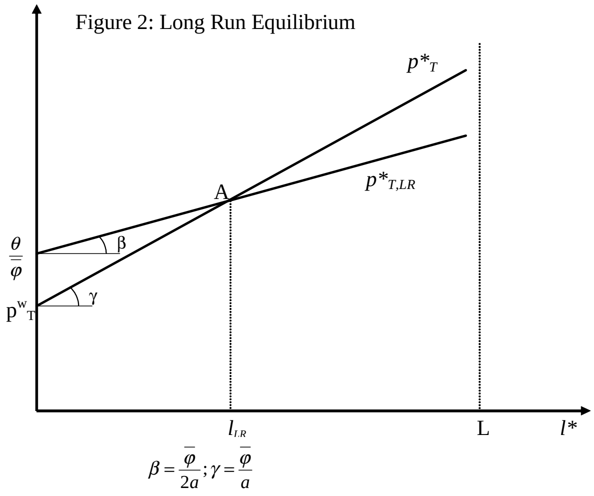
Appendix 1. Long Run Equilibrium

In this part we present another way to see the long run equilibrium.

The result in section 3 can be seen also by considering that the net marginal return of labour in the T sector is given by $p_T^*\bar{\varphi} - \bar{c}^*$ (see footnote 23), while in the N sector it is θ (from (1.2)). From the equalization (and using (1.15)) we obtain:

$$p_{T,LR}^* = \frac{1}{\bar{\varphi}} + \frac{\bar{\varphi}}{2a}l$$

This curve is plotted in the following figure 2 with the short run equilibrium price curve p_T^* (from (1.10)):



Along the $p^*_{T,LR}$ curve workers earn the same wage in the T and in N sector. **QED**

Appendix 2. The Value of Commitment to Free Trade

Recall that the government utility under free trade is:

$$\Omega(1, l_{FT}) = a\left[z - \theta(L - l_{FT}) + \bar{\varphi} l_{FT} + S(p_T^{\omega} = 1)\right]$$

while under the political equilibrium is:

$$\Omega(p_{T,LR}, l_{LR}) = a\left[b - (L - l_{LR}) + p_{T,LR}\bar{\varphi} l_{LR} + r(p_{T,LR}, l_{LR}) + S(p_{T,LR})\right] + l_{LR}\bar{c}^*$$

We have to show that $\triangle\Omega_{LR} = \Omega(p_{T,LR}, l_{LR}) - \Omega(1, l_{FT}) > 0$.
Recalling that $\bar{c}^* = \frac{l\bar{\varphi}^2}{2a}$, we have:

$$\triangle\Omega_{LR} =$$
$$a\left\{\bar{\varphi} p_{T,LR} l_{LR} - l_{FT} + (l_{LR} - l_{FT}) + \frac{\bar{\varphi}}{a} l_{LR}\left(D - 1 - \frac{\bar{\varphi}}{a} l_{LR} - \bar{\varphi} l_{LR}\right) + \frac{\left(D-1-\frac{\bar{\varphi}}{a} l_{LR}\right)^2}{2} - \frac{(D-1)^2}{2}\right\} +$$
$$\frac{\bar{\varphi}^2}{2a} l_{LR}^2$$

Expanding this expression and after simplifying, we get:

$$\triangle\Omega_{LR} = a\left\{\bar{\varphi}\left(l_{LR} - l_{FT}\right) - \frac{\bar{\varphi}^2}{2a^2} l_{LR}^2\right\} + \frac{\bar{\varphi}^2}{2a} l_{LR}^2$$

or also

$$\triangle\Omega_{LR} = a\bar{\varphi}\left(l_{LR} - l_{FT}\right)$$

Moreover, substituting the values of prices from (1.10) and of free trade and long run employment from (1.4) and (1.17) respectively, we have:

$$\triangle\Omega_{LR} = a\bar{\varphi}\left(l_{LR} - l_{FT}\right) = a\bar{\varphi}\left(\bar{\varphi} - b + L\right)\frac{\bar{\varphi}^2}{2a-\bar{\varphi}^2}$$

which is always positive for $\bar{\varphi} > b - L$ and $2a > \bar{\varphi}^2$. **QED**

Appendix 3. Countries Data

In graph 1, D1 is the group of developed countries, while D2 is the group of developing countries. The set of developed countries is represented by (we report the abbreviation only): AUS AUT BEL CAN CHE DNK ESP FIN FRA GBR GER GRC HKG IRL ISL ITA JPN KOR LUX NLD NOR NPL NZL PRT SWE USA.

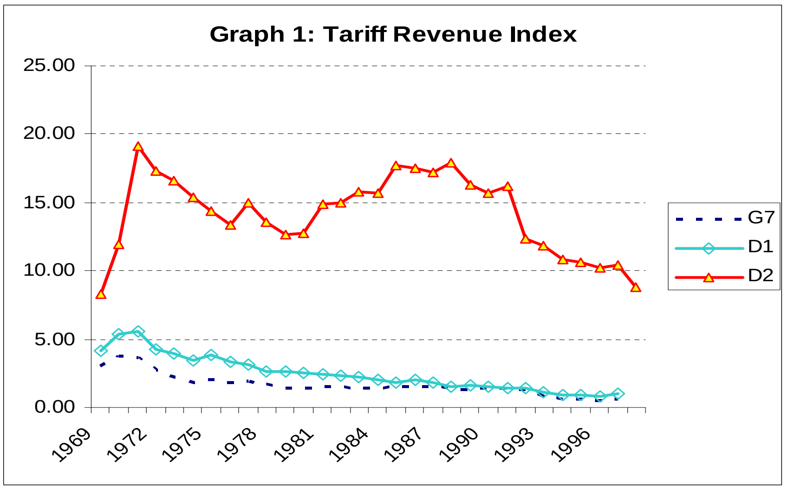
The set of developing countries is represented by: AGO ARG ATG BDI BEL BFA BGD BLZ BOL BRA BRB BWA CAF CHE CHL CHN CIV CMR COG COL COM CPV CRI CYP DMA DOM DZA ECU EGY ETH FJI GAB GHA GIN GMB GNB GNQ GRD GTM GUY HND HTI HUN IDN IND IRN ISR JAM JOR KEN KNA LCA LKA LSO MAR MDG MEX MLI MOZ MRT MUS MWI MYS NAM NER NGA NIC NPL PAK PAN PER PHL PNG POL PRI PRY ROM RWA SEN SGP SLE SLV STP SYC SYR TCD TGO THA TTO TUN TUR TWN TZA UGA URY VCT VEN ZAF ZAR ZMB ZWE.

All values are given by simple mean.

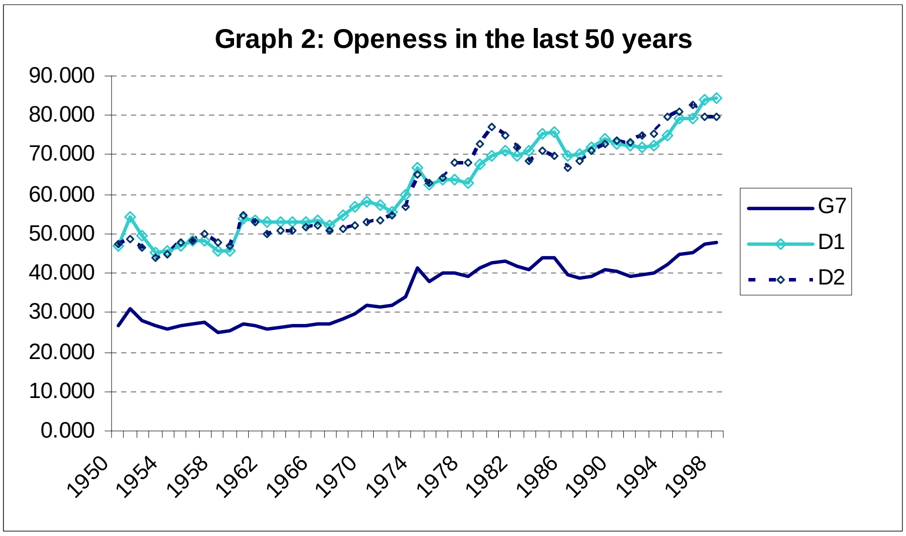
Graphs

In order to have an idea about the degree of trade liberalization, we can see from graph 1 (but see also graph 2 for other trade restriction indexes) that the trade barrier index has been decreasing over the last five decades with the developed countries (D1) having a much higher fall (in percentage values) than developing countries (D2).[37]

[37] See Appendix 3 for more details about the data.



Source: A.Rose (2004)



The two graphs give just a rough idea of the decline of trade barriers,[38] nevertheless they give a clear picture of the trends across groups of countries.

All series were taken from A. K., Rose (2004).

[38]In fact, while the measures used are imperfect measures of trade reastriction, they are the only quite available for such a large set of countries over a long period. For a recent comprehensive reference see Anderson and Neary (2005).

Table 1	*SIMULATION 1: I Vs a and b*			*L=100, D=100, phi=40*						
var: I	*a*									
b	1	2	3	4	5	6	7	8	9	10
0.1	139.90	139.90	139.90	139.90	139.90	139.90	139.90	139.90	139.90	139.90
1.1	138.90	138.90	138.90	138.90	138.90	138.90	138.90	138.90	138.90	138.90
2.1	137.90	137.90	137.90	137.90	137.90	137.90	137.90	137.90	137.90	137.90
3.1	136.90	136.90	136.90	136.90	136.90	136.90	136.90	136.90	136.90	136.90
4.1	135.90	135.90	135.90	135.90	135.90	135.90	135.90	135.90	135.90	135.90
5.1	134.90	134.90	134.90	134.90	134.90	134.90	134.90	134.90	134.90	134.90
6.1	133.90	133.90	133.90	133.90	133.90	133.90	133.90	133.90	133.90	133.90
7.1	132.90	132.90	132.90	132.90	132.90	132.90	132.90	132.90	132.90	132.90
8.1	131.90	131.90	131.90	131.90	131.90	131.90	131.90	131.90	131.90	131.90
9.1	130.90	130.90	130.90	130.90	130.90	130.90	130.90	130.90	130.90	130.90
10.1	129.90	129.90	129.90	129.90	129.90	129.90	129.90	129.90	129.90	129.90
11.1	128.90	128.90	128.90	128.90	128.90	128.90	128.90	128.90	128.90	128.90
12.1	127.90	127.90	127.90	127.90	127.90	127.90	127.90	127.90	127.90	127.90
13.1	126.90	126.90	126.90	126.90	126.90	126.90	126.90	126.90	126.90	126.90
14.1	125.90	125.90	125.90	125.90	125.90	125.90	125.90	125.90	125.90	125.90
15.1	124.90	124.90	124.90	124.90	124.90	124.90	124.90	124.90	124.90	124.90
16.1	123.90	123.90	123.90	123.90	123.90	123.90	123.90	123.90	123.90	123.90
17.1	122.90	122.90	122.90	122.90	122.90	122.90	122.90	122.90	122.90	122.90
18.1	121.90	121.90	121.90	121.90	121.90	121.90	121.90	121.90	121.90	121.90
19.1	120.90	120.90	120.90	120.90	120.90	120.90	120.90	120.90	120.90	120.90
20.1	119.90	119.90	119.90	119.90	119.90	119.90	119.90	119.90	119.90	119.90
21.1	118.90	118.90	118.90	118.90	118.90	118.90	118.90	118.90	118.90	118.90
22.1	117.90	117.90	117.90	117.90	117.90	117.90	117.90	117.90	117.90	117.90
23.1	116.90	116.90	116.90	116.90	116.90	116.90	116.90	116.90	116.90	116.90
24.1	115.90	115.90	115.90	115.90	115.90	115.90	115.90	115.90	115.90	115.90
25.1	114.90	114.90	114.90	114.90	114.90	114.90	114.90	114.90	114.90	114.90
26.1	113.90	113.90	113.90	113.90	113.90	113.90	113.90	113.90	113.90	113.90
27.1	112.90	112.90	112.90	112.90	112.90	112.90	112.90	112.90	112.90	112.90
28.1	111.90	111.90	111.90	111.90	111.90	111.90	111.90	111.90	111.90	111.90
29.1	110.90	110.90	110.90	110.90	110.90	110.90	110.90	110.90	110.90	110.90
30.1	109.90	109.90	109.90	109.90	109.90	109.90	109.90	109.90	109.90	109.90
31.1	108.90	108.90	108.90	108.90	108.90	108.90	108.90	108.90	108.90	108.90
32.1	107.90	107.90	107.90	107.90	107.90	107.90	107.90	107.90	107.90	107.90
33.1	106.90	106.90	106.90	106.90	106.90	106.90	106.90	106.90	106.90	106.90
34.1	105.90	105.90	105.90	105.90	105.90	105.90	105.90	105.90	105.90	105.90
35.1	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
36.1	103.90	103.90	103.90	103.90	103.90	103.90	103.90	103.90	103.90	103.90
37.1	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
38.1	101.90	101.90	101.90	101.90	101.90	101.90	101.90	101.90	101.90	101.90
39.1	100.90	100.90	100.90	100.90	100.90	100.90	100.90	100.90	100.90	100.90
40.1	99.90	99.90	99.90	99.90	99.90	99.90	99.90	99.90	99.90	99.90

Table 2	*SIMULATION 1: Vs a and b*			*L=100, D=100, phi=40*						
var:	*a*									
b	1	2	3	4	5	6	7	8	9	10
0.1	15662000.00	7838500.00	5233800.00	3933800.00	3155800.00	2638700.00	2270800.00	1996000.00	1783400.00	1614300.00
1.1	15439000.00	7726900.00	5159300.00	3877900.00	3111000.00	2601300.00	2238600.00	1967800.00	1758300.00	1591600.00
2.1	15218000.00	7616100.00	5085400.00	3822400.00	3066500.00	2564200.00	2206700.00	1939900.00	1733300.00	1569100.00
3.1	14998000.00	7506100.00	5012000.00	3767300.00	3022400.00	2527300.00	2175100.00	1912100.00	1708600.00	1546700.00
4.1	14780000.00	7396900.00	4939100.00	3712600.00	2978500.00	2490700.00	2143600.00	1884500.00	1684000.00	1524500.00
5.1	14563000.00	7288500.00	4866800.00	3658300.00	2935000.00	2454400.00	2112400.00	1857100.00	1659600.00	1502500.00
6.1	14348000.00	7181000.00	4795000.00	3604400.00	2891800.00	2418400.00	2081500.00	1830000.00	1635400.00	1480700.00
7.1	14135000.00	7074200.00	4723800.00	3550900.00	2849000.00	2382600.00	2050800.00	1803000.00	1611400.00	1459000.00
8.1	13923000.00	6968200.00	4653100.00	3497800.00	2806500.00	2347100.00	2020300.00	1776300.00	1587600.00	1437500.00
9.1	13712000.00	6863000.00	4582900.00	3445100.00	2764200.00	2311900.00	1990000.00	1749800.00	1563900.00	1416100.00
10.1	13504000.00	6758600.00	4513300.00	3392800.00	2722400.00	2276900.00	1960000.00	1723400.00	1540500.00	1395000.00
11.1	13297000.00	6655000.00	4444200.00	3340900.00	2680800.00	2242200.00	1930200.00	1697300.00	1517200.00	1374000.00
12.1	13091000.00	6552300.00	4375600.00	3289500.00	2639600.00	2207800.00	1900700.00	1671400.00	1494100.00	1353100.00
13.1	12887000.00	6450300.00	4307600.00	3238400.00	2598700.00	2173700.00	1871400.00	1645700.00	1471200.00	1332500.00
14.1	12685000.00	6349100.00	4240100.00	3187700.00	2558100.00	2139800.00	1842300.00	1620200.00	1448500.00	1312000.00
15.1	12484000.00	6248700.00	4173100.00	3137500.00	2517800.00	2106200.00	1813400.00	1594900.00	1426000.00	1291700.00
16.1	12285000.00	6149200.00	4106700.00	3087600.00	2477900.00	2072900.00	1784800.00	1569900.00	1403600.00	1271500.00
17.1	12088000.00	6050400.00	4040800.00	3038200.00	2438300.00	2039800.00	1756500.00	1545000.00	1381500.00	1251600.00
18.1	11892000.00	5952400.00	3975500.00	2989100.00	2399000.00	2007100.00	1728300.00	1520300.00	1359500.00	1231800.00
19.1	11698000.00	5855300.00	3910600.00	2940500.00	2360100.00	1974600.00	1700400.00	1495900.00	1337800.00	1212100.00
20.1	11505000.00	5758900.00	3846400.00	2892200.00	2321400.00	1942300.00	1672800.00	1471700.00	1316200.00	1192600.00
21.1	11314000.00	5663400.00	3782600.00	2844400.00	2283100.00	1910400.00	1645300.00	1447600.00	1294800.00	1173300.00
22.1	11125000.00	5568600.00	3719400.00	2797000.00	2245200.00	1878700.00	1618100.00	1423800.00	1273600.00	1154200.00
23.1	10937000.00	5474600.00	3656800.00	2749900.00	2207500.00	1847300.00	1591200.00	1400200.00	1252500.00	1135300.00
24.1	10750000.00	5381500.00	3594600.00	2703300.00	2170200.00	1816200.00	1564500.00	1376800.00	1231700.00	1116500.00
25.1	10566000.00	5289100.00	3533000.00	2657100.00	2133200.00	1785300.00	1538000.00	1353600.00	1211000.00	1097900.00
26.1	10383000.00	5197600.00	3472000.00	2611300.00	2096500.00	1754700.00	1511700.00	1330600.00	1190600.00	1079400.00
27.1	10201000.00	5106800.00	3411500.00	2565800.00	2060100.00	1724400.00	1485700.00	1307800.00	1170300.00	1061100.00
28.1	10021000.00	5016900.00	3351500.00	2520800.00	2024100.00	1694300.00	1459900.00	1285200.00	1150200.00	1043000.00
29.1	9843200.00	4927800.00	3292000.00	2476200.00	1988400.00	1664500.00	1434400.00	1262800.00	1130300.00	1025100.00
30.1	9666500.00	4839400.00	3233100.00	2432000.00	1953000.00	1635000.00	1409100.00	1240700.00	1110600.00	1007300.00
31.1	9491500.00	4751900.00	3174800.00	2388200.00	1918000.00	1605800.00	1384000.00	1218700.00	1091000.00	989720.00
32.1	9318000.00	4665100.00	3116900.00	2344800.00	1883200.00	1576900.00	1359200.00	1197000.00	1071700.00	972290.00
33.1	9146200.00	4579200.00	3059600.00	2301900.00	1848800.00	1548200.00	1334600.00	1175400.00	1052500.00	955030.00
34.1	8975900.00	4494100.00	3002800.00	2259300.00	1814700.00	1519800.00	1310200.00	1154100.00	1033600.00	937940.00
35.1	8807300.00	4409700.00	2946600.00	2217100.00	1781000.00	1491600.00	1286100.00	1133000.00	1014800.00	921030.00
36.1	8640200.00	4326200.00	2890900.00	2175300.00	1747600.00	1463800.00	1262200.00	1112000.00	996170.00	904280.00
37.1	8474800.00	4243500.00	2835800.00	2133900.00	1714500.00	1436200.00	1238500.00	1091300.00	977760.00	887700.00
38.1	8310900.00	4161600.00	2781100.00	2093000.00	1681700.00	1408800.00	1215100.00	1070800.00	959530.00	871290.00
39.1	8148700.00	4080400.00	2727100.00	2052400.00	1649200.00	1381800.00	1191900.00	1050600.00	941490.00	855050.00
40.1	7988100.00	4000100.00	2673500.00	2012200.00	1617100.00	1355000.00	1169000.00	1030500.00	923640.00	838990.00

Table 3	*SIMULATION 2: I Vs a and phi, L=10000*						*L=100, D=100, b=20*									
var: I	*a*															
phi	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
20	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
21	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00	101.00
22	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00
23	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00	103.00
24	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00
25	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00
26	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00
27	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00	107.00
28	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00	108.00
29	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00
30	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00
31	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00
32	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00	112.00
33	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00
34	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00	114.00
35	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00
36	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00
37	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00	117.00
38	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00	118.00
39	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00
40	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00

Table 4	*SIMULATION 2: ___ Vs a and phi, L=10000*				*L=100, D=100, b=20*					
var:	*a*									
phi	1	2	3	4	5	6	7	8	9	10
20	406140.00	204780.00	138420.00	105800.00	86693.00	74331.00	65827.00	59733.00	55247.00	51885.00
21	502230.00	252960.00	170680.00	130160.00	106340.00	90868.00	80168.00	72449.00	66719.00	62380.00
22	610730.00	307340.00	207090.00	157630.00	128470.00	109480.00	96288.00	86724.00	79579.00	74126.00
23	732250.00	368240.00	247840.00	188350.00	153220.00	130270.00	114280.00	102640.00	93895.00	87184.00
24	867430.00	435970.00	293150.00	222490.00	180700.00	153340.00	134220.00	120260.00	109740.00	101620.00
25	1016900.00	510850.00	343230.00	260210.00	211040.00	178790.00	156220.00	139680.00	127180.00	117490.00
26	1181300.00	593210.00	398290.00	301670.00	244380.00	206750.00	180350.00	160980.00	146290.00	134870.00
27	1361400.00	683370.00	458560.00	347040.00	280850.00	237320.00	206730.00	184240.00	167140.00	153820.00
28	1557700.00	781690.00	524260.00	396490.00	320580.00	270600.00	235440.00	209540.00	189810.00	174410.00
29	1771100.00	888500.00	595630.00	450190.00	363720.00	306730.00	266590.00	236980.00	214380.00	196710.00
30	2002100.00	1004200.00	672900.00	508310.00	410390.00	345800.00	300260.00	266630.00	240930.00	220790.00
31	2251500.00	1129000.00	756310.00	571040.00	460750.00	387950.00	336580.00	298590.00	269530.00	246710.00
32	2520000.00	1263400.00	846090.00	638560.00	514950.00	433300.00	375630.00	332950.00	300260.00	274560.00
33	2808500.00	1407800.00	942500.00	711040.00	573120.00	481960.00	417530.00	369800.00	333210.00	304410.00
34	3117500.00	1562500.00	1045800.00	788680.00	635410.00	534060.00	462380.00	409240.00	368450.00	336330.00
35	3447900.00	1727800.00	1156200.00	871670.00	701990.00	589730.00	510290.00	451350.00	406090.00	370390.00
36	3800500.00	1904300.00	1274000.00	960200.00	773010.00	649100.00	561370.00	496250.00	446190.00	406680.00
37	4176000.00	2092200.00	1399400.00	1054500.00	848610.00	712300.00	615740.00	544010.00	488850.00	445280.00
38	4575200.00	2291900.00	1532800.00	1154700.00	928970.00	779460.00	673500.00	594760.00	534150.00	486250.00
39	4999000.00	2504000.00	1674400.00	1261000.00	1014200.00	850720.00	734780.00	648580.00	582200.00	529700.00
40	5448100.00	2728700.00	1824400.00	1373700.00	1104600.00	926210.00	799690.00	705570.00	633070.00	575690.00

