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Essays on the political economy of intellectual property rights

Doctoral Dissertation

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The doctoral dissertation is composed of three chapters, each one containing an essay on the political economy of intellectual property rights. Although this inquiry deals with patent protection, the main ideas can be applied to all intellectual property rights, excluding trademarks. The objective of the doctoral dissertation is not to study why we *should* have patent protection but rather why we *do* have patent protection.

Chapter 1 is called "Lobbying for patent protection" and it deals with the most important political reason of the existence of patent rights, that is, the lobbying activity of inventive firms pushing in favour of the *commodification* of knowledge. Traditionally, patents were considered as a necessary evil to increase innovation. However, more recent contributions have underlined how patents might actually have no effect on innovation. However, what is certain is that patents redistribute profits in favour of inventive firms. I depart from this idea to show that *rent-seeking* by inventive firms could be a sufficient condition to the existence and worldwide diffusion of patent protection. My goal is to show that it is not necessary to take into account the effect of patent protection on innovation to understand why we do have patent rights. Moreover, lobbies lead to an overproduction of patent protection, a result which is suboptimal from a social welfare point of view. I build a model of lobbying in which the special interest of inventive firms in the economy makes political contributions to influence the policy of patent protection set by incumbent politicians. First, I analyze the case of a one-country world in which politicians and the lobby maximize their own welfare. Then, I extend this framework to the case of a world composed of two open economies, one endowed with inventive and the other with imitative capabilities. I show that the chosen strength of national patent protection depends on the market size for the innovative good, the accountability of politicians and the effectiveness of lobbying.

Chapter 2 is called "The fiscal incentives of governments to protect intellectual assets - Theory" and it deals with another political rationale for the existence of patent protection. Contrary to lobbies, this second cause of patent protection has never been identified in the preceding literature. The main idea is that politicians might have a fiscal incentive to modify the strength of patent protection. In fact, when setting patent protection, politicians face a trade-off between the patent-induced tax revenue and the cost of providing patent protection. On the one hand, strengthening patent protection might increase the tax revenue because the former affects the profitability of technical knowledge by definition. Thus, the corporate tax rate on profits generated thanks to the protection of intellectual property is a relevant parameter in the study of patent protection. On the other hand, the cost of providing patent protection increases with its strength because more police, administrative and legal skills are needed. A distinction is drawn both between normative and positive analysis and also between one-country and two-country worlds. The most important finding of Chapter 2 is that the Effective Average Tax Rate (EATR) on highly profitable activities has a positive effect on the strength of patent protection in a closed economy, while it has a positive (negative) effect over (below) a certain threshold of research and development (R&D) expenditure in an open economy. This latter result is the outcome of the immateriality of knowledge and of the principle of *national treatment* that forbids to treat foreign inventors differently from national ones.

Chapter 3 is called "The fiscal incentives of governments to protect intellectual assets - Empirical Tests". In this chapter, I test the most important finding of Chapter 2, as presented above. On the one hand, the test of the positive correlation between the EATR on highly profitable activities and the strength of patent protection in a closed economy uses a qualitative methodology. Here, I highlight how in the Middle Ages and the Modern Era, this mechanism might have been in place. On the other hand, the test of the positive (negative) correlation between the EATR on highly profitable activities and the strength of patent protection over (below) a certain threshold of R&D

expenditure in an open economy hinges on a quantitative methodology. The results of the regression analysis and the corresponding robustness checks do not falsify this potential finding.

Although not investigated in this dissertation, it would be interesting to study how the effects highlighted in Chapter 1 might be linked to those put forward in Chapter 2 (and tested in Chapter 3). In other words, does lobbying influence the incentives of governments to use patent protection as a way to increase their fiscal revenue? And do the fiscal incentives of governments affect the incentive of inventive firms to lobby for patent protection? Although, at this stage, it is impossible to put forward any precise theory in relation to this issue, it is nevertheless possible to anticipate that, if these effects interact, then a multiplicity of equilibria exists. For example, it might be possible that one equilibrium would be characterised by intense lobbying activities and strong fiscal incentives of governments while the other equilibrium by low lobbying and weak fiscal incentives. These two equilibria would be Pareto-rankable since only in this latter equilibrium patent protection would not be affected by the political objectives of inventive firms and goverments fighting for a larger share of the economy's total product.

Chapter 1

Lobbying for patent protection

1.1 Introduction

A patent is a set of exclusive rights granted by a sovereign state to an inventor or innovator for a limited period of time in exchange for detailed public disclosure of her invention or innovation [WIPO (2008)].[1] Without a sovereign state enforcing patents, the private monopoly of inventions could not be possible.[2] Hence, patents create a government-based monopoly on the reproduction of knowledge with its associated static costs. Traditionally, patents have been considered as a necessary evil to the quest of inventivity. According to the majority of economists, there would be no inventions in a perfect competitive market of ideas. Thus, patents would entail a trade-off between the enhanced incentive to invent and the static cost of monopoly, the optimal strength of patent protection being the one equalizing the marginal benefit of new knowledge and the marginal cost of a stronger monopoly on existing knowledge.

[1] An invention is a solution to a specific technological problem of a product or a process introduced for the first time while an innovation occurs if someone improves on or makes a significant contribution to an existing product, process or service. Although an invention is not an innovation, I will use the first term to refer to both throughout this paper.

[2] The analysis does not apply to other forms of intellectual property (IP) such as trademarks but it fits with copyrights which are similar in nature to patents.