Table 5	*SIMULATION 3: I Vs phi and b*			*L=100, D=100, a=53*						
var: I	*phi*									
b	20	21	22	23	24	25	26	27	28	29
0.1	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90	127.90	128.90
1.1	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90	127.90
2.1	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90
3.1	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90
4.1	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90
5.1	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90
6.1	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90
7.1	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90
8.1	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90
9.1	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90
10.1	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90
11.1	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90
12.1	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90
13.1	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90
14.1	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90
15.1	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90
16.1	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90
17.1	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90
18.1	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90
19.1	100.90	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90
20.1	99.90	100.90	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90

Table 6	***SIMULATION 3: ___ Vs phi and b,***			***L=100, D=100, a=53***							
var:	*phi*										
b	20	21	22	23	24	25	26	27	28	29	30
0.1	174900.00	187790.00	201210.00	215180.00	229700.00	244810.00	260510.00	276820.00	293750.00	311340.00	329590.00
1.1	172970.00	185710.00	198970.00	212770.00	227120.00	242050.00	257560.00	273680.00	290420.00	307800.00	325840.00
2.1	171110.00	183690.00	196790.00	210420.00	224600.00	239350.00	254680.00	270610.00	287150.00	304320.00	322150.00
3.1	169300.00	181730.00	194670.00	208140.00	222150.00	236720.00	251870.00	267600.00	283950.00	300920.00	318530.00
4.1	167550.00	179830.00	192620.00	205920.00	219760.00	234150.00	249120.00	264660.00	280810.00	297580.00	314990.00
5.1	165860.00	177990.00	190620.00	203760.00	217440.00	231650.00	246430.00	261790.00	277750.00	294320.00	311510.00
6.1	164240.00	176220.00	188690.00	201670.00	215170.00	229220.00	243820.00	258990.00	274750.00	291120.00	308110.00
7.1	162670.00	174500.00	186820.00	199640.00	212980.00	226850.00	241270.00	256250.00	271820.00	287990.00	304770.00
8.1	161160.00	172850.00	185010.00	197670.00	210840.00	224540.00	238780.00	253580.00	268960.00	284930.00	301510.00
9.1	159720.00	171250.00	183260.00	195770.00	208770.00	222300.00	236360.00	250980.00	266160.00	281940.00	298310.00
10.1	158340.00	169720.00	181580.00	193920.00	206760.00	220120.00	234010.00	248440.00	263440.00	279010.00	295190.00
11.1	157010.00	168250.00	179960.00	192140.00	204820.00	218010.00	231720.00	245970.00	260780.00	276160.00	292130.00
12.1	155750.00	166850.00	178400.00	190430.00	202940.00	215960.00	229500.00	243570.00	258190.00	273370.00	289140.00
13.1	154550.00	165500.00	176900.00	188770.00	201130.00	213980.00	227340.00	241230.00	255660.00	270660.00	286230.00
14.1	153400.00	164210.00	175470.00	187180.00	199380.00	212060.00	225250.00	238960.00	253210.00	268010.00	283380.00
15.1	152320.00	162990.00	174100.00	185660.00	197690.00	210210.00	223220.00	236760.00	250820.00	265430.00	280610.00
16.1	151300.00	161820.00	172780.00	184190.00	196070.00	208420.00	221270.00	234620.00	248500.00	262920.00	277900.00
17.1	150340.00	160720.00	171540.00	182790.00	194510.00	206700.00	219370.00	232550.00	246250.00	260480.00	275260.00
18.1	149440.00	159680.00	170350.00	181450.00	193010.00	205040.00	217540.00	230550.00	244070.00	258110.00	272700.00
19.1	148600.00	158700.00	169220.00	180180.00	191580.00	203440.00	215780.00	228610.00	241950.00	255810.00	270200.00
20.1	147820.00	157780.00	168160.00	178970.00	190210.00	201910.00	214090.00	226740.00	239900.00	253570.00	267780.00

Table 7	***SIMULATION 3.a: I Vs phi and b***			***L=100, D=100, a=1***						
var: I	*phi*									
b	20	21	22	23	24	25	26	27	28	29
0.1	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90	127.90	128.90
1.1	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90	127.90
2.1	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90
3.1	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90
4.1	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90
5.1	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90
6.1	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90
7.1	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90
8.1	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90
9.1	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90
10.1	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90
11.1	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90
12.1	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90
13.1	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90
14.1	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90
15.1	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90
16.1	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90
17.1	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90
18.1	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90
19.1	100.90	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90
20.1	99.90	100.90	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90

Table 8	***SIMULATION 3.a: ___ Vs phi and b***			***L=100, D=100, a=1***						
var:	*phi*									
b	20	21	22	23	24	25	26	27	28	29
0.1	28775.00	3225400.00	3598500.00	3997800.00	4423900.00	4877900.00	5360600.00	5872900.00	6415800.00	6990100.00
1.1	2829700.00	3172300.00	3539800.00	3933000.00	4352800.00	4800100.00	5275800.00	5780700.00	6315800.00	6882100.00
2.1	2782300.00	3119600.00	3481500.00	3868700.00	4282300.00	4723000.00	5191700.00	5689300.00	6216700.00	6774900.00
3.1	2735300.00	3067400.00	3423700.00	3805000.00	4212300.00	4646400.00	5108200.00	5598600.00	6118400.00	6668600.00
4.1	2688800.00	3015600.00	3366300.00	3741800.00	4143000.00	4570500.00	5025500.00	5508600.00	6020800.00	6563100.00
5.1	2642600.00	2964200.00	3309500.00	3679200.00	4074200.00	4495300.00	4943400.00	5419300.00	5924100.00	6458400.00
6.1	2596800.00	2913300.00	3253100.00	3617100.00	4006000.00	4420600.00	4862000.00	5330800.00	5828100.00	6354600.00
7.1	2551400.00	2862900.00	3197300.00	3555500.00	3938300.00	4346600.00	4781200.00	5243000.00	5732900.00	6251700.00
8.1	2506500.00	2812800.00	3141900.00	3494400.00	3871300.00	4273200.00	4701200.00	5156000.00	5638500.00	6149600.00
9.1	2461900.00	2763300.00	3087000.00	3433900.00	3804800.00	4200500.00	4621800.00	5069600.00	5544800.00	6048300.00
10.1	2417700.00	2714100.00	3032600.00	3373900.00	3738900.00	4128300.00	4543100.00	4984000.00	5452000.00	5947800.00
11.1	2374000.00	2665400.00	2978600.00	3314400.00	3673500.00	4056800.00	4465100.00	4899200.00	5359900.00	5848300.00
12.1	2330600.00	2617200.00	2925200.00	3255500.00	3608800.00	3985900.00	4387700.00	4815000.00	5268700.00	5749500.00
13.1	2287600.00	2569400.00	2872200.00	3197100.00	3544600.00	3915600.00	4311000.00	4731600.00	5178200.00	5651600.00
14.1	2245100.00	2522000.00	2819800.00	3139200.00	3481000.00	3846000.00	4235000.00	4648900.00	5088500.00	5554500.00
15.1	2202900.00	2475100.00	2767800.00	3081800.00	3418000.00	3777000.00	4159700.00	4567000.00	4999500.00	5458300.00
16.1	2161100.00	2428600.00	2716300.00	3025000.00	3355500.00	3708600.00	4085100.00	4485700.00	4911400.00	5362900.00
17.1	2119800.00	2382500.00	2665300.00	2968700.00	3293600.00	3640900.00	4011100.00	4405300.00	4824100.00	5268400.00
18.1	2078800.00	2336900.00	2614700.00	2912900.00	3232400.00	3573700.00	3937800.00	4325500.00	4737500.00	5174700.00
19.1	2038200.00	2291800.00	2564700.00	2857700.00	3171600.00	3507200.00	3865200.00	4246500.00	4651700.00	5081800.00
20.1	1998100.00	2247000.00	2515100.00	2803000.00	3111500.00	3441300.00	3793300.00	4168200.00	4566700.00	4989800.00

Table 9	***SIMULATION 3.b: I Vs phi and b***			***L=100, D=100, a=1000***						
var: I	*phi*									
b	20	21	22	23	24	25	26	27	28	29
0.1	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90	127.90	128.90
1.1	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90	127.90
2.1	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90	126.90
3.1	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90	125.90
4.1	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90	124.90
5.1	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90	123.90
6.1	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90	122.90
7.1	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90	121.90
8.1	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90	120.90
9.1	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90	119.90
10.1	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90	118.90
11.1	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90	117.90
12.1	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90	116.90
13.1	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90	115.90
14.1	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90	114.90
15.1	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90	113.90
16.1	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90	112.90
17.1	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90	111.90
18.1	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90	110.90
19.1	100.90	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90	109.90
20.1	99.90	100.90	101.90	102.90	103.90	104.90	105.90	106.90	107.90	108.90

Table 10	***SIMULATION 3.b: ___ Vs phi and b***			***L=100, D=100, a=1000***						
var:	*phi*									
b	20	21	22	23	24	25	26	27	28	29
0.1	22794.00	2399100.00	2519900.00	2641700.00	2764500.00	2888400.00	3013300.00	3139200.00	3266100.00	3394100.00
1.1	2259900.00	2378700.00	2498400.00	2619200.00	2741100.00	2863900.00	2987800.00	3112700.00	3238600.00	3365600.00
2.1	2241500.00	2359200.00	2478000.00	2597800.00	2718600.00	2840400.00	2963300.00	3087200.00	3212100.00	3338100.00
3.1	2224000.00	2340800.00	2458500.00	2577300.00	2697100.00	2817900.00	2939800.00	3062700.00	3186600.00	3311600.00
4.1	2207600.00	2323300.00	2440100.00	2557800.00	2676600.00	2796500.00	2917300.00	3039200.00	3162100.00	3286100.00
5.1	2192100.00	2306900.00	2422600.00	2539400.00	2657200.00	2776000.00	2895800.00	3016700.00	3138600.00	3261600.00
6.1	2177700.00	2291400.00	2406200.00	2521900.00	2638700.00	2756500.00	2875400.00	2995200.00	3116100.00	3238100.00
7.1	2164300.00	2277000.00	2390700.00	2505500.00	2621200.00	2738000.00	2855900.00	2974700.00	3094600.00	3215600.00
8.1	2151800.00	2263500.00	2376200.00	2490000.00	2604800.00	2720600.00	2837400.00	2955300.00	3074100.00	3194100.00
9.1	2140400.00	2251100.00	2362800.00	2475500.00	2589300.00	2704100.00	2819900.00	2936800.00	3054600.00	3173600.00
10.1	2129900.00	2239600.00	2350300.00	2462100.00	2574800.00	2688600.00	2803400.00	2919300.00	3036200.00	3154000.00
11.1	2120500.00	2229200.00	2338900.00	2449600.00	2561400.00	2674200.00	2788000.00	2902800.00	3018700.00	3135600.00
12.1	2112000.00	2219700.00	2328400.00	2438200.00	2548900.00	2660700.00	2773500.00	2887300.00	3002200.00	3118100.00
13.1	2104600.00	2211300.00	2319000.00	2427700.00	2537400.00	2648200.00	2760000.00	2872800.00	2986700.00	3101600.00
14.1	2098100.00	2203800.00	2310500.00	2418200.00	2527000.00	2636700.00	2747500.00	2859400.00	2972200.00	3086100.00
15.1	2092700.00	2197400.00	2303100.00	2409800.00	2517500.00	2626300.00	2736100.00	2846900.00	2958700.00	3071600.00
16.1	2088300.00	2191900.00	2296600.00	2402300.00	2509100.00	2616800.00	2725600.00	2835400.00	2946200.00	3058100.00
17.1	2084800.00	2187500.00	2291200.00	2395900.00	2501600.00	2608300.00	2716100.00	2824900.00	2934700.00	3045600.00
18.1	2082400.00	2184000.00	2286700.00	2390400.00	2495100.00	2600900.00	2707600.00	2815400.00	2924200.00	3034100.00
19.1	2080900.00	2181600.00	2283300.00	2386000.00	2489700.00	2594400.00	2700200.00	2806900.00	2914800.00	3023600.00
20.1	2080500.00	2180100.00	2280800.00	2382500.00	2485200.00	2588900.00	2693700.00	2799500.00	2906300.00	3014100.00

Part II

Essays on Innovation and Finance

Chapter 2

State of Technology, Innovation and Finance

2.1 Introduction

In recent years there has been a wide debate about the financing of innovation. Indeed, often firms have ideas but do not have funds, therefore they have to be financed externally. A major problem of external funding of R&D is that it is greatly affected by information asymmetries. In this sense, a wide literature has focused on various factors, like screening and monitoring by financial investors, investors specialization, level of legal investor protection and contract incompleteness.[1] However, these factors require a different set of conditions that often depend on the countries and the sectors under consideration (Levine, 2005).[2]

One aspect that has received little attention is at what stage of technology advancement financial frictions have more or less severe consequences on innovation activities. In fact, it might be argued that innovation is harder to undertake when the technology available to a firm is more backward. With regard to this point, it is a general argument that technology adoption from a world frontier is more diffused in backward countries,

[1] For financial development, see for example the theoretical contribution of De la Fuente and Marin (1996), while an important empirical contribution is from Rajan and Zingales (1998). For the legal investor protection literature see the seminal papers of La Porta et al. (1997 and 1998). For contract incompleteness, see Aghion and Bolton (1992). For the specialization of investors see for example Gompers and Lerner (2001).

[2] See also Khan (2001), Boyd and Smith (1998), Acemoglu and Zilibotti (1997), Roubini and Sala-i-Martin (1995), De Gregorio (1993), King and Levine (1993b), Bencivenga and Smith (1993), Saint-Paul (1992), Levine (1991) and Greenwood and Jovanovic (1990), are key examples of this strand of literature. Comprehensive surveys on the topic are those by Levine (1997) and Pagano (1993).

while the advancement of the frontier technology is more intense in more technologically advanced countries. Neverthless, it turns out that in these last two decades, some technologically advanced countries have been lagging behind in productivity growth with respect to partner countries endowed with similar technology. This is the noticeable case of some big European countries and Japan (Vs US and UK, mainly), as documented various by authors.[3]

While the literature has provided many explanations for this cross country growth gap, like labour market rigidities or heavier business regulation, we focus mainly on the problems that financial frictions create for undertaking innovation. In doing so, we abstract from technology difficulties to catch up with the technology frontier, and focus only on the role of financial frictions at the stage of financing R&D projects. We show that asymmetric information creates more severe problems of financing innovation when a firm disposes of a more advanced state of technology.

With the term s.o.t. we mean whether an entrepreneur operates in a sector that in her country is more or less distant from the world technology frontier. This variable has an interesting characteristic when related to innovation. Namely, the s.o.t. determines whether entrepreneurs have profitable alternatives to innovation. For example, in sectors at the world technology frontier entrepreneurs may only undertake projects that shift out the current frontier (innovation), while in sectors inside the frontier entrepreneurs may also undertake projects that improve upon the local sector technology, but that do not reach the world frontier (imitation).[4] We show that there can be states of technology of short distance to the world frontier where not only financial frictions may be more severe for financing of innovation projects, but also that in some cases a form of financial development may not occur.

In particular, when a sector is inside but close to the frontier, due to financial frictions, highly skilled entrepreneurs are financed but do not undertake innovation, but the less productive activity (imitation). This is because as the distance to the world frontier is shorter, the opportunity cost of undertaking innovation increases: imitation profits increase relatively to those of innovation. Then, unless the interest rate changes, entrepreneurs prefer to undertake imitation rather than innovation. In this sense, the paper shows that innovation can suffer of a form adverse selection, which differs from

[3] To mention just a few, see for example Daveri (2004), OECD (2003).

[4] This activity usually consits of adoption of technology from the world frontier. While this concept has been also adopted in various papers (see for example AAZ (2006)), an empirical finding of the relevance of imitation and innovation as sources of productivity growth is given by Redding, Griffith and Van Reenen (2004).

the usual models of credit rationing because, the investor does not refuse to finance the investment, as for example in Stiglitz and Weiss (1981); instead, entrepreneurs are financed, but the most skilled use the funds to undertake the less productive project.

Moreover, we study the implementability of two devices that allow to remove the inefficiencies deriving from adverse selection: a form of financial development, that we call monitoring (by the investor over the firm activity) and a form of signalling, through education, that allows low skilled entrepreneurs to increase their skills and become high skilled. In particular, monitoring allows the investor to reveal the true type of entrepreneur, so that a proper form of financial contract can be designed. We design monitoring according two main characteristics: quality and cost of monitoring. Quality can be perfect (so that monitoring allows the investor to reveal the true type of entrepreneur) or more realistically it can be imperfect (when the true type revelation is not always possible). Secondly, monitoring is costly and the cost can be shared between the two parties: entrepreneur and investor. Since the cost share in the model depends on the relative bargaining power of the parties, it also represents a proxy of the market concentration of the financial investors (we keep the distribution of firms fixed). In our discussion about monitoring, we correlate quality and the cost share parameters according to different scenarios; that is, we show that innovation is undertaken when: a) quality of monitoring high and the investors cost share is highest; or b) poor quality of monitoring and the investor cost share is lower.

While monitoring is executed during the research period, education is an ex-ante activity as it is undertaken before research has started. Education also differs from monitoring because its cost is always fully paid by the entrepreneur and it allows the entrepreneur to send a signal to the investor revealing her true type. Education increases entrepreneurs skills of low skilled entrepreneurs, with a positive probability, while high skilled when undertaking education benefit of a signal that *always* reveals their true type.

For both these devices we study their implementability in states of technology close to the frontier, that is when the problems created by the financial frictions are most severe. In this way, the model highlights that the state of technology is a relevant variable for the policymaker deciding to undertake two main policies for the promotion of growth: financial development by reducing the bargaining power of the financial investors and/or improvement of monitoring quality; educational programs improving entrepreneurship.

In short, with regard to monitoring and education we show that:

1. Innovation with perfect monitoring can be implemented in the region of technology

of "close distance" to the frontier;

2. Innovation with imperfect monitoring cannot always be implemented in the "close distance" region if the cost share of the investor is excessively high.

   In turn, with regard to education:

3. Innovation with education can always be implemented in the "close distance" to the frontier region.

The results of this model may help to explore the analysis of the recent growth gap between countries with a similar technology advancement . Notably, the case of Continental Europe, where in the last decade financing of innovation has lagged behind that of the US.

2.1.1 Related Literature

This paper is related to different strands of literature. First, the paper is related to a recent contribution by Aghion, Acemoglu, Zilibotti ((2006), AAZ henceforth). In their model, due to credit-market imperfections, the retained earnings of entrepreneurs enable them to undertake greater investments (imitation) rather than selection of good managers necessary for innovation. Therefore, credit market imperfections matter for the trade-off between imitation and innovation, especially when the distance to frontier is short.[5] Our paper has three main similarities with AAZ: first, firms inside the frontier have a double technology choice (innovation/imitation); second, there are imperfections in the financial markets; third and most important, the severity of financial frictions matters for regions close to the world technology frontier. Differently from them, in this paper we address two different issues: first, monitoring and education can mitigate financial frictions. Secondly, we also explore the role of a second device: education. An important consequence of this is that while AAZ conclude that the change of the type of investment strategy is key to avoid poverty traps, we instead focus on the costs of financial frictions which may be reduced through appropriate policies for the financial sector and for the formation of human capital.

With regard to monitoring, the paper is related to the literature on the link between financial competition and relationship lending. The theoretical literature offers opposing

[5] They show that "if an economy does not switch out of the investment-based strategy before this threshold, it will be stuck in a non convergence trap where convergence to the frontier stops." AAZ, page 6.

views on whether financial competition is beneficial for growth or rather it hampers credit expansion. We mention just few contributions, which are most related to our work. In Cetorelli and Peretto (2000) relationship lending in competitive credit markets can have negative consequences for capital accumulation and growth: in presence of market power banks have more incentive to undertake screening activities since they can extract a rent from the information advantage this would generate. Our paper finds different results, because in our case screening quality has to be improved when investors competition is harder. Similarly, Cordella and Yeyati (2002) show that banking competition leads to a lower investment in monitoring by the banks. On the other hand, Shaffer (1998) shows that the number of loans increases with the number of banks.[6] Our paper is related to Shaffer (1998) because the screening technology used by banks is imperfect. Boot and Thakor (2000) argue that in a competitive environment banks may increase relationship lending because in this way they avoid the decrease of profits (as it happens in transactional lending).[7]

With regard to education, the paper is related to the literature on the role of human capital in fostering innovation. In particular, the most related paper is from Aghion, Costas and Vandenbussche (ACV henceforth (2004)). ACV show that the contribution of human capital (especially tertiary education) to productivity growth depends crucially on the relative composition of skilled and unskilled labour, with skilled labour productivity increasing as the country is closer to the technology frontier. We share with ACV the view that education plays an important role to innovation through an increase of the stock of human capital available in the economy and that the impact of education on the economy is more important for more advanced states of technology. However, differently from ACV we model the link between education and growth: education spurs growth by reducing the severity of financial frictions.

Moreover, other works have studied the role of education on growth. The new endogenous growth theories by Romer (1990) and Aghion and Howitt (1992) give a theoretical support to the role of human capital as the engine of growth through innovation, but also other works have explored the role of human capital accumulation and growth.[8]

[6] Shaffer further explains the effects of his findings: the more banks there are, the less chance there is that any given borrower will not get a loan.

[7] Moreover, empirical tests of the relationship between market structure and growth also offer mixed evidence. On the one hand, Petersen and Rajan (1995) offer evidence that firms are less credit constrained and face cheaper credit the more concentrated is the credit market. Similarly, Cetorelli and Gambera (2001) find that the impact of financial market concentration on growth is negative. On the other hand, Black and Stranhan (2002) find that less concentration favours the creation of new firms.

[8] See for example Krueger and Lindahl (2001), Bassanini and Scarpetta (2001), Cohen and Soto (2001) and De la Fuente and Domenech (2002).

Finally, the paper is also related to the wide literature on the financing of innovation. It is beyond the scope of this paper to present an exhaustive review of the literature here, but we report few relevant contributions. The early literature has focused on credit rationing to high tech firms by banks; for example Guiso (1998) has argued that banks in Italy ration credit to innovative firms while preferring to finance traditional activities, since they know more about their businesses than about high tech firms. This paper is key in motivating our analysis, because it highlights that financial investors may prefer not to finance innovation but less productive activities. Moreover, a huge literature has looked at the role of specialized investors (Gompers and Lerner, 2001) like venture capitalists and the type of financial contracts they use (Kaplan and Stromberg (2003). Differently from this literature, this work does not explore in depth the role of specialized investors, but simply considers the link between the s.o.t. and the financial contracts for innovation. This work differs also from the literature on financial development and growth in the context of innovation-based growth models, as for example in De la Fuente and Marin (2002) and Aghion et al. (2005).[9] While in all these works financial development has a positive impact on growth at all stages of technology, in our work we consider how the state of technology impacts the economy through financial frictions.

The rest of the paper is structured as follows. The following section contains the basic set-up of the model and it explains the role of the financial frictions in the region of "close distance"; in section 3 we review a form of financial development of the basic contract: monitoring, In section 4 we explore the role of signalling on innovation through education. Section 5 concludes.

2.2 The model

Consider an economy where there are three different production levels: a unique final good Y produced competitively; the final good is produced by assembling V intermediate inputs x_v (for $i = 1, 2..., v, ..., V$) which are produced under monopoly. Each intermediate input is created at a preceding stage, where entrepreneurs undertake R&D projects in a patent race. At this stage firms are competitive and there is free entry. The winner of the patent race becomes a monopolist at the intermediate production stage.[10]

The final good is produced according to the following production function:

[9] Moreover, Bencivenga and Smith (1993) showed that credit rationing reduces growth due to adverse selection problems.

[10] Alternatively, he can sell the blueprint at the value of the expected profits.

$$Y_t = \frac{1}{\alpha} \sum_{v=1}^{V} A(v)^{1-\alpha} k(v)^{\alpha} \tag{2.1}$$

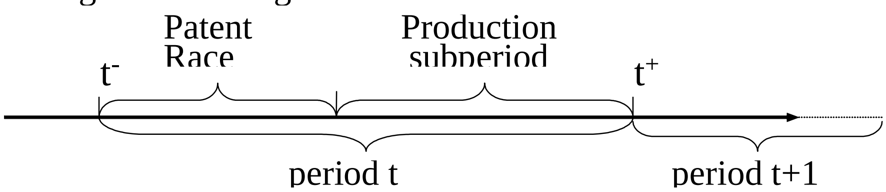
where $0 < \alpha < 1$, $A(v)$ is the state of technology of sector v, and $k(v)$ is the amount of the v^{th} intermediate input.

2.2.1 Timing

Each period is divided into two consecutive subperiods. At the beginning of the research subperiod entrepreneurs engage in a patent race undertaking R&D projects. Each entrepreneur may undertake a project of innovation or of imitation (see below about the technology choice).[11] After the completion of the R&D subperiod, the winner of the patent race gets a monopoly right to produce the blueprint during the second subperiod. At the end of the second subperiod, a new period starts, where the highest state of technology, reached by the winner of the patent race of the previous period, becomes publicly available to all agents; this means that at the beginning of the patent race subperiod, in each of the intermediate sectors the highest level of the previous period TFP $[A_{t-1}]$ is available to any firm.[12]

Finally, the timing comes at regular intervals for simplicity and it is shown in figure 1:

Figure 1: Timing Line:



2.2.2 R&D stage

Entrepreneurs at this stage may undertake one (and only one) of the three available technologies: innovation, imitation and a storage technology. Innovation and imitation activities allow to produce blueprints at a higher productivity with respect to the starting level; in particular, innovation is such that it shifts out the current frontier, while

[11] If the entrepreneur undertakes the storage technology, the investment lasts all the period: from t^- to t^+.

[12] With some abuse of terminology, quality, knowledge and TFP are used indifferently.

imitation improves upon the local sector technology, but does not reach the world frontier. Finally, the storage technology is a riskless bond, which implies no improvement of technology.

The investment required to undertake each of the productive activities is N and it is fixed. Entrepreneurs undertaking innovation/imitation have ideas but do not have funds,[13] so they have to be financed externally by a lender that we call generally investor. Let R be the gross interest rate, representing the cost of external financing for the entrepreneur. In the case of innovation, there is a patent race; the winner of this race is a monopolist of the blueprint, that grants him a monopoly profit of $\delta\bar{A}$ (where $\bar{A}$ is the frontier state of technology and δ is a positive parameter, so as derived in Appendix 1). Similarly, the successful imitator will sell the intermediate good at a production profit δA (see Appendix 1). Notice that innovation allows higher production profits than imitation, so that ex-ante all entrepreneurs would like to undertake innovation. However, this choice is not trivial if we are to take into consideration the costs of external financing, as it will be explained below.

Entrepreneurs differ each other in skills, where skills matter only for innovation. In particular, differences in skills take the simplest form: there is a mass H of high skilled entrepreneurs, and a mass L of low skilled ones (we will refer to them as H and L types respectively), and let $X = H + L$ be the total number of entrepreneurs. The type of skill is a private information of each entrepreneur.

In the following lines we will set up the technology choice set and will derive the conditions such that innovation is undertaken (by the entrepreneur) and financed (by the investor) in presence of asymmetric information.

Technologies

The technologies available to an entrepreneur at the R&D stage have been briefly described above. When we consider also the financing costs, then net profits from the three technologies become:

1. Profits from imitation: $\pi_M = \delta A - RN$
2. Expected profits from Innovation: $E(\pi_j) = f_j \left(\delta\bar{A} - RN\right)$ for $j = H, L$
3. Storage technology (bond): $\pi_B = r_0 N$

[13] An extension with the entrepreneurs own funds is described in Appendix 2.

where R is the gross interest rate to be contracted between the parties, r_0 is the riskless interest rate and $f_j = \frac{p_j}{Hp_H + Lp_L}$ is the conditional probability of success of a j-type entrepreneur. The probabilities are constructed as follows. Each entrepreneur has an intrinsic probability of success that depends on its type: p_j, for $j = H, L$, with $p_H > p_L$. The individual probability of success p_j is unconditional on others participants to the R&D race. Since production profits from innovation are higher than those of imitation (see Appendix 1), all entrepreneurs are willing to undertake innovation by participating to the innovation R&D race. Therefore, the conditional individual probability of success depends also on the number of participants to the R&D race: $f_j = p_j / (p_H H + p_L L)$: as the actual number of entrepreneurs participating in the patent race for innovation increases, the individual probability of success is reduced.[14]

Expected innovation's profits depend on the conditional probability of success f_j, and they also increase with the level of production profits $\delta \bar{A}$ minus the cost of financing RN. This specification implies that in case of failure the borrower will default on his debt. Note that innovation (and only innovation) bears a risk of default on the amount borrowed. Profits from imitation π_M are composed of the production profits level δA (see Appendix 1), and of the financial cost, that is given by RN. Finally, the storage technology offers a riskless rate r_0.[15]

Investment choices

Investment choices are non contractible ex-ante between investor and entrepreneur. This means that ex ante the entrepreneur may declare to borrow to undertake one type of project and actually implement another type. Since the outcome of the project is publicly known (for example the outcome of innovation is patented), the contracted interest rate might differ from the one that is actually due, implying a potential loss for the investor. We assume that the investor prefers to appropriately structure the contract

[14] The probability of success is modelled with two implicit assumptions: first, each type of entrepreneur uses the same research strategy, so that the probability depends only on intrinsic skills; second, there cannot be two winners at the same time: this ensures not only that the winner gets a monopoly power (for a similar approach, see Zeira (2003)). Moreover, this probability is increasing (at a decreasing rate β with $0 < \beta < 1$) in the amount of funds invested: N^{β}: $f_j = \frac{p_j N^{\beta}}{Hp_H N^{\beta} + Lp_L N^{\beta}} = \frac{p_j}{Hp_H + Lp_L}$.

[15] We can determine which is the minimum state of technology such that imitation and innovation can be undertaken. For imitation, we have that $\pi_M \geq \pi_B \Longrightarrow \delta A - RN \geq r_0 N$. Moreover, from the indifference relation of the investor for imitation, we have that: $RN - N \geq r_0 N \Longrightarrow R_M = 1 + r_0$. Substituting R_M into the first expression above we find A_M: $A \geq A_M = \frac{(1+2r_0)}{N}$

While for Innovation we have: $E(\pi_j) = f_j \left[\delta \bar{A} - RN \right] \geq \pi_B = r_0 N$

or also: $\bar{A} \geq \bar{A}_0 = \frac{r_0 N^2 (1-f_j) + f_j \delta A}{f_j \delta [N(1-f_j) - f_j A]}$. The proof is in the appendix.

so that he does not incur in expected losses.[16] Then, the investor considers that a j-type entrepreneur undertakes innovation if:

$$E(\pi_j) \geq \pi_M \Longrightarrow f_j \left[\delta \bar{A} - RN\right] \geq \delta A - RN$$

which gives $R \leq R_j$:

$$R_j = \frac{\delta \bar{A}}{N} \frac{a - f_j}{1 - f_j} \tag{2.2}$$

R_j is the maximum interest that the entrepreneur may accept in order to credibly commit to undertake innovation; $a_t = \frac{A_t}{\bar{A}_t}$ is an inverse index of distance to the frontier (or conversely a direct index of proximity to the frontier).[17] In (2.2) the equality sign derives from the free entry condition. In addition, note that $R_H < R_L$: for innovation a lower skilled entrepreneur is willing to pay up to an interest rate (R_L) higher than what higher skilled may want (R_H), because the former, having lower skills, he know that his project is more risky.

Note that R_j increases with the index a. The intuition of this can be seen from the next figure. Note that as we move closer to the technology frontier (namely, an increase of A, or an increase in a), then R_j increases. This is because when $A/\bar{A}$ increases, for the same level of the interest rate imitation becomes relatively more convenient to innovation. Then, the entrepreneur will be again indifferent between the two activities only for a higher interest rate.

[16] One possible explanation is that the renegotiation costs of enforcement is excessively costly.

[17] For example, when $a_t = 1$ the sector is at the frontier, while if $a_t = \frac{1}{2}$ the sector is at half distance and so on.

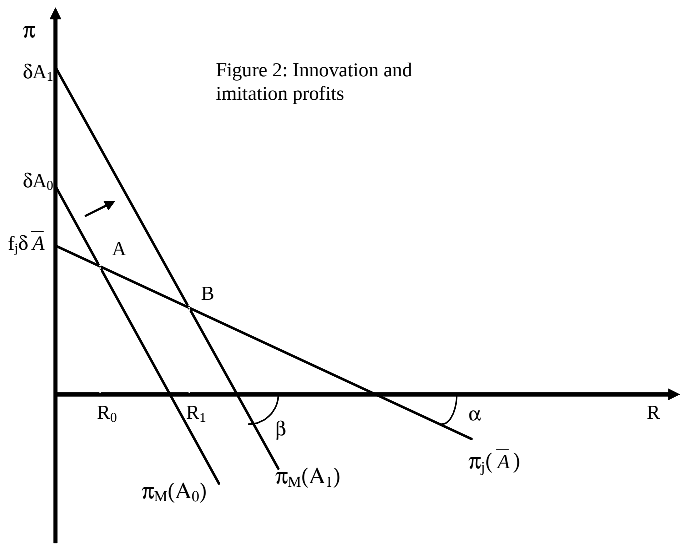


Figure 2: Innovation and imitation profits

$$tg\alpha = -f_jN;\ tg\beta = -N$$

In turn, the investor will finance j-type entrepreneur if the expected returns are higher than those of a storage technology:[18]

$$E(\pi^i_j) \geq \pi_B \Longrightarrow f_jRN - N \geq r_0N$$

and so $R \geq R^i_j$ (i stays for investor):

$$R^i_j = \frac{R_0}{f_j} \tag{2.3}$$

Notice that $R^i_H < R^i_L$ means that financing less skilled entrepreneurs implies a charging them a higher interest rate.

In order to have that the financial outlay is actually spent for innovation, we need to consider the inequalities, that is: $R \leq R_j$ and $R \geq R^i_j$ for any $j = H, L$. These inequalities mean that innovation: *i)* is undertaken by a j-type entrepreneur if the contracted interest rate is not greater than R_j; *ii)* it is financed by an investor if the contracted interest rate is not smaller R^i_j; then, the contracted interest rate has to be in the range $R^i_j \leq R \leq R_j$ (for any j). In order to have a unique solution, we assume that in equilibrium the interest rate contracted is the lowest for the entrepreneur: R^i_j.[19]

[18] More formally, the investor finances the innovation project if the expected returns are higher than those of imitation and those of a storage technology: $f_jRN - N \geq RN - N \geq R_0N - N$. From the second inequality we have that $R_M = R_0$, where R_0 is the gross interest rate on imitation. Replacing R_M into the first inequality we end with the inequality that is in the main text.

[19] One way to think of this situation is to think that there are more investors than entrepreneurs.

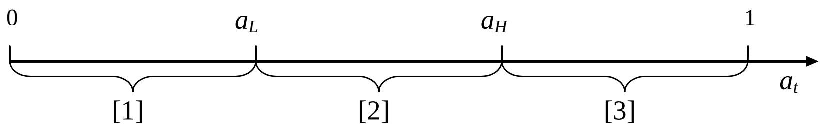
In general, for an innovation project to be implemented (that is to say that it is financed by an investor and undertaken by a j-type entrepreneur) the necessary condition is $R_j^i \leq R_j$ (we call this the 'implementability' condition), which can be translated into the distance to the frontier index:

$$a \geq a_j = f_j + \frac{R_0 N}{\delta \bar{A}} \frac{1 - f_j}{f_j} \tag{2.4}$$

a_j defines the minimum state of technology such that innovation can be undertaken by a j-type entrepreneur and financed by an investor.

Furthermore, assuming that $a_L < a_H$,[20] that is to say that H-types can be financed for innovation only for a shorter distance to the frontier than L-types, as shown in the following figure:

Figure 3: regions of innovation / imitation



With this ordering,[21] we can divide the distance to the frontier range into three regions:

(1) $0 < a < a_L$, where $R_j^i > R_j \ \ \forall j$; for each type of entrepreneur the minimum interest rate charged by the investor is higher than the maximum interest rate such that an entrepreneur undertakes innovation. This implies that H and L types are financed for imitation only.

(2) $a_L < a < a_H$, where $R_H^i > R_H$; the argument of region [1] can also be applied here for H-types; in fact, they still cannot be financed for innovation while $R_L^i \leq R_L$ implies that L-types can be financed for innovation.

(3) $a_H < a < 1$, where $R_j^i \leq R_j \ \ \forall j$; this implies that both H and L-types can be financed for innovation.[22]

[20] Fot this ordering we need to impose to impose that $\delta \bar{A} f_H f_L > R_0 N$.

[21] The opposite ordering, with $a_H < a_L$, is not discussed in the ensuing discussion. While we skip the discussion of this second case for sake of brevity, the results are not affected by the ordering. For example, see the next footnote.

[22] Note that if we had $a_L > a_H$, then in region [2] only H types would be financed for innovation, while in region [3] still both types could be financed for innovation.

It is immediate to see that regions (1) and (2) do not create problems of asymmetric information, therefore we focus on region (3).[23] Had we not asymmetric information, H-types would undertake innovation at the interest rate R_H^i and L-types at R_L^i. However, when we introduce asymmetric information, we show that this matters for financing of innovation at advanced states of technology. Indeed, this can be seen by considering first the following lemma:

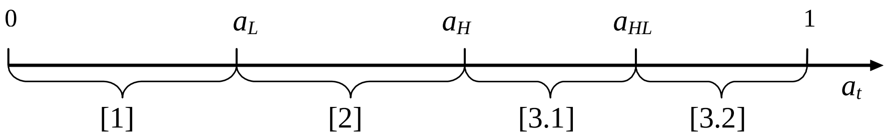
Lemma 1 *In region (3), because of asymmetric information, L-types have always an incentive to hide and claim to be H-types, so that they can pay R_H^i instead of R_L^i.*

The incentive to claim the other type for lower skilled entrepreneurs is given by the temptation to pay a lower interest rate: R_H^i instead of R_L^i. Note that in region (2) asymmetric information does not matter because it is public information that only L-types can undertake innovation.[24]

Going back to region (3), we assume, without loss of generality, that because of hidden information by L-types, the investor may at first consider to propose a pooling contract to the borrower; that is to say he offers a contract with an average interest rate $\bar{R}^i = hR_H^i + (1-h)\,R_L^i$,[25] so that $R_H^i < \bar{R}^i < R_L^i$.

Since $\bar{R}^i$ can be higher or lower than R_H, we can derive two subregions: (3.1) where $R_H < R_L^i$ and (3.2) where $R_H \geq R_L^i$, as shown in figure 4:

Figure 4: regions of innovation / imitation



We can further subdivide subregion [3.1] into two possible subregions (depending on whether $\bar{R}^i$ is greater or smaller than R_H):

(3.1.1) $R_H^i < \bar{R}^i < R_H < R_L^i < R_L$ (with $\bar{R}^i < R_H$)

[23] With regard to the size of this region, notice that it is wider as the frontier technology $\bar{A}$ moves forward. In fact, from (2.4), as $\bar{A}$ increases, the threshold decreases, so widening the range of region (3).

[24] In region [1] asymmetric information does not matter as innovation is undertaken by neither type of entrepreneurs.

[25] $\bar{R}^i = \frac{HR_H^i + LR_L^i}{X} = hR_H^i + (1-h)\,R_L^i$, where $h = \frac{H}{X}$ and $l = \frac{L}{X}$.

and

(3.1.2) $R_H^i < R_H < \bar{R}^i < R_L^i < R_L$ (with $R_H < \bar{R}^i$)

Starting with the case (3.1.1), we have the following result:

Proposition 4 *If $R_H^i < \bar{R}^i < R_H < R_L^i < R_L$, then $\bar{R}^i$ is a pooling equilibrium interest rate where both types of entrepreneurs undertake innovation.*

Proof. Since $\bar{R}^i < R_L^i$, L-types have an incentive to lie and claim to be H-types. In this case if the investor proposes $\bar{R}^i$: L-types accept it (and undertake innovation) and H-types also accept it (also for innovation) because even if $\bar{R}^i > R_H^i$, still $\bar{R}^i < R_H$. ■

The subregion (3.1.2) is characterized by $R_H < \bar{R}^i$. In this region, it turns out that there is a separating contract where only L-types undertake innovation:

Proposition 5 *If $R_H^i < R_H < \bar{R}^i < R_L^i < R_L$, then there is a pooling equilibrium, where H-types entrepreneurs undertake imitation while L-types entrepreneurs undertake innovation.*

Proof. Since $\bar{R}^i < R_L^i$, L-types have an incentive to lie and claim to be H-types. In this case if the investor proposes $\bar{R}^i$, L-types accept it (and undertake innovation), while H-types also accept it but undertake imitation because $\bar{R}^i > R_H$. ■

Note that this result is a form of adverse selection, because the less (more) skilled entrepreneurs undertake the more (less) productive activity.

We now move to the case of region (3.2), where $R_L^i \leq R_H$; in this case the ordering is: $R_H^i < \bar{R}^i < R_L^i \leq R_H < R_L$. In this case we have a pooling equilibrium:

Proposition 6 *If $R_H^i < \bar{R}^i < R_L^i \leq R_H < R_L$, then $\bar{R}^i$ is a pooling equilibrium interest rate where both types of entrepreneurs undertake innovation.*

Proof. Since $\bar{R}^i < R_L^i$, L-types have an incentive to lie and claim to be H-types. In this case if the investor proposes $\bar{R}^i$: L-types accept it (and undertake innovation) because $\bar{R}^i < R_L^i$, and H-types also accept it because $\bar{R}^i < R_H$ and undertake innovation. ■

Summing up, we find a pooling equilibrium in all the regions there is a pooling equilibrium . However, note that while in regions (3.1.1) and (3.2) both types undertake innovation, in region (3.2) the equilibrium is inefficient, since only the less skilled entrepreneurs undertake the most productive technology (innovation). In this way the model shows that there can be an equilibrium with credit rationing for innovation. The novelty of this adverse selection result, which is the one we will focus on in the rest of the paper, is that we relate it to the state of technology. In this sense, we differentiate with respect to other papers that found that financial imperfections work through other mechanisms. For example, Bernanke and Gertler (1989) and Aghion et al. (2005) have assumed that access to external finance is limited by a multiple of the entrepreneur's own wealth. Differently from them, no such mechanism is assumed here, since usually entrepreneurs have no collateral at all for innovation activities, but our model can also be replicated to the case where there is collateral without chaining the main results. Moreover, while the early models of credit rationing (Stiglitz and Weiss (1981)) focus on the rationing of credit by banks that avoids to undertake excessive risk, here the entrepreneur is always financed, but there may be equilibria such that she undertakes the less productive technology; in particular, the inefficiency takes the form of higher skilled entrepreneurs undertaking imitation.

From the discussion that follows it will be explained that there may be social gains if the financial contract is improved. It will be shown that this improvement can also be applied not only to the most inefficient equilibrium (separating), but also for the pooling equilibria. We will proceed in the following sections to review different tools typically used to remove or reduce the inefficiencies of the financial frictions: monitoring and signalling.

2.3 Financial contract with monitoring

In this section we describe the equilibrium contracts for innovation by allowing a form of monitoring by the investor over the entrepreneur's activity. Monitoring takes place during the R&D process and it allows the investor to reveal the true type of the borrower. Moreover, monitoring is modeled in a way that it does not affect the productivity and probability of success of the project.

In order to describe monitoring in a realistic way, we consider initially a general form of this activity according to two main characteristics: quality and cost. With respect to quality, monitoring is imperfect, as it is not always able to reveal the true type of the borrower. Moreover, monitoring implies a cost that can be shared between the two parties. We will proceed in the following subsections to review different cases of monitoring, from the general case where the cost is shared between the parties to the case where this cost is fully paid by the entrepreneur, to more extreme cases where: *i)* the cost is fully paid by one or the other party; *ii)* monitoring is perfect. In this way we are able to have a more complete view of this contract device.

The conclusions of this section will enable us to draw some normative implications regarding the interaction between the quality and the cost sharing of monitoring. We will start considering monitoring in region [3.1.1], but will also consider whether this device can be extended to regions [3.1.2] and [3.2].

2.3.1 Imperfect monitoring with cost sharing

Monitoring is costly and we the cost is proportional to the innovation targeted level of technology $\bar{A}$ and to the amount of funds invested N. Letting Z be the total cost of monitoring, we assume a linear form of cost: $Z = z\bar{A}N$,[26] where z is a positive constant. The cost is split between the investor and the entrepreneur in the proportions λ and $1-\lambda$ respectively, where λ is exogenous. For example, being that the total cost of monitoring is $Z = z\bar{A}N$, the investor pays a cost of monitoring equal to $\lambda z\bar{A}N$.

Moreover, monitoring is imperfect, as it is able to reveal the true type only with in some cases. In particular, an H-type entrepreneur has a probability q of being considered as H-type by the investor after monitoring has taken place (and with prob. $1-q$ of being wrongly considered as L-type). Similarly, let s be the probability that an L-type entrepreneur is considered as L-type. In this sense, q (and s) stands for a proxy of monitoring quality. Consequently, the (weighted average) conditional probability of success of an innovation project is:

$$\overset{\frown}{f} = [qf_H + (1-q)\, f_L]\, h + [(1-s)\, f_H + sf_L]\,(1-h) \tag{2.5}$$

where $h = H/X$. That is to say that with a frequency h $(1-h)$ high (low) skills entrepreneurs are monitored and considered as being H-types (L-types) with a probability q (s). It can be verified that the following comparative statics results hold for (2.5): a) $\frac{\partial \overset{\frown}{f}}{\partial q} > 0$; b) $\frac{\partial \overset{\frown}{f}}{\partial h} > 0$; c) $\frac{\partial \overset{\frown}{f}}{\partial s} < 0$; d) $\frac{\partial \overset{\frown}{f}}{\partial f_{H/L}} > 0$; e) $f_L < \overset{\frown}{f} < f_H$.

Starting the analysis from region (3.1.1), recall that the ordering of the interest rates is the following: $R^i_H < \bar{R}^i < R_H < R^i_L < R_L$. From proposition 2, we derived that

[26] We impose that the monitoring cost is proportional to the target state of technology $\bar{A}$ and to the amount of funds N for analytical convenience. However, the results, at the cost of some complication do not change if we remove this proportionality assumption. In any case, letting the cost of monitoring be increasing in the state of technology can be justified on the basis that when the investor monitors the entrepreneur for innovation, he needs to know what type of activity the entrepreneur is undertaking. Being informed about this activity requires some knowledge that the investor has to acquire; since technology is cumulative in this framework, knowledge acquisition by the investor requires a cost that is proportional to the level of the s.o.t.

H-types (if not monitored) pay in equilibrium an interest rate equal to $\bar{R}^i$, therefore their loss due asymmetric information is equal to $f_H\left(\bar{R}^i - R_H^i\right)N$. It is reasonable to assume that they would prefer a financial contract which prescribes a form of monitoring that allows them to pay their appropriate interest rate R_H^i.

A j-type entrepreneur will accept financing for innovation with monitoring if his expected profit $(E(\pi_{j,\lambda}) = f_j\left(\delta\bar{A} - RN\right) - (1-\lambda)z\bar{A}N)$ are at least as big as that of imitation:[27]

$$f_j\left(\delta\bar{A} - RN\right) - (1-\lambda)z\bar{A}N \geq \delta\bar{A} - RN$$

that is for $R \leq R_{j,\lambda}$, where:

$$R_{j,\lambda} = \frac{\delta\bar{A}}{N}\frac{a-f_j}{1-f_j} + (1-\lambda)\frac{z\bar{A}}{(1-f_j)} \tag{2.6}$$

where the second component on the right hand side is the additional cost due to monitoring. The investor's expected profits from financing innovation are $E(\breve{\pi}_j^i) = \breve{f}RN - N - \lambda z\bar{A}N$.[28] The investor will finance innovation if $E(\breve{\pi}_j^i) \geq \pi_B$, or also: $\breve{f}RN - N - \lambda z\bar{A}N \geq r_0N$. This implies that $R \geq \breve{R}_\lambda^i$, where:

$$\breve{R}_\lambda^i = \frac{R_0 + \lambda z\bar{A}}{\breve{f}} \tag{2.7}$$

It turns out that innovation is undertaken and financed if: $\breve{R}_\lambda^i \leq R_{j,\lambda}$, which holds for $a \geq \breve{a}_{j,\lambda}$, where:

$$\breve{a}_{j,\lambda} = f_j + \frac{N}{\delta\breve{f}}\left\{\frac{R_0}{\bar{A}}(1-f_j) + z\left[\lambda\left(1+\breve{f}-f_j\right) - \breve{f}\right]\right\} \tag{2.8}$$

Since we are interested to see whether this form of monitoring can be implemented in our region of interest (region [3]), we have to check whether $\breve{a}_{H,\lambda} \leq a_H$.[29] Imposing this condition, we have the following result:

Proposition 7 *Imperfect monitoring with cost sharing is always feasible in region [3] for H-type entrepreneurs as long as the cost share of the investor is not higher than* λ_H*,*

[27] In this case the probability of success is f_j because the true type is known to each entrepreneur.

[28] The investor uses the conditional probability $(\breve{f})$ since the true type is unknown to him.

[29] It can be shown that $\breve{a}_{L,\lambda} < \breve{a}_{H,\lambda}$.

where

$$\lambda_H = \frac{\breve{f}}{1 - h(1-q) - s(1-h)} \tag{2.9}$$

Proof. Recall that imperfect monitoring (with cost sharing) can always be implemented for $a \geq \breve{a}_{j,\lambda}$. Then, for this monitoring to be implemented in region [3] (that is $a \in [a_H, 1]$), we need to show that $\breve{a}_{H,\lambda} \leq a_H$. Substituting the values from (2.4) and (2.8) we have: $z\left[\lambda\left(1+\breve{f}-f_H\right)-\breve{f}\right] \leq 0$. The following step is to consider that since z is always positive, then the negativity condition holds for: $\lambda < \lambda_H = \frac{\breve{f}}{1+\breve{f}-f_H}$. Substituting $\breve{f}$ from (2.5), we have the result in the proposition. ■

According to the proposition, if the cost share of the investor is low enough ($\lambda < \lambda_H$), we have that $\breve{a}_{H,\lambda} < a_H$: this contract can always be implemented in region [3]. In fact, because monitoring is imperfect, the investor cost charges the extra cost (of uncertain of monitoring) to the borrower ($\lambda z\bar{A}/\breve{f}$). In turn, because the entrepreneur is charged this extra cost, she will undertake innovation (with monitoring) iff the cost share is low enough.

When the cost share λ is excessively high ($\lambda \geq \lambda_H$), there is a region ($a_H < a < \breve{a}_{H,\lambda}$) where this type of contract cannot be implemented (region of 'non-implementation'). In this sense, we can restore implementability by increasing the quality of monitoring of H-types. In fact, it can be shown that by improving the quality of monitoring, the region of non-implementation is narrower (and eventually it shrinks when $\lambda = \lambda_H$). This is stated in the following proposition:

Proposition 8 *When the quality of monitoring q increases, the region of implementation of imperfect monitoring with cost sharing for H-types ($a \geq \breve{a}_{H,\lambda}$) is wider.*

Proof. From (2.8), recall that $\breve{a}_{H,\lambda}$ increases with λ. Then, from (2.9) we see that by partially differentiating λ_H with respect to q, we have that: $\frac{\partial \lambda_H}{\partial q} < 0$. Then, by the chain rule we see from (2.8) that $\breve{a}_{H,\lambda}$ decreases, that is the region of implementation $[a \in [\breve{a}_{H,\lambda}, 1)]$ is wider. ■

We can further understand the importance behind this result considering that the cost share variable λ as a proxy of the relative bargaining power between the parties. In this sense, λ is also a proxy of the degree of concentration of investors. In fact, being the distribution of R&D firms fixed (indeed, we have assumed that entry if free for firms in the R&D markets[30]), then λ can be considered as a proxy of the degree of concentration

[30] Recall that in the model knowledge is non rival at the beginning of the R&D subperiod. In fact, as

in the investors' market, where they compete each other by offering entrepreneurs to pay a higher share of monitoring costs (higher λ).

Under this interpretation, we derive two observations. First, allowing more financial competition too soon does not always favour financial development, unless we improve the quality of the financial investors. In fact, more financial competition increases the cost share of the investor such that $\lambda > \lambda_H$; then by proposition 6, the imperfect monitoring contract cannot be implemented. However, we can reduce the threshold λ_H by increasing the quality of the monitoring (q), so that $\widehat{a}_{H,\lambda}$ shrinks to a_H. Intuitively, if it is more likely that monitoring will reveal the entrepreneur's true type, the investor is more willing to monitor even if the cost share is higher.

The second point follows from the first; in fact, if we do not change the quality of the financial investors, the imperfect monitoring contract is implementable only for a higher level of concentration of the banking sector (lower λ).

Finally, from these two observations we can derive two possible extreme scenarios for imperfect monitoring to occur. The first is with high financial concentration ($\lambda \longrightarrow 0$) and low quality of the investors (q low), while the second scenario is with low financial concentration ($\lambda \longrightarrow 1$) and high monitoring quality of the investors (q high). In particular, the last scenario is closely related to the seminal paper of Rajan and Petersen (1995) in which banking competition does not allow the banks to extract the future rents of a young firm. Our model is related to their results because often R&D firms have cash flows only in later periods and banking competition does not allow the bank to establish a close relationship with the borrower. The details of the extreme scenarios are better described in the next subsection.

2.3.2 Particular cases

In this subsection, we proceed to study more in detail three particular cases of monitoring. In the first two, we let monitoring to be imperfect, but allocate all of the cost share to one party or the other. In the third case, the cost is shared between the two parties, but monitoring is perfect. These particular cases help us to shed some light on the parameters that most affect the implementability of the financial contract.

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stated in section 2, at the beginning of each period, previous period knowledge is common knowledge to entrepreneurs. Because of the non rivarly of knowledge and being that there are not other barriers to enter the patent race, we have free entry of entrepreneurs.

Imperfect monitoring fully paid by the investor

When the investor pays the full cost of monitoring, we have $\lambda = 1$. The corresponding interest rate required by the investor to finance innovation is:

$$\breve{R}_1^i = \frac{R_0 + z\bar{A}}{\breve{f}} \tag{2.10}$$

which is greater than (2.7); indeed, since the investor pays all the monitoring cost, then in a competitive setting it charges the extra cost of monitoring to the entrepreneur. In turn, the entrepreneur is willing to undertake innovation as long as the contracted interest rate is not greater than R_j as given by (2.2). In fact, since the entrepreneur does not pay (directly) any cost of being monitored, the maximum interest rate such that she undertakes innovation is unchanged with respect to the case of no monitoring.

Finally, the implementability condition is given by the following inequality: $\breve{R}_1^i \leq R_j$. In terms of state of technology, this is $a \geq \breve{a}_{j,1}$:

$$\breve{a}_{j,1} = f_j + \frac{N}{\delta \breve{f}} \left[\frac{R_0}{\bar{A}} (1 - f_j) + z (1 - f_j) \right] \tag{2.11}$$

From (2.11) we can state the following:

Proposition 9 *Imperfect monitoring when $\lambda = 1$ can be implemented by H-types in region [3] only for $a > \breve{a}_{H,1} > a_H$.*

Proof. In order to verify the proposition above set the following condition: $\breve{a}_{H,1} < a_H$. Substituting the values from (2.11) and (2.4) we find immediately find $\frac{R_0}{\bar{A}} \frac{f_H - \breve{f}}{f_H \breve{f}} + \frac{z}{\breve{f}} < 0$; since both sides are always non negative, then $\breve{a}_{H,1} > a_H$. ■

This implies that there is a region of non implementation $a \in [a_H, \breve{a}_{H,1}]$ for this type of contract. The intuition for this result is quite straightforward: since the investor pays the full cost of monitoring, then he charges the extra cost on the entrepreneur. In turn, this implies that the entrepreneur has to pay an excessive interest rate; and unless the state of technology is advanced enough, innovation is not undertaken with this type of contract.

Imperfect monitoring fully paid by the entrepreneur

In this case, since the entrepreneur pays directly the full cost of monitoring ($\lambda = 0$), minimum the interest rate such that an investor finances innovation is:

$$\breve{R}_2^i = \frac{R_0}{\breve{f}} \tag{2.12}$$

while the entrepreneur undertakes innovation with this contract if the interest rate is not greater than

$$R_{j,2} = \frac{\delta \bar{A}}{N} \frac{a - f_j}{1 - f_j} + \frac{z\bar{A}}{1 - f_j} \tag{2.13}$$

Note that this interest rate is greater than the one in (2.6), because the entrepreneur now pays directly the full cost of monitoring.

This type of contract can be implemented for $\breve{R}_2^i \leq R_{j,2}$; that is, from (2.12) and (2.13) we have:

$$\breve{a}_{j,2} = f_j + \frac{N}{\delta} \left[\frac{R_0}{\bar{A}\breve{f}} (1 - f_j) - z \right] \tag{2.14}$$

We can show the conditions such that this contract can always be implemented in region [3]:

Proposition 10 *Imperfect monitoring when $\lambda = 0$ can be implemented by H-types in region [3] for $z > \frac{R_0}{\bar{A}} (1 - f_H) \frac{f_H - \breve{f}}{f_H \breve{f}}$.*

Proof. In order to show the proposition, consider that the implementability of this type of imperfect monitoring contract in region [3] depends on $\breve{a}_{H,0} \leq a_H$. Substituting from (2.14) and (2.4) respectively we have: $\frac{R_0}{\bar{A}\breve{f}} (1 - f_H) - z \leq \frac{R_0}{\bar{A} f_H} (1 - f_H)$, which can be rewritten as: $z > \frac{R_0}{\bar{A}} (1 - f_H) \frac{f_H - \breve{f}}{f_H \breve{f}}$. ■

Perfect monitoring with cost sharing

This type of contract implies that monitoring is perfect, that is to say that after monitoring the investor is always able to reveal the true type of entrepreneur. Therefore, the investor's expected profits from financing a j-type entrepreneur are: $E(\pi^i_{j,\lambda}) = f_j RN - N - \lambda z \bar{A} N$. The investor will finance the j-type entrepreneur if $E(\pi^i_{j,\lambda}) \geq \pi_B$ that is: $f_j RN - N - \lambda z \bar{A} N \geq r_0 N$; that is for $R \geq R^i_\lambda$:[31]

[31] Note that as for (2.3) the ordering of the two interest rates is $R^i_{H,\lambda} \leq R^i_{L,\lambda}$, and comparing (2.15) with (2.3) we have that $R^i_{H,\lambda} > R^i_H$ and $R^i_{L,\lambda} > R^i_L$: the minimum interest rate (such that the investor finances innovation to the j-type entrepreneur) in this case is higher because a part of the cost is paid by the investor.

$$R^i_{j,\lambda} = \frac{R_0 + \lambda z\bar{A}}{f_j} \tag{2.15}$$

In turn, a j-type entrepreneur will accept this form of monitoring to undertake innovation if his expected profit $\left(E\left(\pi_{j,\lambda}\right) = f_j\left(\delta\bar{A} - RN\right) - (1-\lambda)\, z\bar{A}N\right)$ are at least as big as those of imitation: $f_j\left(\delta\bar{A} - RN\right) - (1-\lambda)\, z\bar{A}N \geq \delta\bar{A} - RN$. This is for $R \leq R_{j,\lambda}$, where where R^i_λ is given by (2.15).[32]

Innovation can be implemented with this form of monitoring if $R^i_{j,\lambda} \leq R_{j,\lambda}$, that is to say for $a \geq a_{j,\lambda}$, where from (2.6) and (2.15) we have:

$$a_{j,\lambda} = f_j + \frac{N}{f_j\delta\bar{A}}\left[R_0\left(1-f_j\right) + z\bar{A}\left(\lambda - f_j\right)\right] \tag{2.16}$$

Recall that our analysis started taking into consideration region (3.1.1), where $a \in [a_H, 1]$; nevertheless, again it can be generalized to all the range of region (3). In fact, since $a_{H,\lambda} > a_{L,\lambda}$ in the following proposition we derive the condition such that this form of monitoring can take place in this region:

Proposition 11 *Perfect monitoring with cost sharing can be implemented in region [3] for $\lambda > f_H$.*

Proof. From (2.4) and (2.16), it can be shown that $a_{H,\lambda} \leq a_H$: $f_H + \frac{R_0 N}{\delta\bar{A}}\frac{(1-f_H)}{f_H} - \frac{z(\lambda - f_H)}{\delta f_H} \leq f_H + \frac{R_0 N}{\delta\bar{A}}\frac{1-f_H}{f_H} \Longrightarrow \frac{z(\lambda-f_H)}{\delta f_H} > 0$. This positivity condition holds for $\lambda > f_H$. ■

Therefore, if the cost share of the investor is higher than the probability of success of H-types, then innovation by H-types can be implemented with perfect monitoring and cost sharing. The intuition for this condition can be obtained by comparing this result with that of the previous subsection. Since the true type is always revealed (that is $q = 1$), the investor charges a lower interest rate ($R^i_\lambda > R_{H,\lambda}$). In turn, being that quality does not change in this case (indeed it is highest), the extra cost of monitoring is borne by the entrepreneur undertaking innovation only if this is not excessively high.

With cost sharing, while H-types entrepreneurs pay only part of the monitoring cost, the investor pays the residual share (λ). This increases the equilibrium interest rate paid by the entrepreneur (compare (2.3) and (2.15)). Therefore, H-types undertake innovation only if their cost share is relatively low.

Finally, consider the behaviour of L-types. It can be shown that in any case (that is for any value of λ with respect to f_H) L-types always prefer not to undertake innovation

[32] In fact, this corresponds to the general case because: *i)* the cost is shared in the proportions λ and $1-\lambda$; *ii)* whether monitoring is perfect or not, the true type is always known to each entrepreneur.

with cost-sharing and perfect monitoring. In fact, in the case that $\lambda > f_H$, H-types undertake innovation with cost-sharing monitoring, while L-types know that since monitoring is perfect, their type would be perfectly revealed. Then, they prefer not to incur the extra costs of monitoring (recall that $R^i_{j,\lambda} > R^i_j$) but simply declare their true type. The same reasoning applies to the case of $\lambda < f_H$. In fact, in this case since $a_H < a_{H,\lambda}$ H-types do not undertake costly monitoring, while again L-types would never accept this contract because they do not want to incur the extra costs of perfect monitoring.

2.4 Financial contract with signalling

In this section we study a second device to repair the problems of adverse selection. Entrepreneurs may undertake an ex-ante activity (that we call education for simplicity),[33] which is capable of sending a perfect signal to the investor about the true type of entrepreneur.

The main result of this section is that innovation with H-types can always be implemented in region (3) with this type of contract. This result is an improvement with respect to monitoring where in the most realistic case the contract for innovation cannot always be implemented in that region (it is possible only for some parameters values). The different result depends on the way we model this signalling device, as shown below.

Education can be skill improving for L-types, but not for H-types, as they already have the highest available skills in the economy; in this sense, if undertaken by H-types, education sends a signal that perfectly reveals their true type;[34] instead, L-types may become high skilled if they are successful at improving their skills, through education, which happens with a positive probability. Once education is finished, the signal is perfectly revealing of their true type. This structure creates an asymmetry between the high and low skilled, which impacts on the ex-ante choice of both types entrepreneurs to undertake innovation. We will find that, in general, H-types always prefer to invest ex-ante in education, as this allows to reveal their type more easily, while L-types are willing to undertake education only in some circumstances.

Let the sum to be invested in education by a j-type entrepreneur be equal to $kN\bar{A}$, where k is a positive constant. Again, the sum is proportional to the target technology

[33] Education differentiates from monitoring because it is an activity undertaken ex-ante, that is before the single period in which the research has started. However, this difference does not have important consequences over the results of the model.

[34] Then, education is useful for H-types only for "certifying" that they are high skilled.

$\bar{A}$ and to the amount of funds invested N.[35] Since education has asymmetric effects on the two types, we study them separately. Starting the analysis with H-types, their expected profits are:

$$E(\pi_{H,e}) = f'_H\left(\delta\bar{A} - RN\right) - k\bar{A}N$$

where $f'_H = \frac{p_H}{H'p_H + L'p_L}$ and $H' = H + eL$, $L' = (1-e)L$. The basic probabilities have changed since the number of H-types has increased with the proportion of L-types (eL) who successfully increased their skills through education. With this definition we have: $f'_H < f_H$. As usual, entrepreneurs undertake innovation (instead of imitation) if expected profits are greater: $E(\pi_{H,e}) \geq \pi_M$. That is if the interest rater is not greater than:

$$R_{H,e} = \frac{\delta\bar{A}}{N}\frac{a - f'_H}{1 - f'_H} + \frac{k\bar{A}}{1 - f'_H}$$

where the second component is due to the extra-cost of education. Investors finance innovation to H-types if the interest rate is not lower than R^i_H as from (2.3): indeed, as the signal is perfect, the investor is always able to reveal the true type of the high skilled.

Then, the innovation project can be implemented for the high skilled if $R_{H,e} \geq R^i_H$, that is if the state of technology is at least as great as:

$$a_{H,e} = f'_H + \frac{N}{\delta\bar{A}}\left[\frac{R_0(1 - f'_H)}{f'_H} - k\bar{A}\right] \tag{2.17}$$

Comparing $a_{H,e}$(2.17) with a_H from (2.4), we have the following result:

Proposition 12 *Innovation with education signalling can always be implemented with H-types in region (3).*

Proof. Substituting the values of $a_{H,e}$ and a_H from (2.17) and (2.4) respectively, the inequality $a_{H,e} < a_H$ holds for $R_0N < \delta\bar{A}f'_Hf_H$. We need to show that this last condition is not more restrictive than the one we imposed in section 2 (see footnote 20): $R_0N < \delta\bar{A}f_Lf_H$. That is, $\delta\bar{A}f_Lf_H > \delta\bar{A}f'_Hf_H$. For a given frontier state of technology $\bar{A}$, we have that $f'_H < f_L$; this implies that $[Hp_H + Lp_L]\,p_H > p_L\,[Hp_H + Lp_L + eL(p_H - p_L)]$ $\Longrightarrow$ $(p_H - p_L)(Hp_H + Lp_L(1-e)) > 0$. ■

[35] This assumption is not essential for the model, but it simplifies the ensuing analysis.

While the signalling contract can always be implemented, we want to understand whether implementation actually takes place. To this end, note that H-types consider also what L-types do. Education allows L-types to become H-types with a probability equal to e, otherwise they remain L-types. Therefore, the expected probability of success of an L-type entrepreneur that undertakes innovation is:

$$\bar{f}_L = ef'_H + (1-e)\, f'_L$$

where $f'_L < \bar{f}_L < f'_H$.

Expected profits are:

$$E\left(\pi_{L,e}\right) = \bar{f}_L \left(\delta\bar{A} - RN\right) - k\bar{A}N$$

L-types entrepreneurs undertake innovation if: $E\left(\pi_{L,e}\right) \geq \pi_M$, that is if the interest rate is lower than:

$$R_{L,e} = \frac{\delta\bar{A}}{N}\frac{a-\bar{f}_L}{1-\bar{f}_L} + \frac{k\bar{A}}{1-\bar{f}_L}$$

where the second component on the right hand side derives from the extra cost due to education.

On the other side, the condition for investors to finance innovation to L-types (undertaking education) is:

$$E(\tilde{\pi}^i_L) \geq \pi_B \Longrightarrow \bar{f}_L RN - N \geq r_0 N$$

That is if the interest rate is not lower than:

$$R^i_{L,e} = \frac{R_0}{\bar{f}_L} \tag{2.18}$$

From the implementability condition ($R_{L,e} \geq R^i_{L,e}$) we derive the following threshold of the state of technology:

$$a_{L,e} = \bar{f}_L + \frac{N}{\delta\bar{A}}\left[\frac{R_0\left(1-\bar{f}_L\right)}{\bar{f}_L} - k\bar{A}\right]$$

Then, innovation with education signalling can be implemented to L-types only for a state of technology that is higher or equal to $a_{L,e}$. Nevertheless, L-types decide to undertake innovation with the education signal only if expected profits are greater (than without education) at the respective equilibrium interest rates. From this consideration, we obtain the following result:

Proposition 13 *L-types entrepreneurs undertake innovation with the education signal only if the cost of education is not greater than* $k_L = \frac{\delta e \Delta f}{N}$*, where* $\Delta f = f_H - f_L$*.*

Proof. The comparison of profits at the equilibrium interest rates is $E\left(\pi_{L,e}\left(R^i_{L,e}\right)\right) \geq E(\pi_L\left(R^i_L\right))$. Plug R^i_L from (2.3) and $R^i_{L,e}$ from (2.18) into $E(\pi_L)$ and $E\left(\pi_{L,e}\right)$ respectively. Denoting $\bar{f}_L = f_L + e\Delta f$ where $\Delta f = f_H - f_L$, we immediately have the result above. ■

Finally, note that this type of contract can be implemented for L-types in region [3] only if $a_{L,e} < a_H$. While this condition is not always satisfied, what is relevant is to note that innovation with education signal can always be implemented in region [3] by H-types, independently of what L-types may or want to do. In fact, if we suppose that, because of the parameters of the model, it is $a_{L,e} > a_H$, then there is a region of state of technology ($a \in [a_H, a_{L,e})$) where this contract cannot be implemented for L-types. Since in this case L-types would still behave as predicted by lemma 1, that is they would hide their type, H-types may still have an incentive to undertake the educational program, in order to benefit of the signal. On the contrary, if the parameters are such that $a_{L,e} < a_H$, then L-types may always undertake innovation with the educational signal in region [3], and the same do H-types.

Therefore, the main result of this section consists of the role of education in overcoming the difficulties of improving the financial contract that we encountered with monitoring. Education can always be implemented by H-types in the region close to the technology frontier. This allows to overcome the problems of asymmetric information and the result holds independently of the convenience of L-types to undertake this or another contract. In this sense, this model shares with ACV (2004) the view that education, by increasing the composition of skilled labour in the economy matters for productivity growth for countries that are closer to the technology frontier.

2.5 Conclusions

In this paper, we have analyzed the interaction between the initial state of technology and the financing of innovation to explain why a country that is close to the technology frontier may suffer of financial frictions more severely than if its technology were less advanced. In this sense, the paper contributes to the literature on more general discussions, like understanding if there is an advantage or disadvantage of backwardness in the process of development,[36] by looking at the role financial markets. The model provides a theoretical answer to the problems of financing innovation with the view that the reduction of financial frictions not only contributes to finance highly productive investments more easily, but it may induce entrepreneurs to undertake more risky projects.

The first finding of this paper is that for a sector inside the frontier there can be a form of adverse selection for innovation. This finding reflects a very well known fact of asymmetric information for the financing of risky projects. The second result is that the financial contract can be improved with monitoring by the investor; however, there can be states of technology where this contract cannot be implemented. In this case, an increase of the quality of monitoring allows to implement the contract at lower states of technology. Finally, the adverse selection problems of the financial contract can also be removed through a signal, that is the outcome of an ex-ante activity of education is undertaken by the entrepreneurs. In this last case, the paper shows that education can always be implemented in the state of technology region of interest.

It turns out that the analysis conducted contributes by providing a view where the role of factors relative to human capital accumulation and improvement of financial intermediation is fundamental for the growth strategy of technologically advanced countries, like Continental Europe. In fact, while these countries have just a small productivity gap with respect to the US (which can be considered as the world technology leader), there are still many high technology sectors where the investment levels on innovation are low or the returns on innovation projects are lower than in the US.

Finally, while the model highlights the important role of two innovation factors in spurring growth, it is clear that many other factors are behind the process of growth of countries, like law enforcement, labor regulation, trade openness and so on. While we trust that these other factors are to be studied extensively in further research, we are confident that the approach taken in this paper may clear how to face problems faced by the financing of innovation in advanced economies.

[36] This debate regards arguments as how much the world technology can be transferred to backward countries. In fact, if world's best technology may spread from leader countries to technology laggards without restrictions, the question is if countries benefit from being backward or not. While some literature has focused on productivity differences or financial development, there is no consensus about the so called "advantage of backwardness."In the sense that there is an advantage if "the further a country falls behind the world's technology leaders the easier it is for that country to progress technologically simply by implementing new technologies that have been discovered elsewhere.Aghion Howitt, Foulkes (2003), page 1. The original idea of advantage of backwardness is due to Gensckenkon (1962).

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Appendix 1. Production Profits

In order to better understand the expression form of production profits from innovation ($\delta\bar{A}$) and imitation (δA), consider that in order to produce k units of the intermediate v, it is necessary to employ one unit of the final good; so production profits of innovation are:

$$\Pi(v) = P(v)k(v) - k(v) = [P(v) - 1]k(v)$$

where $P(v)$ is the price of the intermediate good. Now, since the final good is produced competitively, the price of the intermediate good can be set to a constant (χ) that is equal to the marginal product with respect to that input. Then, in the case of innovation the price is:

$$P(v) = \chi = \frac{\vartheta Y}{\vartheta k(v)} = \bar{A}(v)^{1-\alpha} k(v)^{\alpha-1} \tag{2.19}$$

while in the case of imitation it is:

$$P(v) = \chi = \frac{\vartheta Y}{\vartheta k(v)} = A(v)^{1-\alpha} k(v)^{\alpha-1} \tag{2.20}$$

So (following only the innovation case for simplicity), the optimal demand for the input is:

$$k(v) = \chi^{\frac{1}{\alpha-1}} \bar{A}(v) \tag{2.21}$$

and production profits are:

$$\Pi(v) = (\chi - 1)\, \chi^{\frac{1}{\alpha-1}} \bar{A}(v)$$

or if we set $\delta(\chi) = (\chi - 1)\, \chi^{\frac{1}{\alpha-1}}$, they become:

$$\Pi_{Inn.} = \delta(\chi) \bar{A}(v) \tag{2.22}$$

where the TFP here is $\bar{A}(v) = \gamma A_{-1}(v)$ if innovation is successful; in the case of imitation, production profits become:

$$E\left(\Pi_M\right) = \delta(\chi) \bar{A}(v)$$

where the TFP here is $A(v) = \gamma A_{-1}(v)$. **QED**

Appendix 2. Minimum State of Technology for Innovation

The frontier state of technology has to be sufficiently high such that innovation returns are higher than the storage technology. This means that it must be that:

$$f_j \left[\delta \bar{A} - RN\right] \geq r_0 N$$

Plugging R_j from (2.2) $\left[R_j = \frac{\delta \bar{A}}{N} \frac{a - f_j}{1 - f_j}\right]$ into the previous expression we have that:

$$f_j \delta \bar{A} \geq r_0 N + f_j \tfrac{\delta \bar{A}}{N} \tfrac{a - f_j}{1 - f_j}$$

or also

$$\bar{A} \geq \frac{r_0 N^2 (1-f_j)}{f_j[(1-f_j)N-(a-f_j)]}$$

Solving this expression for $\bar{A}$ we have:

$$\bar{A} \geq \bar{A}_0 = \frac{r_0 N^2 (1 - f_j) + f_j \delta A}{f_j \delta [N (1 - f_j) - f_j A]}$$

QED

Appendix 3. Entrepreneur's own funds

The financial contract for innovation with the entrepreneur participating with her own wealth is defined as follows. Let Entrepreneur's wealth be a fraction θ of the total amount of funds due for the project. Then, the participation for a debt contract inside the frontier becomes

$$f_j \left[\delta(\chi)\bar{A} - (1 - \theta) RN\right] - \theta RN \geq \delta(\chi)A_t - RN$$

Then the participation constraint can be rewritten as (imposing the equality):

$$f_j \left[\delta(\chi)\bar{A} - (1 - \theta) RN\right] - \theta RN = \delta(\chi)A_t - RN$$

solving this expression becomes

$$R_j : R = \frac{\delta(\chi)\bar{A}}{N} \frac{(a_t - f_j)}{(1 - \theta)(1 - f_j)}$$

It can be shown that for this expression: $\frac{\partial R}{\partial f_j} < 0$, so that $R_H < R_L$.

With regard to investors, it is immediate to see that their indifference curves are exactly the same as without collateral. In fact, rewrite the indifference relation for the investor as follows

$$f_j R (1 - \theta) N - (1 - \theta) N = r_0 (1 - \theta) N$$

Deleting $(1 - \theta)$ on both sides of this expression we get back exactly to the previous case described in the text. Therefore, all the analysis conducted with debt inside the frontier holds also in the case the entrepreneur participates with its own wealth. **QED**

Chapter 3

State of Technology, the Legal System and Finance

3.1 Introduction

Why do countries keep different levels of creditor protection? The usual answer in the literature is that interested groups lobby against political reforms. However, while this argument can explain the difficulty of policymakers to reform, it does not sufficiently explain why different countries start with different legal creditor protection levels. In this regard, a recent approach is to consider the different legal origin of countries. Since the path-breaking papers of La Porta et. al. (1997, 1998), it has been recognized that legal origins may indeed explain different institutional arrangements across countries. Indeed, legal origins can explain cross country variations much better than the old classification between bank based and market based financial systems (La Porta et al., 1997).

In particular, a recent empirical work by Djankov et al. (2005) finds that there are persisting differences across countries in terms of legal creditor protection. They have reported that there is "*very little convergence in creditor rights scores [...]. The differences persist over the 25 year period.*" Moreover, they find "*[...] a pronounced legal origin effect in credit market institutions, with common law countries having sharply higher creditor rights scores than French civil law countries.*"[1] In Figure 1 we report the magnitude of these effects over private credit.

[1] Djanov + al. (2005), page 4. Their sample spans over 25 years, from 1978 to 2003.

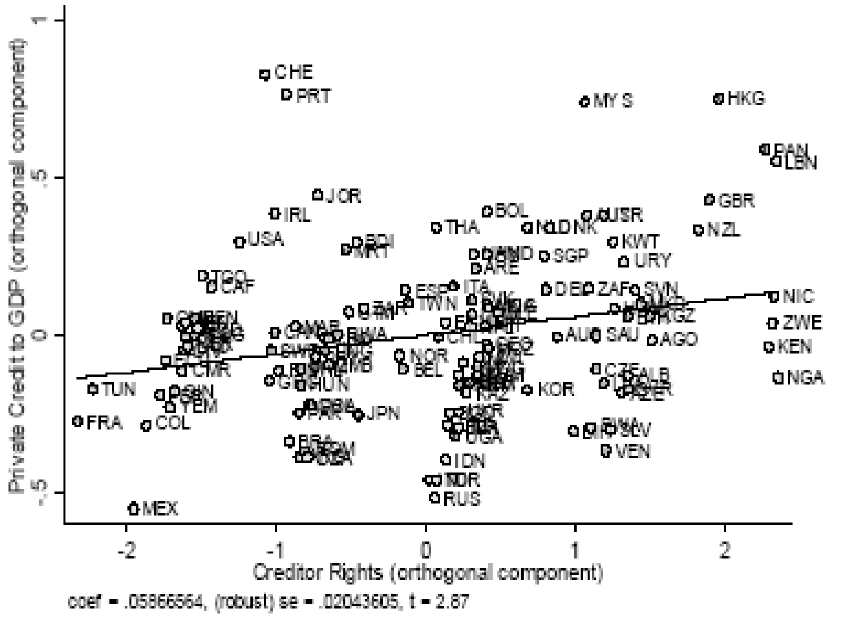


Fig. 1: Creditor Right Scores and Private Credit to GDP (Djankov et al. 2004)

However, the legal origin explanation does not explain the higher and higher variance of creditor rights scores across countries within each family. Therefore, we need additional assumptions about the institutional factors affecting the dispersion of creditors rights scores. In particular, the idea is that the level of creditor protection is determined not only by the traditional and long time historically rooted practices, but also by technology factors. We model the differences in the historical components as a variety of growth strategies that the government may pursue, where each variety corresponds to the maximization of the productivity, whose input is most abundant in a given country.[2] Moreover, in order to implement these growth strategies, a country may face also technology constraints, which are of impediment to achieve the first best policy of creditor protection.[3] Therefore, capital constraints may help to explain the greater variance of the creditor rights scores within the family origins. In this way, the paper adds to the current literature an insight over an institutional factor behind the choice of the policy

[2] Since the relative abundance of a factor does not change but slowly over time, also the growth strategies are persistent. In this sense, this approach is consistent with the legal origins explanation.

[3] The technology constraints are introduced as minimum size requirements in the level of capital required for investments projects. These minimum size requirements are dependent on the state of technology of a country.

instrument. Our point of view is not that a different level of creditor protection explains different institutional arrangements, but the other way around: the institutional choice (specifically the growth strategy chosen and the state of technology achieved in a country explains why there are different levels of creditor protection.

More specifically, the variety of the growth strategies consists of the government aiming different policy targets, where each target is given by the maximization of the different three inputs available in the economy: entrepreneur's effort (entrepreneurship), investor's effort (creditor activism) and capital. With regard to the role of these inputs, while there is no particular novelty over the role of capital and there is by now a wide consensus over the role of entrepreneurship in fostering productivity growth, for creditor activism we mean the involvement of the creditor beyond the initial financial outlay; for example, this consists of monitoring, screening, and also in some cases governance into the project.[4] Consequently, the growth strategies considered are based on: i) maximizing entrepreneurship; ii) maximizing creditor activism; iii) maximizing growth with the contribution of all of the three inputs.[5] Since the choice of the policy parameter (creditor protection) has diverging effects on one or the other of these inputs, a country might choose to purse a particular growth strategy on the basis of the maximization of the contribution of one only input, if this is relatively more abundant in the country.[6]

While the paper predicts that the optimal policy is to set creditor protection at the highest level, the result does not depend on assuming that this policy instrument affects the quantity of credit, as predicted by the creditor power theories[7]. Instead, this is derived endogenously in equilibrium, from a general setting where the demand of capital is decreasing with respect to the creditor protection level.[8] Moreover, in the appendix the

[4] In the model, creditor activism will be set as a variable that increases the productivity of capital investment.

[5] In the appendix the maximization of the level of capital is also considered, and this corresponds, in the model, to assuming that there is free entry both in the investors and entrepreneurs' market.

[6] In particular, to understand the role of these inputs, we consider investment projects that increase productivity if they are successful. Success happens with a probability that depends on the three inputs: entrepreneur's effort, creditor's effort and capital. In this sense, the specification of the model borrows the set up from Bottazzi, Da Rin and Hellman (2005, henceforth BDH), with some differences as it will be explained later.

[7] A formalization of the creditor power theories can be found in Townsend (1979), Aghion and Bolton (1992), and Hart and Moore (1994, 1998).

[8] This is because with low creditor protection, the amount of expected repayment is lower, therefore, the total cost of capital is lower. By standard arguments, when capital is less costly the demand for capital increases. Indeed, the evidence with regard to the lending volumes is non conclusive: "*The prediction regarding lending volume is mixed. On the one hand, cheaper funds should lead to larger lending volumes. This is a supply-side effect. On the other hand, a pro-creditor bias in credit regulations may reduce the demand for credit.*" Padilla and Requego (2000), page 15.

effects of entry on growth are examined with respect to each growth strategy. Differently from the political economy literature, which has been focused on viability of reforms,[9] we explain in which cases lifting entry barriers may have positive effects on growth.[10]

In this way we find the following results:

1) a policy aimed at maximizing entrepreneurship requires a low level of creditor protection;

2) a creditor activism based growth strategy may require a high level of creditor activism;

3) a "global inputs" based strategy requires a high level creditor protection.

4) adding technology constraints helps to predict the dispersion of the level of creditor protection across countries.

Note that the results in points 1), 2) and 3) above explain the dispersion of the creditor protection level across countries. The dispersion is better explained when the analysis is enriched with the introduction of technology constraints, as stated in point 4).

More intuitively, the first point is simply explained by considering that a lower creditor protection increases the expected pay-off of the entrepreneur, because he will credibly expect to do a lower repayment. Therefore entrepreneur's effort is maximum when legal creditor protection is minimum.

The intuition for the second result is also straightforward: the creditor exerts more effort into the project the more the legal system is protecting his expected repayment (we call this "protection effect"). Note that this point is similar to one of the so called creditor power theories, for which the more the legal system guarantees creditor expected repayment, the more creditors are willing to extend credit.

For the third result, by global inputs strategy we mean the one aimed at maximizing the overall probability of success of a project. Since this probability depends on all the three inputs, then the term global inputs follows. Then, this strategy might be considered as the sum of the previous two. Therefore, one might expect that the optimal policy is to set the creditor protection at an intermediate level. Actually, our model predicts that this is not the case. In particular, the protection effect over creditor activism is stronger than the entrepreneurship effect, and therefore the desired level of creditor protection is the highest.

Finally, when we add the technology constraint, we can better describe the dispersion

[9] See for example Gennaioli and Caselli (2005) and Perotti and Volpin (2005) for recent contributions.

[10] Indeed, we enrich the study each of the three growth strategies considering the case that there are barriers to entry and when entry is free (in both the creditors and entrepreneurs market).

of the different creditor protection levels across countries also in terms of the state of technology. This means that some policies are feasible only if the country has a minimum state of technology.

Summing up, we have that different government objectives can explain different levels of creditor protection. This explanation not only is in line with the story of legal origins, but adds to the existing literature an insight of what type of institutional arrangement a different legal origin can imply. While Djankov et al. (2005) find that differences of legal creditor protection across groups of countries (of the same legal origin) are persistent over time, we add to this literature that differences in the states of technology across countries can better the dispersion of the creditor rights scores.

3.1.1 Related Literature

This paper is related to two different strands of the literature. It is related to the literature on legal origins and to the one on the political economy of finance and regulation. Moreover, as stated above we borrow the model set up from BDH.

With regard to the legal origins literature, since the path-breaking works of La Porta et. al. (1997, 1998), an increasing literature has focused on the role of legal system on the economic and financial performance. The idea is that countries financial system differences are closely related to different origins of the legal system. In particular, the various legal origin systems differ in terms of the investor protection level. This paper is related to this literature because it tries to explain what are the possible sources of different legal origins. In particular, since it is focused on the different levels of creditor protection, it is closely related to the empirical findings of Djankov et al. (2005). Glaeser and Shleifer (2002) also provide an explanation of sources of legal origins based on historical differences in the level of independence of judges between France and England.[11] Differently from them, in this paper we argue that the source of different legal origins is in the relative abundance of an input factor that justifies a growth strategy based on maximizing the contribution of this factor to growth. In this sense, our paper shares with Glaeser et al. (2004) the so called "development view" that economic growth and factor accumulation cause institutional improvement, rather than the other way around, as instead it is argued by the "institutional view" (Acemoglu, Johnson and Robinson (2001, 2002)),[12]

[11] France and England are the countries where modern Civil Law and Common Law systems were originated.

[12] According to the institutional view, the political institutions that limit government presence in the

Moreover, this paper is also related to a literature that explains the persistence of low investor protection and entry regulation on the basis of political economy arguments. We do not pretend to be exhaustive here, but we will cite two most related papers. An important contribution is by Caselli and Gennaioli (2005, GC henceforth), who compare the viability of competition reform with that of legal investor protection reform. In another paper, Perotti and Volpin (2005, PV henceforth) argue that low creditor protection is a barrier to entry that incumbents use in order to prevent entrants from raising capital. Both these works focus on the political system that support these institutional arrangements and on the viability of reforms. Differently from these works, we do not take a political economy approach to explain persistence of investor protection, but we explain the level of creditor protection as the outcome of different growth strategies and of competition policies.

Finally, as stated above, this model is related to BDH, from which we borrow the main set up, but with some differences. The main difference is that we consider only the credit financial contract, while their analysis includes also equity; we do this simplification because our focus is mainly on the creditor protection level in general, while their model is focused on describing the venture capital financing. Nevertheless, as an extension we check whether our results are robust by including the equity share (to be determined in equilibrium) in the financial contract.

The rest of the proceeds as follows. Section 2 contains the main model equations. Section 3 shows the optimal level of creditor protection under different growth strategies when there are only financial constraints. In section 4 we repeat the analysis of section 3 with the inclusion of technology constraints. While section 5 briefly summarizes the results, in section 6 we extend the contract by including the equity share. Finally, section 7 concludes.

3.2 The Model

Consider an economy where there are V intermediate productive sectors $(1, 2, ...v, .., V)$. These inputs are used to produce a unique final good (Y) according to the following production function:

economy cause economic growth. Further references are: Easterly and Levine (2003), Dollar and Kraay (2003), Rodrik, Subramanian, and Trebbi (2002).

$$Y_t = \frac{1}{\alpha}\sum_{i=1}^{I} A_{i,t}^{1-\alpha} x_{i,t}^{\alpha} \tag{3.1}$$

where $A_{i,t}$ is the TFP[13] of firms operating in sector i at time t. $A_{i,t}$ also represents the quality level of that good), $x_{i,t}$ is the total amount of input i used in the final good production. The final good is produced competitively, while the intermediate goods are produced by a monopolist. Intermediate products are invented by entrepreneurs who run individual *R&D* firms. The invention is the outcome of a research project, it is patented (so we can call it innovation) and it is sold to an intermediate producing firm. These entrepreneurs have the ideas and the skills to develop the research project but do not have funds; in turn, there are creditors, who have funds but do not have the skills to develop the projects on their own. In this way we introduce a financial gap at R&D stage and our focus will be to investigate the financing of projects that increase productivity of intermediates (we assume away uncertainty in the final goods production). Each entrepreneur at the research stage runs a firm. The research activity consists of a project such that will deliver a gross return of π with probability p, and in case of failure (with probability $1-p$) the return is null. Moreover, the outcome of the *R&D* is considered as an innovation, that is patented (as in the tradition of the endogenous growth models) as it increases the productivity of the intermediate good by a factor $\gamma > 1$ with respect to the existing productivity level A_0: $A_1 = \gamma A_0$. More in detail, the return on a project is $\pi = \delta A$, where δ is a positive constant (see Appendix 1 for details), and the probability of success is $p = e + vk^{\alpha}$, where e is the effort level exerted by the entrepreneur, k is the amount of capital to be invested in the project and $\alpha \in (0,1)$ captures the decreasing returns of capital in the R&D process. Moreover, v represents the degree of creditor activism into the research firm or alternatively it describes creditor's effort into the project.[14] Indeed, R&D financing is often not only limited to the initial outlay, but the creditor often participates actively to the research process, as its uncertain nature implies an extra-effort by the side of the financier.[15]

The cost of effort for the entrepreneur and for the creditor are quadratic; respectively:

[13]Throughout the paper, the terms quality and TFP (Total Factor Productivity) and state of technology are used interchancgeably, where this creates no confusion. Moreover, since we consider each sector separately, we drop subscript (i).

[14]The terms creditor effort and creditor activism will be used intechangeably in the text. Moreover, note also that the parameter v is limited by $v < (1-e)/k^{\alpha}$, since $0 < p < 1$.

[15]For example a wide literature on venture capital has documented the role of the investor in the figure of the venture capitalist: we do not pretend to be exhaustive, but see for example Casamatta (2003), Hellman (1998) for theoretical contributions.

$e^2/2$ and $v/2$. Moreover, because creditor protection can be partial, the entrepreneur pays back to the lender a fraction λ (so that $0 \leq \lambda \leq 1$) of the initial outlay k. Here λ represents the quality of the legal system to recover part of the profits from the borrower in case of success: indeed, since the success depends on the efforts of both parties, they split the pie in shares that are for the moment dependent only on the institutional exogenous parameter λ. For example, it can represent the ability of a court to recover the funds borrowed by the entrepreneur. Then, λ can be thought of being fixed by the policymaker, and so it represents the policy parameter of the model. Moreover, r is the interest rate, and the due repayment to the creditor at the end of the period is rk, while due to legal system imperfections, the actual expected repayment is λrk. In turn, the creditor can grab part of the profits in a proportion λ.[16] Therefore, the entrepreneur's utility is given by:

$$V_E = (1 - \lambda)(e + vk^{\alpha})\pi - \lambda rk - \frac{e^2}{2} + \overset{\frown}{\beta} \tag{3.2}$$

where the underlying assumption is that the outcome of the project π is fully verifiable by both parties. The entrepreneur has no pre-existing assets, but through moral hazard he can retain private benefits $\overset{\frown}{\beta}$, whenever his effort is not maximized. Specifically, $\overset{\frown}{\beta} = [0, \beta]$, that is they are null in the optimal contract where the entrepreneurs' effort is subject to the incentive compatibility constraint, to be determined below.

On the other hand, in front of the initial outlay k, the creditor will be paid back with the residual fraction of returns λ from the project and with a fraction λ of the due repayment rk; therefore, her utility is given by:

$$V_I = \lambda (e + vk^{\alpha})\pi + \lambda rk - k - \frac{v^2}{2} \tag{3.3}$$

Entrepreneurs effort is maximized profits by choosing the optimal effort level (entrepreneur's incentive compatibility constraint):

$$e^* = (1 - \lambda)\pi \tag{3.4}$$

[16] In principle, this part of repayment might differ from the share of repayment retained by the entrepreneur. For simplicity we set them to be equal to the same value λ, as both represent the quality of the legal investor protection.

The level of effort is independent of the creditor choices, but depends on the level of creditor protection. Moreover, entrepreneurs demand of capital is

$$k^d = \left[\frac{(1-\lambda)\,\alpha\upsilon\pi}{\lambda r}\right]^{\frac{1}{1-\alpha}} \tag{3.5}$$

while the creditor will optimize its profits by supplying capital according to the following:

$$k^s = \left[\frac{\lambda\alpha\upsilon\pi}{1-\lambda r}\right]^{\frac{1}{1-\alpha}} \tag{3.6}$$

where k^s and k^d are two different curves with respect to λ. More in detail, notice that the supply of capital increases when legal creditor protection is higher, and while it is the reverse for the demand of capital. The first effect corresponds to what is predicted by the (so called) "creditor power theories", for which as creditors are more protected over repayment, they are also more willing to extend credit. The demand for capital is diminishing with respect to the level of creditor protection because a lower creditor protection implies a lower expected repayment by the entrepreneur, who, in turn, is induced to demand more capital (we may indeed consider the fraction of expected repayment λ as the inverse of the discount rate).

Finally, k^s and k^d are two different curves with respect to r and they cross at the equilibrium interest rate

$$r^* = \frac{1}{\lambda} - 1 \tag{3.7}$$

Two observations are due with regard to the equilibrium interest rate. First, the equilibrium interest rate clears the market for any level of legal creditor protection. Second, the equilibrium interest rate is decreasing with the level of creditor protection. This is because the interest rate has a compensating effect over the losses of missed repayment: say, since expected repayment for a given amount of capital is lower with a poor creditor protection, the optimal contract will have a higher interest rate.[17] By plugging (3.7) into (3.6), the level of capital is given by:

$$k^* = (\alpha\upsilon\pi)^{\frac{1}{1-\alpha}} \tag{3.8}$$

The level of creditor activism is determined by the maximization of the creditor

[17] When $\lambda = 1$, the equilibrium interest rate $r^* = 0$. This situation corresponds to an interest rate equal to the risk free rate (which is zero in this model).

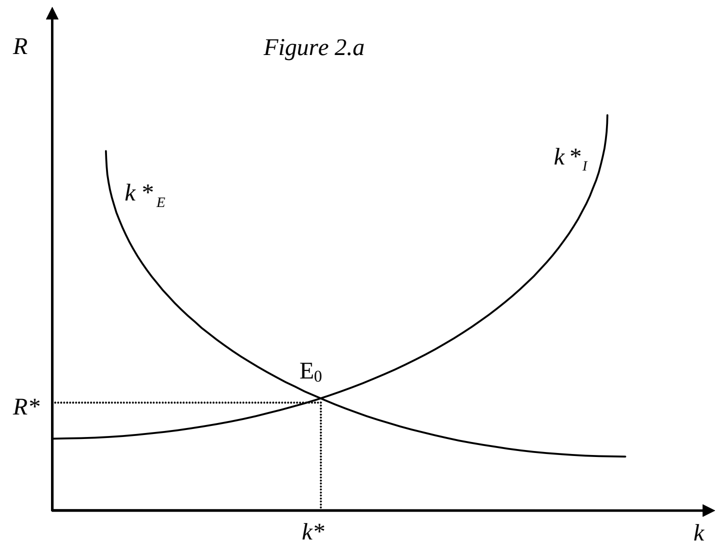
utility function (3.3) and substituting the value of capital in (3.8):

$$v^* = \lambda^{\frac{1-\alpha}{1-2\alpha}} \left(\alpha^\alpha \pi\right)^{\frac{1}{1-2\alpha}} \tag{3.9}$$

which represents the equilibrium value of the creditor protection, while the equilibrium level of capital is given by:

$$k^* = \left(\lambda \alpha \pi^2\right)^{\frac{1}{1-2\alpha}} \tag{3.10}$$

The two curves are shown in figure 2.a



From figure 2.a we see that with lower credit protection the demand for capital increases, while the supply decreases. This is true for both the case with and without free entry. For the supply side, this model shares with the creditor power theories the view that more creditor protection induces creditors to lend more easily (supply effect), but it is different because we consider also the demand side effects, that is entrepreneurs are more willing to borrow the lower is the expected credit repayment.

Moreover, as it is evident from figure 2.b, the curves derived under free entry condition in (3.36) and (3.35) lie always above the demand and supply curves derived in (3.5) and (3.6). This means that in order to maximize the probability of success, it *may* be more appropriate to set the capital level at the maximum possible amount, which is exactly the one given by the free entry curves $\bar{k}_I$ and $\bar{k}_E$(the appropriateness of this competitive policy will discussed in detail below).

In summary, in this section we have explained the main equations of the model and we have derived the equilibrium of the model under the assumption that the government does not pursue any particular policy; this means that the level of creditor protection λ has been insofar exogenous. In the rest of the paper we focus the attention on the particular policies that the government may pursue so as to endogenize the choice of λ.

3.2.1 Decentralized equilibrium

So far we have described an economy where all of the parameters are decided by the two parties, except for the policy parameter λ, which has been left exogenous. It turns out that in such an economy, if we were to let the government to be neutral to both parties, the only way to decide a value for λ is to maximize both the incomes of the entrepreneur and of the investor respectively: $V = V_E + V_I$.

Assume that in the economy there is an equal mass of entrepreneurs and of investors, and that there is no unmatched pair in equilibrium. Then, define as decentralized equilibrium, the one that can be obtained by maximizing the total income of the economy (V), taking as given the equilibrium values of efforts and of capital as defined above, since these are fully contractible between the parties and may not realistically be decided by an external authority, except for the parameter λ.

Therefore a decentralized equilibrium is given by:

$$\begin{aligned} \underset{\lambda}{max}\ V &= (e + vk^{\alpha})\,\pi - k - \frac{e^2}{2} - \frac{v^2}{2} && (3.11) \\ s.t.\ \ e &= e^*,\ v = v^*,\ k = k^* && (3.12) \end{aligned}$$

where e^*, v^* and k^* are given by (3.4), (3.9) and (3.10) respectively. Plugging in all the values, we obtain the following nonlinear expression:

$V^* = (1-\lambda)\,\pi^2 + A^{2\alpha}B\lambda^{\frac{1}{1-2\alpha}} - AB\left(\lambda^{\frac{2\alpha}{1-2\alpha}} - \lambda^{\frac{1}{1-2\alpha}}\right) - \frac{1}{2}\left[(1-\lambda)^2\,\pi^2 + A^{2\alpha}b\lambda^{\frac{2(1-\alpha)}{1-2\alpha}}\right]$

where $A = \alpha^{\frac{1}{1-2\alpha}}$ and $B = \pi^{\frac{2}{1-2\alpha}}$. Derivating V^*, the maximum value of λ is given by the solution of the following:

$$\pi^2 = \gamma A^{2\alpha}B\lambda^{\psi} - AB\gamma\left(2\alpha\lambda^{\varepsilon} - \lambda^{\psi}\right) - (1-\lambda)\,\pi^2 + A^{2\alpha}B\gamma\,(1-\alpha)\,\lambda^{\gamma} \tag{3.13}$$

where $\gamma = \frac{1}{1-2\alpha}$, $\psi = 2\alpha\gamma$, $\varepsilon = (4\alpha - 1)\,\gamma$. The expression above, cannot be solved analytically, but through simulation, where we allow λ to vary according to the capital intensity parameter (α) and the technology parameter (A) composing the profit function $\pi = \delta A$. Assuming a value of $\delta = 1$ and letting A vary in the range $[0.1, 1]$ and

$\alpha\epsilon\,[0.1, 0.4]$,[18] we obtain, as shown in figure 3, that λ clearly declines with the technology parameter A. This solution is somewhat puzzling, as it implies that countries with higher technology endowments benefit of lower creditor protection, which is clearly not true. Since we cannot accept this simple explanation for the determination of λ, as casual observation usually implies the opposite,[19] we turn to a different approach in the next section where the government pursues a policy aimed at achieving a more targeted policy.

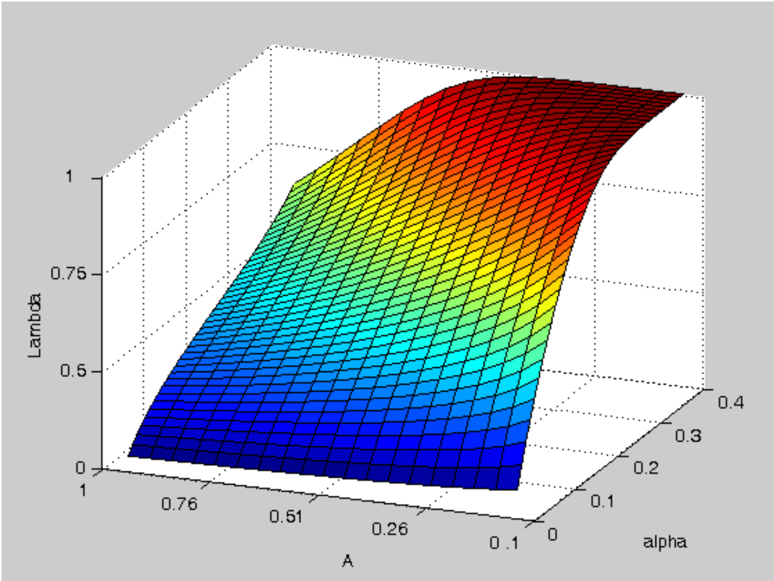


Figure 3: λ versus A and α.

3.3 Growth Policy with financial constraints

While in the previous section the policymaker was neutral between the parties, in this section we describe the different policy strategy that may help to explain why countries the dispersion of creditor protection levels across countries. We assume in this section that entrepreneurs face only a credit constraint, while in the next section we will enrich the analysis with also technology constraints.

The discussion that follows depends crucially on the determinants of growth in this model. From (3.1) and the definition of the probability ($p = e + vk^{\alpha}$), the productivity growth rate (g); this is given by

[18] These values are chosen so as to avoid complex roots, but for α, the capital intensity , we let it vary in a range around the usual value of 0.3.

[19] See for example Doingbusiness (2007).

$$g = (1 + \gamma)\, p - 1 = (1 + \gamma)\, (e + vk^{\alpha}) - 1$$

In the ensuing subsections we consider the government to pursue a policy aimed at maximizing g in three different cases, where in the first two the government maximizes the contribution of each one component separately (e for the entrepreneurship case, and v for the creditor activism case), while in the third we consider all of the three components at the same time. But why should a country choose to focus on the maximization of only one input, instead of all of them? There are two reasons for this choice. First, as it will be shown below, the creditor protection policy instrument has opposing effects on the inputs: in general, an increase of the investor protection decreases entrepreneur's effort, but it increases creditor's effort and level of capital, so that the first is substitute of the other two, not complementary. Secondly, because of this substitution, a country in which one of the inputs is relatively more abundant than the others, might choose to implement a growth strategy based on the maximization of this input contribution in the growth process. It is also possible that a country is well endowed with all three of the inputs: in this case it is worth studying the different growth strategies because of the substitutability mentioned above.

3.3.1 Entrepreneurship Policy

It is easy to verify from (3.4) that this policy requires to set the level of legal creditor protection at the lowest level $\lambda = 0$. This is because, with a higher creditor protection the entrepreneur's expected pay-off decreases, and this discourages the entrepreneur from exerting more effort. Analytically, $e^* = (1 - \lambda)\pi$ is an ever decreasing function of the level of creditor protection. Moreover, note that the optimum level of effort is independent of the other two inputs, that is the capital and the level of creditor activism, therefore solution is straightforward: the optimal level of creditor protection is zero.[20]

The result that entrepreneurs favour a low level of creditor protection is not new in the literature. In fact, this result is similar to the findings of Perotti and Volpin (2004), where entrepreneurs seek a low level of effective creditor protection (but in their case incumbents want to prevent potential entrants from raising capital).

[20] Note that when $\lambda = 0$, both k^* and $\bar{k}$ are null, so it makes no difference to consider the model with and without free entry.

3.3.2 Creditor Activism Policy

In this section we investigate the policy aimed at maximizing creditor activism, when capital is given by the equilibrium value in (3.8), the equilibrium interest rate is given by (3.7) and the level of effort by (3.4).[21] In this case it is possible to determine the optimal policy of creditor protection, as explained by the following proposition:

Proposition 14 *When the government pursues a policy of maximizing creditor activism, the optimal policy is to set the level of creditor protection at the highest level:* $\lambda = 1$.

Proof. Creditor activism is determined by maximizing the creditor utility function V_I for a the equilibrium level of capital given by (3.8) k^*, the equilibrium interest rate r^* given by (3.7) and the equilibrium level of effort given by (3.4). This means that the utility function (3.3) is $V_I = \lambda\left(e^* + vk^{*\alpha}\right)\pi + \lambda r^* k^* - k^* - \frac{v^2}{2}$ where replacing all the values we have $V_I = \lambda\left(1-\lambda\right)\pi^2 + \lambda\left(\alpha^\alpha \pi\right)^{\frac{1}{1-\alpha}} v^{\frac{1}{1-\alpha}}\left(1-\alpha\right) - \frac{v^2}{2}$. The zero of the V_I function with respect to v is: $v^*_{CA} = \lambda\left(\alpha^\alpha \pi\right)^{\frac{1}{1-2\alpha}}$. Therefore the level of creditor protection which maximizes v^*_{CA} is $\lambda = 1$. ■

Since the creditor has some positive profit, he finds profitable to increase the level of effort when his loan is more protected. This result is due to what we call "protection" effect, for which creditors are more willing to exert effort when the level of creditor protection is higher, as stated by the theoretical literature on creditor power, for which an increase in credit protection enhances investor's activism in the project.

3.3.3 Global inputs Policy

Suppose that the government wants to maximize the probability of success considering all the three inputs. Then, the government plan is:

$$\max_{\{\lambda\}} p = e + vk^\alpha \tag{3.14}$$

[21] This analysis excludes free entry on both sides of the market, since in equilibrium, both the entrepreneur and the investor are allowed to earn a postive rent. The other case, when the equilibrium capital is given by the free entry condition in both the creditors and the R&D markets is developed in the appendix.

Since the level of capital is highest when there is free entry, it is useful to compare this result under two distinctive assumptions. Consider that in this case the level of capital is given by (3.10) and the level of effort by (3.4), while the level of creditor activism is from (3.9).

Global Inputs policy

Also in this case, we find that the optimal policy is to set the highest level of creditor protection. This is shown in the following proposition:

Proposition 15 *When the government pursues a policy of maximizing the total probability of success, the optimal level of creditor protection is* $\lambda = 1$ *if* $\pi > \pi^+ = \left(\frac{1}{\alpha^{2\alpha}}\right)^{\frac{1}{\alpha^2+5\alpha-1}}$.

Proof. From the discussion in the previous section we have the equilibrium level of capital from (3.10) is $k^* = (\lambda\alpha\pi^2)^{\frac{1}{1-2\alpha}}$ and the corresponding expression of creditor activism from (3.9) is $v^* = \lambda^{\frac{1-\alpha}{1-2\alpha}} (\alpha^\alpha \pi)^{\frac{1}{1-2\alpha}}$. Plugging these values into the total probability expression, we have that the maximization plan is

$$\max_{\{\lambda\}} p^* = e^* + v^* k^{*\alpha} = (1-\lambda)\,\pi^2 + \lambda^{\frac{1}{1-2\alpha}} \alpha^{\frac{2\alpha}{1-2\alpha}} \pi^{\frac{1+2\alpha}{1-2\alpha}}$$

The solution to this plan is a minimum at $\lambda_{\min} = \left[\frac{(1-2\alpha)\pi^2}{\alpha^2}\right]^{\frac{1-2\alpha}{\alpha}}$. Moreover the function p^* has two extremes at the values $\lambda = 0$ and $\lambda = 1$. It can easily be verified that the maximum of p^* is at $\lambda^* = 1$ (that is $p^*|_{\lambda=1} > p^*|_{\lambda=0}$) for $\pi > \pi^+ = \left(\frac{1}{\alpha^{2\alpha}}\right)^{\frac{1}{6\alpha-1}}$.
■

Therefore, the optimal level of creditor protection is 1, for $\pi > \pi^+$. This result depends on two factors. First, the condition on production profits, where this is high enough for a high level of technology (indeed, recall that $\pi = \delta A$). Secondly, it depends on the technical assumption that creditor activism, differently form entrepreneur's effort, is a variable that affects the productivity of capital directly, as it is evident from (3.3) and (3.8). Therefore, for a state of technology high enough, we have a double effect on p^*, which more than compensates the entrepreneurship effect, for which the preferred λ is zero.

In summary, in this section we have analyzed three different growth strategies. While the creditor protection index is to be set lowest to maximize entrepreneurship, it is to be set highest under the creditor activism strategy. Finally, under the global inputs strategy, this is to be set at the highest level, provided that state of technology is sufficiently high. Since the global inputs strategy is the most realistic case, this last consideration drives to concentrate in the role of the state of technology in the determination of λ, as explained in the following section.

3.4 Growth Policy Strategies with technology and financial constraints

While in the previous section the growth strategy included only financial constraints, in this part we make a further extension by including also technology constraints. This extension helps to explain the dispersion of the creditor protection levels across countries, as it is shown in figure 1. In the model, all the parameter choices are due to different growth strategies, therefore we extend the model in order to include also technology constraints, in the way suggested by the growth literature. We will show that while the main properties of the model derived in the previous section still hold, the inclusion of the technology constraints allows to pin down more exactly the values of the policy parameter λ.

With regard to the technology constraints that might affect a productivity increasing project, we have that two opposing views are considered. The fist is the "Standing on the Shoulder of Giants" view (henceforth SSG), which considers that projects are easier to under undertake at more advanced stages of technology, and the other is the "Fishing Out Effect" view (henceforth FOE), for which productivity increases are more and more difficult to obtain as we move the technology frontier forward. For references, with regard to the first view see for example Acemoglu and Zilibotti (1997), where it is argued that the minimum capital requirement of projects increases with technology, while for the second see for example Aghion and Howitt (2004). In this section we analyze the SSG case only, because it implies that countries with a more advanced technology are endowed with more capital.[22]

According to the SSG view, each project must have, in addition to the financial constraints introduced in the previous sections, also a minimum size requirement, which is our technology constraint. That is to say that research projects can be undertaken only if the capital investment is higher than a minimum threshold level. We call this a technology constraint because the minimum size requirement depends inversely on

[22] As we already mentioned in the comment of the simulation, it is not realistic to assume that countries with a more advanced state of technology are endowed with a lower level of creditor protection. This means also that for countries with higher technology endowments, the amount of capital is higher, as explained by (3.8); in turn, this implies that for the same level of capital, the capital-technology constraint on constraint on the projects is lower.

technology (in other words, productivity increasing projects are easier to undertake when technology is more advanced). In this way, the SSG constraint we introduce here is similar to Acemoglu and Zilibotti (1997). Specifically, if the initial state of technology is A, then the minimum amount of capital required to undertake the project of expected return π and that allows a fixed jump of technology γ is (in its simplest form)

$$k(A) = \left(\frac{\zeta}{A}\right)^{\frac{1}{1-2\alpha}} \tag{3.15}$$

where the minimum size $(k(A))$ is decreasing with the state of technology A, which means that the minimum amount of capital required to undertake a step innovation project is lower and lower as the state of technology improves.[23] The minimum size constraint depends also on a constant $\zeta > 1$.[24] We now proceed to review the three different growth strategies considering also the constraint in (3.15).

3.4.1 Entrepreneurship Policy

Under this policy, recall that the function to be maximized is given by (3.4). However, while the original prediction was to set the creditor protection parameter λ to zero, here we have that the constraint actually affects this choice. Indeed, also in this case from the maximization of e^*, the optimal level of λ should be zero. However, since the technology constraint delivers a minimum positive value of λ, the optimal policy changes accordingly. This is stated in the following proposition:

Proposition 16 *When the government pursues a policy aimed at maximizing entrepreneurship and there is SSG technology constraint, the optimal value of creditor protection is*

$\lambda_E = \frac{\zeta}{\alpha^{(1-\alpha)}\delta^{(1-2\alpha)}A^{(1-\alpha)(1-2\alpha)}}$.

Proof. The technology constraint is $k^* \geq k(A)$, where substituting from (3.10) and (3.15) we have that: $\lambda \geq \lambda_E = \left(\frac{\zeta}{\alpha\delta^{1+\alpha}A^{2+\alpha}}\right)^{\frac{1}{\alpha}}$. ■

[23] Alternatively one could set that the minimum size requirement is increasing with the state of technology A, but it allows higher and higher steps in technology improvement.

[24] Imposing $\zeta > 1$, implies that the SSG technology constraint is not trivial. In fact, if we had $\zeta \leq 1$, then we would always have $k(A) < 1$.

Note that this minimum level of λ decreases with the initial technology level A. Therefore, as the technology in a country improves, the constrained maximum λ_E approaches the unconstrained one ($\lambda = 0$). This means that a country with a higher technology will have a higher entrepreneurship level, under this growth strategy.

3.4.2 Creditor Activism Policy

In this case, creditor activism is chosen by the maximization of (3.3) with respect to v , and the optimal level of creditor protection is as before: $\lambda = 1$. In the following proposition we argue that the optimal level of creditor protection is feasible under a specified technology constraint.

Proposition 17 *When the government pursues a policy of maximizing creditor activism with a SSG technology constraint, the optimal level of creditor protection ($\lambda^{**} = 1$) can be obtained only if the state if:* $A \geq A_{CA} = \left(\frac{\zeta}{\alpha\delta^{1+\alpha}}\right)^{\frac{1}{2+\alpha}}$.

Proof. The technology constraint is $k^* \geq k(A)$, where k^* is given by (3.10) and $k(A)$ by (3.15). Since the optimal policy is $\lambda = 1$, solving the constraint for A, the technology constraint is $A \geq A_{CA} = \left(\frac{\zeta}{\alpha\delta^2}\right)^{\frac{1}{3}}$. ■

From the proposition it is clear that the state of technology has to be at least a big as A_{CA} in order to achieve the first best policy. Therefore, again, the presence of an SSG constraint affect the choice of the policy parameter.

3.4.3 Global Inputs policy

When the government wants to maximize the probability of success considering all the three inputs, the government plan is given by (3.14). In this case, we find that the optimal policy is to set creditor protection to the highest level, and that (as in the case of free entry) the role of the SSG technology constraint is to impose a minimum state of technology for this policy to be feasible. This is shown in the following proposition:

Proposition 18 *When the government pursues a policy of maximizing the total probability of success, there is not free entry and there is a SSG technology constraint, the optimal level of creditor protection λ is 1, and the technology condition is:* $A \geq A_{g,1} = \frac{\alpha^{\frac{2\alpha}{1-5\alpha-\alpha^2}}}{\delta}$.

Proof. As in the previous section, the equilibrium level of capital is k^* from (3.10) and the level of creditor activism is v^* from (3.21). Plugging these values into the total probability expression, we have that $\lambda = 1$. Again, the maximum of p^* is at $\lambda = 1$ if $\pi > \pi^+ = \left(\frac{1}{\alpha^{2\alpha}}\right)^{\frac{1}{6\alpha-1}}$. Replacing $\pi = \delta A$ into the previous expression, we obtain: $A \geq A_{g,1} = \frac{\alpha^{\frac{2\alpha}{1--6\alpha}}}{\delta}$ (first technology constraint of this proof). Moreover, from the SSG technology constraint $k^* \geq K(A)$ with $\lambda^* = 1$), we have that $A \geq A_{CA} = \left(\frac{\zeta}{\alpha\delta^2}\right)^{\frac{1}{3}}$. It can be shown that for $\zeta < \frac{\alpha^{\frac{1}{1-6\alpha}}}{\delta}$, $A_{g,1} > A_{CA}$. ■

Also in this case, with respect to the case of only financial constraint, introducing an SSG constraint restricts the state of technology range where this policy can be implemented. More in general, the introduction of the SSG constraint makes such that with or without free entry the optimal policy ($\lambda = 1$) is feasible only at an advanced state of technology.

3.5 Summary of the results

In this section, given the heavy taxonomy of the previous two sections, we briefly summarize the results obtained insofar, with the help of the following table:[25]

TABLE 1	Finl. Constraint only	Fin + Tech. Constraints
max e	λ=0	$\lambda>\lambda_E$
max v_{FE}	λ indeterminate and v=0	λ indeterminate and v_E>0
max v_{BE}	λ=1	λ=1, if $A>A_{CA}$
max p_{FE}	λ=1	λ=1, if $A>A_{g,1}$
max p_{BE}	λ=1 if $\pi>\pi^+$	λ=1, if $A>A_{g2}$

In the second and third column we report the optimal policy when there are only financial constraints and when there are also technology constraints respectively. The rows correspond to different growth strategies: the first row is the entrepreneurship strategy, the second and third are the creditor activism strategy with free entry (FE) and with barriers to entry (BE), while the fourth and fifth correspond to the global input strategy.

From the table above we can derive some considerations about the growth strategy predictions in general, and also about the role of the technology constraint and that of free entry. First, comparing the different growth strategies, the general picture one gets is that introducing the SSG constraint restricts the state if technology range in which the creditor activism and the global inputs policies are feasible. In particular, with regard

[25] This table contains also the results with free entry, which are analytically exposed in detail in the appendix.

to the viability of the entry deregulation reform, note that we can state the following:

Lemma 2 *Removing barriers to entry increases the level of investor activism.*

In particular, while in the global inputs strategy we have that the optimal policy is feasible for a state of technology at least as high as $A_{g,1}$.

Moreover, it is clear that the entrepreneurship strategy requires a low level of creditor protection, while the creditor activism may require protection to be high. The global strategy also requires that creditor protection is high. This consideration reveals that in the global inputs strategy the protection effect is stronger than the entrepreneurship effect.

Finally, while free entry has no effects for the entrepreneurship strategy, it does in the other two strategies. This is because free entry affects positively the level of capital in equilibrium. In the case of creditor activism, lifting entry barriers lets λ be undetermined and the level of creditor protection positive (under technology constraint). Instead, if we adopt a global inputs strategy, we can apply the optimal policy value ($\lambda = 1$) provided that the technology constraints are not binding.

3.6 The equity and debt optimal contract

In this section we expand the previous model by including equity. In the previous sections the underlying assumption was that the share of profits, except for the parameter λ, was fixed. Differently, the idea of this section is that the imperfection due to partial legal creditor protection can be solved by appropriately designing a contract that allows to reward the investor for a share of profits in addition to the interest rate, where the equity share is to be determined contractually. We will proceed the analysis by making two cases. In the first, we consider just entrepreneurs without pre-existing assets. This corresponds to the case of the start up firms, in which entrepreneurs lack not only of funding, even for initial personal wealth. In the second case we introduce equity with entrepreneur's pre-existing assets. We believe that this corresponds to the case of incumbent entrepreneurs, who have already accumulated wealth in the past.[26] It will be shown that introducing personal wealth in the contract alters the incentives by including a downside protection for the investor. Finally, the incumbent case is enriched by including an opportunity cost given by a bond. This allows to fix the interest rate,

[26] Moreover, since the contract is extended to equity, it will be convenient to rename λ as legal investor protection variable.

and in this case we find that the level of legal investor protection λ is increasing with the state of technology A.

3.6.1 Start-up firms

Let s be the share of profits to the investor to be determined in the equity contract. The utility of the entrepreneur and of the investor are respectively

$$V_E = (1 - \lambda s)(e + vk^\alpha)\pi - \lambda rk - \frac{e^2}{2} + \widehat{\beta} \tag{3.16}$$

$$V_I = \lambda s (e + vk^\alpha)\pi + \lambda rk - k - \frac{v^2}{2} \tag{3.17}$$

Since the entrepreneur's utility does not depend on his pre-existing assets, and this case represents the situation of start-up firms. From the maximization of (3.16) and of (3.17), we have that the entrepreneur demand of capital is

$$k^d = \left[\frac{(1 - \lambda s)\alpha v\pi}{\lambda r}\right]^{\frac{1}{1-\alpha}} \tag{3.18}$$

and investor supply of capital is:

$$k^s = \left[\frac{\lambda s\alpha v\pi}{1 - \lambda r}\right]^{\frac{1}{1-\alpha}} \tag{3.19}$$

Note that k^s and k^d keep the main same properties of those derived in the previous sections, except for the new component s. Indeed, the demand of capital is lower as the investor share of profits s increases; conversely, the investor supplies more capital if he is given a higher share s.

In accordance with the analysis of the previous section, we introduce technology constraints in terms of capital constraints. In particular, we again introduce a SSG type of capital constraint that can be binding for the demand or for the supply of capital. Starting the analysis with a binding constraint in the demand of capital, we have:[27]

[27] We have changed the normalization factor to $\frac{1}{1-\alpha}$ for simplicity.

$$k^d = \bar{k}(A) = \left(\frac{\zeta}{A}\right)^{\frac{1}{1-\alpha}}$$

Analogously with the previous section, note that entrepreneur's effort is given by the maximization of (3.16):

$$e^* = (1 - \lambda s)\,\pi \tag{3.20}$$

and respectively investor activism is given by:

$$v^* = \lambda s \bar{k}^{\alpha}\,\pi \tag{3.21}$$

where $\bar{k} = \bar{k}(A)$. Moreover, we determine the optimal value of the share of profits (s^*) by maximizing the joint utility $V = V_E + V_I$. The first-order condition for s^* is

$$\frac{\partial V}{\partial s} = 0 \Longrightarrow (\pi - e)\,\frac{de}{ds} + (\pi - v)\,\frac{dv}{ds} = 0$$

where, substituting the values e^* and v^*, we have that s^* is

$$s^* = \frac{\bar{k}^{2\alpha}}{\lambda\left(1 + \bar{k}^{2\alpha}\right)} \tag{3.22}$$

As expected, the optimal value of s decreases with legal investor protection, because as the investor is less protected from default, he will pretend a higher share of profits. From this value we have the following proposition:

Proposition 19 *When the capital constraint is binding for the demand of capital by a start up firm, the optimal level of effort of the entrepreneur and of the investor do not depend on legal investor protection.*

Proof. Plugging the optimal value of s from (3.22) into e^* and v^*, we have that optimal values of efforts are: $e^* = \frac{\pi}{1+\bar{k}^{2\alpha}}$ and $v^* = \frac{\bar{k}^{3\alpha}\pi}{1+\bar{k}^{2\alpha}}$. ■

Finally, the equilibrium interest rate (r^*) is given by equalizing demand and supply of capital: $k^s = \bar{k}$. Solving for r^* and plugging the optimal value of v we have

$$r^* = \frac{1}{\lambda}\left[1 - \alpha\pi\bar{k}^{6\alpha-1}\right] \tag{3.23}$$

Note that similarly to s^*, also the interest rate decreases with the level of legal creditor protection. Again, the intuition is that as the legal system gives less protection to the investor, his interest repayment has to increase.

From the inspection of (3.22) and of (3.23), we have that both depend negatively on the level of legal investor protection λ. So, one could expect that also the utilities of the two players depend on λ. However, it turns out that is not the case. In fact, the mix of debt and equity is such that legal investor protection does not matter for the entrepreneurs nor for the investor:

Proposition 20 *When the capital constraint is binding for the demand of capital, the equilibrium utility levels of the entrepreneur and of the investor do not depend on the level of legal investor protection λ.*

Proof. *Plugging (3.22) and (3.23) into V_E and V_I we have that*

$$V_E = \left(\frac{\bar{k}^{2\alpha}}{1+\bar{k}^{2\alpha}}\right)\left(1 - \frac{\bar{k}^{2\alpha}\pi}{1+\bar{k}^{2\alpha}} + \frac{\bar{k}^{4\alpha}\pi}{1+\bar{k}^{2\alpha}}\right)\pi - \frac{\pi^2}{2\left(1+\bar{k}^{2\alpha}\right)^2} - \left[1 - \alpha\pi^2\bar{k}^{6\alpha-1}\right]\bar{k}$$

and $V_I = \left(\frac{\bar{k}^{\alpha}\pi}{1+\bar{k}^{2\alpha}}\right)^2\left(1 + \bar{k}^{4\alpha}\right) - \frac{1}{2}\left(\frac{\bar{k}^{3\alpha}\pi}{1+\bar{k}^{2\alpha}}\right)^2 - \alpha\pi^2\bar{k}^{7\alpha-1}.$

As it is evident from the two previous expressions, they both do not depend on λ. ■

Therefore, from the proposition above one can conclude that in the case of financing a start-up firm, legal investor protection does not matter, as the mixed contract of debt and equity can completely solve the problems of the partial repayment in case of default. In a more intuitive way, the investor expected losses from impartial default are the interest repayment and the share of profits. In our case, these two instruments (s and r) are appropriately designed (in the contract) so as to correct the imperfections of the legal system.

Moving to the case that the capital constraint is binding for the supply of capital, the results obtained so far would not be changed. In fact, set $k^s = \bar{k}(A) = \left(\frac{\zeta}{A}\right)^{\frac{1}{1-\alpha}}$. The optimal levels of e and of s are unchanged, while the equilibrium interest rate (r^*) is given by equalizing demand and supply of capital: $k^d = k^s$, or also $\left[\frac{(1-\lambda s)\alpha v\pi}{\lambda r}\right]^{\frac{1}{1-\alpha}} = \bar{k}$. Solving for r^* and plugging the optimal value of v from (3.21) we have

$$r^* = \frac{1}{\lambda}\left[1 - \frac{\alpha\pi^2\bar{k}^{5\alpha-1}}{\left(1+\bar{k}^{2\alpha}\right)^2}\right] \tag{3.24}$$

Again, plugging (3.22) and (3.24) into V_E and V_I we have that $V_E = \left(\frac{1}{1+\bar{k}^{2\alpha}}\right)\left(\frac{\pi^2}{1+\bar{k}^{2\alpha}} + \frac{\bar{k}^{4\alpha}\pi^2}{1+\bar{k}^{2\alpha}}\right) - \left(\frac{\pi}{1+\bar{k}^{2\alpha}}\right)^2 - \frac{\alpha\pi^2\bar{k}^{6\alpha-1}}{\left(1+\bar{k}^{2\alpha}\right)^2}$ and
$V_I = \left(\frac{\bar{k}^{2\alpha}}{1+\bar{k}^{2\alpha}}\right)\left(\frac{\pi^2}{1+\bar{k}^{2\alpha}} + \frac{\bar{k}^{4\alpha}\pi^2}{1+\bar{k}^{2\alpha}}\right) - \left(\frac{\bar{k}^{3\alpha}\pi}{1+\bar{k}^{2\alpha}}\right)^2 + \frac{\alpha\pi^2\bar{k}^{6\alpha-1}}{\left(1+\bar{k}^{2\alpha}\right)^2} - \bar{k}$.

Also in this case, both V_E and V_I do not depend on λ. So, whether capital constraints affect the demand or the supply of capital and the entrepreneur has no pre-existing assets, then the imperfection of the legal investor protection is completely solved by the optimal contract between the parties.[28]

One consequence of the results in this subsection is that they do not help to explain how legal investor protection is determined. Therefore, the determination of the level of the legal investor protection is due to other factors. With regard to this, in the following section we analyze the case of incumbent firms.

3.6.2 Incumbent firms

As stated above, we denote by incumbents the firms whose entrepreneurs have a stock of wealth on which the mixed debt-equity contract can set claims in favour of the investor. Let W be the entrepreneur's wealth stock (W is given). In this case the utility functions can be rewritten as follows:

$$V_E = (1-\lambda s)\left(e + vk^{\alpha}\right)\pi - \lambda rk - \frac{e^2}{2} - s\left(W - k\right) \tag{3.25}$$

$$V_I = \lambda s\left(e + vk^{\alpha}\right)\pi + \lambda rk - k - \frac{v^2}{2} + s\left(W - k\right) \tag{3.26}$$

[28] Note that the reason for this result mainly depends on the fact that there is no contract incompleteness between the parties that cannot be resolved contractually.

The additional feature is the share s of net wealth $(W-k)$. Investor's utility increases by this factor, while the entrepreneur's utility decreases for the same amount. Note that this new component does not depend on λ. Indeed, hiding profits is much easier than hiding wealth!

Following from maximization of (3.25) and of (3.26), we have that the entrepreneur demand of capital is

$$k^d = \left[\frac{(1-\lambda s)\,\alpha v\pi}{\lambda r - s}\right]^{\frac{1}{1-\alpha}} \tag{3.27}$$

and investor supply of capital is:

$$k^s = \left[\frac{\lambda s\alpha v\pi}{1+s-\lambda r}\right]^{\frac{1}{1-\alpha}} \tag{3.28}$$

Note that k^s and k^d keep the same properties of those derived above in (3.5) and (3.6). Nevertheless, the entrepreneur demands less capital if the investor share of profits increases, and the investor supplies even more capital if he is given a higher share s. This additional effect on k^d and k^s derives directly from the additional component of the basic contract: $s\,(W-k)$; in fact, investors supply less capital so that they can grab a higher portion of net wealth, and conversely entrepreneurs also demand less capital, in order to be less expropriated.

Analogously with the previous subsection, we have that entrepreneurs' effort is given by maximization of V_E from (3.25) and investor activism by maximization of V_I from (3.26). From these we have still the values derived in (3.20) and (3.21) respectively.

Moreover, still following the analysis of the previous section, we introduce capital constraints (in the form of technology constraints). In particular, we introduce a demand for capital that is always binding with the technology constraint: $k^d = \bar{k}\,(A) = \left(\frac{\zeta}{A}\right)^{\frac{1}{1-\alpha}}$.

Equalizing capital supply with constrained demand, that is $\left[\frac{\lambda s\alpha v\pi}{1+s-\lambda r}\right]^{\frac{1}{1-\alpha}} = \bar{k}$, and plugging the optimal value of v from (3.21) and using (3.22) for s^*, we find that the equilibrium interest rate (r^*) is given by

$$r^* = \frac{1}{\lambda}\left[1 - \frac{\alpha\pi^2\bar{k}^{6\alpha-1}}{1+\bar{k}^{2\alpha}} + \frac{\bar{k}^{2\alpha}}{\lambda\left(1+\bar{k}^{2\alpha}\right)}\right] \tag{3.29}$$

From the results of (3.5) and of (3.29), we obtain the following result:

Proposition 21 *When the technology constraint is binding for the demand of capital* *by an incumbent firm, the equilibrium utility of the entrepreneur depends positively on the level of legal investor protection λ, while the equilibrium utility level of the investor depends negatively on legal investor protection.*

Proof. *Plugging (3.22) and (3.29) into V_E and V_I we have that*

$$V_E = \left(\frac{1}{1+\bar{k}^{2\alpha}}\right)\left(\frac{1+\bar{k}^{3\alpha}\pi}{1+\bar{k}^{2\alpha}}\right)\pi^2 - \frac{\pi^2}{2\left(1+\bar{k}^{2\alpha}\right)^2} - \left[1 - \frac{\bar{k}^{6\alpha-1}\alpha\pi^2}{1+\bar{k}^{2\alpha}} + \frac{\bar{k}^{2\alpha}}{\lambda\left(1+\bar{k}^{2\alpha}\right)}\right]\bar{k} \quad \text{and}$$

$$V_I = \frac{\bar{k}^{2\alpha}\pi^2}{1+\bar{k}^{2\alpha}}\left(\frac{1+\bar{k}^{3\alpha}\pi}{1+\bar{k}^{2\alpha}}\right) - \frac{1}{2}\left(\frac{\bar{k}^{3\alpha}\pi}{1+\bar{k}^{2\alpha}}\right)^2 + \frac{\bar{k}^{2\alpha}}{\lambda\left(1+\bar{k}^{2\alpha}\right)}.$$

As it is evident from the two previous expressions, V_E depends positively on λ, while V_I depends negatively on λ. ■

From the proposition above one can conclude that in the case of financing an incumbent firm, legal investor protection matters. In particular, the entrepreneur's utility increases with legal investor protection because as λ increases, the entrepreneurs share of profits is also higher and this tends to decrease the expected loss on profits and on the pre-existing assets $(W - k)$. Analogously, investor's utility is lower because the additional gain from entrepreneur's existing assets decreases with a higher λ.[29]

In general, these findings suggest some non-immediately intuitive results. Namely, entrepreneurs are in favour of a higher legal investor protection, while investors are in favour of a lower level of this variable. This is certainly at odds with some recent literature on the determination of the legal investor protection. For example, Perotti and Volpin (2004) argue that *wealthier entrepreneurs do not need much external finance for investment, they lobby to seek weak investor protection, to block access to funding for entry by less wealthy entrepreneurs.*[30] Conversely, in this paper we find that since the share s of the net assets $(W - k)$ for the investor does not depend on λ (indeed, hiding profits is more difficult than hiding wealth), the equilibrium interest rate is lower for a factor λ. In turn, this implies that also the utilities V_E and V_I depend on λ; in particular, since the interest rate is lower, the entrepreneur's utility increases, while the investor's utility decreases.

Incumbent firms with fixed interest rate

In the analysis developed so far all imperfections from the legal protection have been solved in the contract perfectly (as in the case of start-up firms) or imperfectly (incumbent firms). In this latter case, the interest rate reflected this contractual imperfection

[29] The same predictions of the two previous propositions hold also in the case of capital constraint on the supply of capital.

[30] Perotti and Volpin (2004), page 1.

by a factor λ, because of the investor's claim on the entrepreneur's wealth $(W - k)$. It is therefore interesting to study the case in which the interest rate is instead fixed. This situation is common to the cases where only the equity share is determined in the contract.

Consider a government bond which offers a repayment of r^* at maturity without uncertainty. The risk neutral investor chooses to finance the entrepreneur's project only if the expected rate of return is higher than the bond. This can be briefly summarized by a schedule of the contract interest rate which, for given s,[31] is:

$$r = \begin{cases} r\left(k^d\right) & \text{if } r\left(k^d\right) > r^* \\ r^* & \text{if } r\left(k^d\right) \leq r^* \end{cases}$$

Since we are interested to see the case of fixed interest rate, consider that the relevant case is $r\left(k^d\right) = r^*$.[32] Note that still $e^*, v^*$and s^* are given by (3.20), (3.21) and (3.22) respectively. Plugging theses values into (3.27):

$$k^d = \left[\frac{(1-\lambda s)\alpha v\pi}{\lambda r}\right]^{\frac{1}{1-\alpha}}$$

we can solve the previous expression for λ:

$$\overset{\frown}{\lambda} = \frac{\alpha\pi^2\bar{k}^{4\alpha-1}}{r^*\left(1+\bar{k}^{2\alpha}\right)^2} \tag{3.30}$$

Consider that $\overset{\frown}{\lambda}$ is a function of $\bar{k}$, the only variable which depends on the state of technology (recall that $\bar{k}(A) = (\zeta/A)^{\frac{1}{1-\alpha}}$. It can be shown that

Proposition 22 *The level of legal investor protection $\overset{\frown}{\lambda}$ is increasing in the state of technology A.*

Proof. *By direct differentiation, $\overset{\frown}{\lambda}$ is a non monotonic function of $\bar{k}(A)$, with a maximum at $\bar{k}(A)_{\max} = (4\alpha - 1)^{\frac{1}{1-\alpha}}$; for example, with $\frac{1}{4} < \alpha < 1$, $\bar{k}(A)_{\max}$ is a very low number confirming that in the more interesting range ($\bar{k}(A) > \bar{k}(A)_{\max}$) $\overset{\frown}{\lambda}$ is decreasing in $\bar{k}(A)$, and consequently it is increasing in A.* ■

[31] In the previous subsection we had that the share of profits was unchanged, so it is interesting to compare the results of this subsection leaving s unchanged. Indeed, note that since e^* and v^* do not depend on r, then s^* is still given by (3.22).

[32] If $r\left(k^d\right) > r^*$, then by introducing a capital constraint the analysis is the same as that of the previous subsection.

This result implies that countries that impose regulation on the financial markets (so as to regulate the interest rate), or that have government bond paying high interest rate may only increase legal investor protection if their state of technology is high enough. On the other hand, this also mean that in the process of development of a country, when the state of technology increases, the government can reform to increase legal investor protection when the interest rates remain stable.

3.7 Conclusions

In this paper we have analyzed how different growth strategies <and states of technology may be the source of variance of creditor protection levels across countries. In particular, the analysis has focused on the role of growth strategies based on the maximization of the entrepreneurship factor, the creditor activism factor and on a global inputs strategy. Then, this analysis has been enriched by including a technology constraints: projects have a minimum capital requirement which is decreasing in the state of technology. then We have on purpose excluded from this theoretical analysis the political economic considerations component, because we do not focus on explaining the difficulties to reform, but rather make the point that countries relatively more endowed with one or the other input factor may prefer (through a particular growth strategy) a different level of creditor protection. Moreover, we have analyzed each growth strategy when there barriers to entry and when these barriers are lifted. The main results we find is that a policy aimed at maximizing the entrepreneurship factor would set the creditor protection level at the minimum; a policy aimed at maximizing the creditor activism into the project would set creditor protection at the maximum. Interestingly, also a more realistic policy (global inputs) requires that the optimal level of creditor protection is highest, when the technology is high enough. This reveals that the protection effect is stronger than the entrepreneurship effect and that in general countries need adopt higher investor protection levels to spur growth. Moreover, the dispersion of the creditor protection levels is described in more detail when we include also technology constraints. In particular, we have included a Standing on the Shoulder of Giants technology constraint.

Secondly, we have extended the model by including an endogenous equity share. Interestingly, a low level of investor protection may benefit the investor and it harms the entrepreneur. Moreover, when we fix the interest rate we find that the optimal level of creditor protection increases with the state of technology.

Finally, we have considered the various inputs (entrepreneurship, creditor activism and capital) as endowments, that is to say as purely exogenous to the model. Therefore we have excluded from the analysis processes of skills and capital accumulation. We let the study of these processes to future research.

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Appendix 1. Production Profits

In order to better understand the expression form of production profits π, consider that in order to produce the x_t units of the intermediate good, it is necessary to employ one unit of the final good; so production profits are:

$$\pi_t = p_t x_t - x_t = [p_t - 1]x_t \tag{3.31}$$

where p_t is the price of the intermediate good. Now, since the final good is produced competitively, the price of the intermediate good can be set to a constant (χ) that is equal to the marginal product with respect to that input:

$$p_t = \chi = \frac{\vartheta Y_t}{\vartheta x_t} = A_t(v)^{1-\alpha} x_t^{\alpha-1} \tag{3.32}$$

So, the optimal demand for the input is:

$$x_t = \chi^{\frac{1}{\alpha-1}} A_t \tag{3.33}$$

So, production profits are: $\pi_t = (\chi - 1)\,\chi^{\frac{1}{\alpha-1}} A_t$ or if we set $\delta = (\chi - 1)\,\chi^{\frac{1}{\alpha-1}}$, they become:

$$\pi_t = \delta A_t \tag{3.34}$$

QED

Appendix 2. The model under free entry

Finally, it is useful to study the model under free entry. In detail, we analyze the individual rationality constraints of the creditor and of the entrepreneur respectively. This is equivalent to impose free entry in the model (the return on the alternative activity is null) and corresponds to the case in which the government has already fully lifted entry barriers in the creditors and the R&D markets. Deriving the free entry values is useful for comparing the results under this entry policy with others in the existing literature. For the creditor, we have that $V_I \geq 0$ for (see details in Appendix 3)

$$k \leq \bar{k}_I = \left[\frac{\lambda v \pi}{1 - \lambda r}\right]^{\frac{1}{1-\alpha}} \tag{3.35}$$

while for the entrepreneur, $V_E \geq 0$ for (see details in Appendix 3)

$$k \leq \bar{k}_E = \left[\frac{(1 - \lambda)\, v \pi}{\lambda r}\right]^{\frac{1}{1-\alpha}} \tag{3.36}$$

(see appendix 3 for details). Both $\bar{k}_I$ and $\bar{k}_E$ represent two curves with respect to the policy parameter λ. Moreover, as shown in figure 2.b, both these curves lie above the respective ones of capital demand and supply: $\bar{k}_I > k^s$ and $\bar{k}_E > k^d$ far any value of λ.

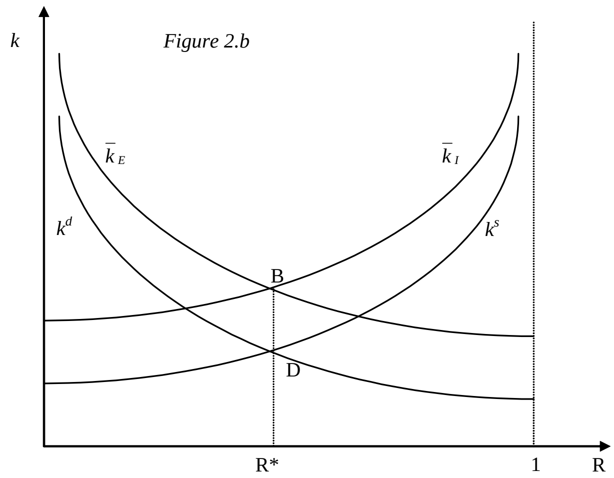
The curves grow asymptotically for $\lambda \rightarrow 0$ and $\lambda \rightarrow \infty$. Moreover, note that $\bar{k}_I$and $\bar{k}_E$cross at the equilibrium interest rate r^* found in (3.7). Finally, the equilibrium level of capital is given by

$$\bar{k} = (v\pi)^{\frac{1}{1-\alpha}} \tag{3.37}$$

where this equation is for a generic value of the variable v.[33] It is due to notice that $\bar{k}$

[33] Indeed, under free entry the model cannot retrieve a specific value for v, however, this will not impede the discussion of the growth strategies under free entry below.

is higher than the equilibrium level without free entry in (3.8) of a factor $1/\alpha$. The curves are shown in figure 2.b:



From the figure above we see that both the demand and the supply of capital shift upward when there is free entry: both the curves lie always above the demand and supply curves derived without free entry ((3.5) and (3.6)). This means that in order to maximize the probability of success, it *may* be more appropriate to set the capital level at the maximum possible amount, which is exactly the one given by the free entry curves $\bar{k}_I$ and $\bar{k}_E$(the appropriateness of this competitive policy will discussed in detail below).

Growth Stategies with financial constraints

In this subsection we review the growth strategies of creditor activism and global inputs under the assumption of free entry.

Creditor Activism with free entry and financial constraints only

When we consider the free entry values, the demand and supply of capital curves given by (3.36) and (3.35) meet at the level of capital given by (3.37). In this case, the following proposition holds:

Proposition 23 *When there is free entry, the optimal level of creditor activism v for the creditor is always zero, independently of the policy parameter λ.*

Proof. Consider that creditor activism is determined by maximizing the creditor utility function V_I for a the equilibrium level of capital given by (3.37) $\bar{k}$, the equilibrium interest rate r^* given by (3.7) and the equilibrium level of effort given by (3.4). This means that the utility function (3.3) is $V_I = \lambda \left(e^* + v\bar{k}^{\alpha} \right) \pi + \lambda r^* \bar{k} - \bar{k} - \frac{v^2}{2}$ where replacing all the values we have $V_I = \lambda (1 - \lambda) \pi + \lambda (v\pi)^{\frac{1}{1-\alpha}} - \lambda (v\pi)^{\frac{1}{1-\alpha}} - \frac{v^2}{2} \Longrightarrow V_I = \lambda (1 - \lambda) \pi - \frac{v^2}{2}$. This function has a zero at $v = 0$. ■

The proposition above says that for any level of creditor protection creditor activism is at the lowest level. This is because when creditor returns are set at zero level it is of no benefit for the creditor to increase his effort. Therefore the optimal choice for the creditor is to exert no effort at all.

Global Inputs policy with free entry

Under the free entry condition, we have the following proposition:

Proposition 24 *When the government pursues a policy of maximizing the total probability of success, the optimal level of creditor protection λ with free entry is always 1.*

Proof. Plugging the equilibrium level of capital in (3.37) into the general expression of creditor activism (3.9), we first solve for the equilibrium level of capital and of creditor activism. They are: $\bar{v} = \lambda^{\frac{1-\alpha}{1-2\alpha}} \pi^{\frac{1}{1-2\alpha}}$ $\quad \bar{k} = (\lambda \pi^2)^{\frac{1}{1-2\alpha}}$. Plugging these values into the general expression of probability p, the maximization plan is

$$\max_{\{\lambda\}} \ \bar{p} = e^* + \bar{v}\bar{k}^{\alpha} = (1 - \lambda) \pi^2 + \lambda^{\frac{1}{1-2\alpha}} \pi^{\frac{1+2\alpha}{1-2\alpha}}$$

The solution to this plan is a minimum at $\lambda_{\min} = \frac{(1-2\alpha)^{\frac{1-2\alpha}{2\alpha}}}{\pi^{4\alpha-1}}$. Moreover the function $\bar{p}$ has two extremes at the values $\lambda = 0$ and $\lambda = 1$. It can easily be verified that the maximum of $\bar{p}$ is at $\bar{\lambda} = 1$. ■

Again, when all of the three inputs are considered for the growth strategy, then the result suggests that the protection effect (which increases with λ) and the capital effect (the capital depends positively on λ) dominate the entrepreneurship effect (which instead depends negatively on λ), and this is for the same reasons as for the previous case.

Growth Stategies with financial and technology constraints

In this subsection we review the growth strategies of maximization of creditor activism and of global inputs, under the financial and technology constraints considering that both markets are under free entry.

Creditor Activism Policy with free entry

Recall from the previous section that the optimal policy value for λ was not determined and that the predicted level of creditor protection v was zero. However, because of the technology constraint, the analysis changes slightly, as it is stated in the following proposition:

Proposition 25 *When the government pursues a policy of maximizing creditor activism with free entry and a SSG technology constraint, the optimal level of creditor activism v is given by $v_E = \frac{\zeta}{A^\alpha \delta}$, independently of the policy parameter λ.*

Proof. Consider that the constraint is $\bar{k} \geq k(A)$, which can also be rewritten (from (3.37) and (3.15)) as $(v\delta A)^{\frac{1}{1-\alpha}} \geq \left(\frac{\zeta}{A}\right)^{\frac{1}{1-2\alpha}}$. Solving for v, we have: $v \geq v_E = \frac{\zeta'}{\delta A^{\frac{2-3\alpha}{1-2\alpha}}}$ (with $\alpha < 2/3$). From the maximization of (3.3) with respect to v, we have that the optimal value is $v = 0$, but since v_E is always positive, the optimal level of v is exactly v_E. Again, this policy does not give an indication about the optimal value of the legal creditor protection parameter λ. ■

Comparing this result with the other of entry barriers, we have that here the policy constraint may be highest also at a low state of technology, instead with barriers to entry the policy is constrained for low states of technology.

Finally, we observe (in comparison with the one without technology constraint) that adding the SSG constraint increases the level of creditor activism.[34] This is because the level of capital may not be set at the zero profit level, and so the optimal level of creditor activism is positive.

Global Inputs policy with free entry

When there is free entry the following proposition holds:

Proposition 26 *When the government pursues a policy of maximizing the total probability of success with free entry and there is a SSG technology constraint, the optimal level of creditor protection λ is 1, if the technology condition holds: $A \geq A_{g,2} = \left(\frac{1}{\delta}\right)^{\frac{1}{2}}$.*

Proof. As in the respective subsection (i.e.: without the technology constraints) the equilibrium level of capital is $\bar{k} = (\lambda\pi^2)^{\frac{1}{1-2\alpha}}$ and that of creditor activism is $\bar{v} = \lambda^{\frac{1-\alpha}{1-2\alpha}}\pi^{\frac{1}{1-2\alpha}}$. Plugging these values into the total probability expression, we have again

[34] Note that for $\frac{\zeta}{A^\alpha \delta} = \left(1 - \frac{1-\lambda}{K^\alpha}\right)$ we have the p_k is at the maximum level.

that the the maximum of $\bar{p}$ is at $\lambda = 1$. Moreover, the technology constraint is $\bar{k} \geq k(A)$ $\Longrightarrow \left[\lambda\left(\delta A\right)^2\right]^{\frac{1}{1-2\alpha}} \geq \left(\frac{1}{A}\right)^{\frac{1}{1-2\alpha}}$, or also (solving for A) $A \geq A_{g,2} = \left(\frac{1}{\delta}\right)^{\frac{1}{2}}$.[35] ■

Again, only if a country has an advanced state of technology, the optimal policy can be implemented. The role of the SSG technology constraint is clear: only at higher levels of technology ($A \geq A_{g,2}$) we have that creditor protection is at the optimal level ($\lambda = 1$).

Appendix 3. Threshold values for free entry case

In order to find the threshold values given by (3.35) and (3.36) we proceed as follows.

For $\bar{k}_I$, set $V_I \geq 0$. This means that

$$\lambda\left(e + vk^{\alpha}\right)\pi + \left(\lambda r - 1\right)k - \tfrac{v^2}{2} \geq 0$$

or also

$$\lambda v k^{\alpha}\pi + \left(\lambda r - 1\right)k \geq \frac{v^2}{2} - \lambda e\pi \tag{3.38}$$

If the right hand side of (3.38) is always negative, then a sufficient condition for the inequality to hold is that the left hand side is positive. We show first the negativity of the rhs. We require that

$$\tfrac{v^2}{2} \leq \lambda e\pi$$

substitute the highest possible value of v: this is $v = \frac{1-(1-\lambda)}{k^{\alpha}}$,[36] and e^* from (3.4). Then, we have:

$$\left[1 - \left(1 - \lambda\right)\pi\right]^2 \leq 2\lambda\left(1 - \lambda\right)\pi^2 k^{2\alpha}$$

Solving the inequality above for λ, we have:

$$\lambda \geq \lambda_0 = 0 \quad \text{and} \quad \lambda \leq \lambda_1 = \frac{\pi^{2\alpha+1}+2\pi+\sqrt{\left(\pi^{2\alpha+1}+2\pi\right)^2-\left(\pi^{2\alpha+1}+3\pi\right)\left(\pi^2+1\right)}}{\left(\pi^{2\alpha+1}+3\pi\right)}$$

[35] Note that this constraint may be binding for $\delta < 1$.

[36] We derive this value from the upper bound of the probability p: $p \leq 1 : e + vk^{\alpha} \leq 1$.

where, for $\pi > 1$, $\lambda_1 > 1$. This means that all over the meaningful range of λ (i.e.: $0 < \lambda < 1$), the rhs of (3.38) is always negative.

Then, since the right hand side of (3.38) is always negative, a sufficient condition for (3.38) to hold is that $\lambda v k^{\alpha}\pi - \lambda k \geq 0$. Solving this inequality for k, we get:

$$k \leq \left[\frac{\lambda v \pi}{1-\lambda r}\right]^{\frac{1}{1-\alpha}} = \bar{k}_I$$

where $\bar{k}_I$is always positive.

QED

The free entry condition for the entrepreneur is

$$V_E = (1-\lambda)(e + vk^{\alpha})\pi - \lambda r k - \frac{e^2}{2} + \breve{\beta} \geq 0$$

or also

$$(1-\lambda) v k^{\alpha}\pi - \lambda r k \geq \frac{e^2}{2} - (1-\lambda) e\pi - \breve{\beta} \tag{3.39}$$

Substituting e^* from (3.4) and correspondingly setting $\breve{\beta} = 0$, we immediately have that the right hand side of (3.39) is negative:

$$e^*\left[\frac{e^*}{2} - \pi(1-\lambda)\right] < 0 \Longrightarrow \frac{1-\lambda}{2}\pi - (1-\lambda)\pi < 0$$

Again, since the rhs of (3.39) is negative, we can simply solve it for:

$$(1-\lambda) v k^{\alpha}\pi - \lambda r k \geq 0$$

That is to say that

$$k \leq \left[\frac{(1-\lambda) v \pi}{\lambda r}\right]^{\frac{1}{1-\alpha}} = \bar{k}_E$$

QED