However, a more recent strand of literature has raised two objections to this traditional trade-off: 1) inventions are possible without government intervention in the form of public R&D or patent protection [Boldrin and Levine (2008a, 2008b)], 2) patents entail *dynamic costs*, that is, they increase the cost of inventing [Heller (1998); Besse and Maskin (2009)].

Related to the first point, it is generally argued that, without government intervention, firms would not be compensated for their inventive efforts and hence there would be no invention at all in the economy. The idea is that, without patent protection, firms are able to exploit inventions of competitors without incurring in the research costs generating them. Hence, patent protection would be a tool to overcome the free-rider problems inherent in the *immateriality* of knowledge that spreads freely in the economy. In theory, it is true that if privately-created knowledge is not rewarded, then the private incentive to generate it would lack. Intuitively, no private agent is willing to finance the research cost of an invention if there is no compensation for it. This is the fundamental insight that was put forward for the first time by Arrow (1962) and that kicked off the beginning of the *economics of information*. However, successive developments in the literature have shown that knowledge can be rewarded a positive value even without government intervention. First, because the reproduction of a piece of information might be in itself a costly activity. If this is so, then the marginal cost of an invention is positive and *perfectly competitive inventions* are possible [(Boldrin and Levine (2008b)]. Second, because there might be a difference between what inventors get in value for selling inventions and their marginal cost, thus allowing for a reward in the form of a *rent*. This rent is the fruit of the so called *first-mover advantage* due to technical and market barriers to imitation. These two barriers, respectively called *implementation* and *commercialization costs*, mark the difference between having access to a piece of information and starting a production process exploiting it. Notice that this rent can be gained even if information is freely accessible since the absorptive capacity of firms to recognize the value of new information, assimilate it and apply it to commercial ends is costly to acquire [Cohen and Levinthal (1990)].[3]

Concerning the second point, patents generate dynamic costs for a variety of reasons. Knowledge is a special kind of commodity, information being complementary, sequential [Bessen and Maskin (2009)] and cumulative [Scotchmer (1991)]. The recombination of old information generates new information in an *emerging property.* In a market with *transaction costs*, the private appropriation of old information can create a situation of underproduction of new information, a phenomen usually referred to as the *tragedy of the anticommons* [Heller and Eisenberg (1998)].[4] Also, patents are not only a mean to reduce copying but are strategically used to prevent competing firms from patenting related inventions, a phenomenon usually referred to as *patent blocking* [(Cohen, Nelson and Walsh (2000)]. This deprives consumers of cheaper and higher-quality substitutes and it is a majour source of dynamic cost.[5] Another somewhat neglected negative effect of patents on inventivity is that trade secrets are complementary to the existence of a legal monopoly, as illustrated in the case of hybrid seeds [Boldrin and Levine (2004)]. Uncertainty about legal rights in terms of exposures to infringement claims by others increases the risks concerning research investment and represents a potential source of dynamic cost. Moreover, patenting activities of firms absorb large amounts of resources that could be alternatively dedicated to productive and welfare-enhancing R&D and

[3]Somewhat misleadingly, Boldrin and Levine (2008b) define as perfectly competitive inventions also those inventions financed by the first-mover advantage and not only those with positive marginal cost. Notice also that, in Arrow (1962), perfectly competitive inventions are not possible because he assumes zero marginal cost of information.

[4]This concept was not coined specifically for knowledge but it more generally indicates a coordination breakdown in which a single resource has numerous rightholders who prevent others from using it. Thus, to avoid this tragedy, complementary goods such as knowledge should be owned by the same owner [Pagano (2004)].

[5]Matthew Boulton and James Watt patent-blocking the high-pressure steam engine invented by William Murdoch is estimated to have delayed the First Industrial Revolution by sixteen years [Boldrin and Levine (2008a)].

the more so the stronger patent protection. For example, in the 1990s, in parallel with the global strengthening of patent protection that followed the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), the number of IP lawyers has exploded while the uncertainty about patent infrigements has not been reduced. Last but not least, the fixed-term patent protection's system is incompatible with optimal dynamic resource allocation and different kinds of firms should be protected differently [Acemoglu and Akcigit (2012)].

One might try to respond to these critisms by verifying empirically whether patent protection stimulates inventivity. Here, the results are mixed. Nevertheless, what is clear is that history is full of examples of inventions without government intervention. This clearly points to the fact that at least some inventions would be rewarded in competition, either because copying is costly or because inventors are able to gain temporary rents.

However, although it is becoming both theoretically and empirically more difficult to explain the existence of the patent system on the grounds of the enhanced inventivity, it is nevertheless possible to provide an alternative explanation. If the rationale of the existence, diffusion and worldwide strengthening of the patent system is not to be found in its *economics*, then it might be found in its *politics*. Although it is not possible to exclude other explanations based on irrationality or cultural attachment to the idea of private property regardless its potential social cost, my intent in this chapter is to provide the simplest possible *political economy* explanation of patent protection. This is connected to the concept of *rent-seeking*, that is, the attempt to increase one's share of existing wealth to the expense of others. The baseline idea is that patent protection is not used to stimulate inventivity but to defend the monopolistic interests of inventive firms. What I put forward is that *lobbying* by these firms is a sufficient condition to the existence, diffusion and worlwide strengthening of the patent system.

Previous research on the politics of patent protection is mainly qualitative and undertaken by social scientists. Drahos and Braithwaite (2002) provide an account of how the lobbying activity by inventive firms actually takes place, with a particular emphasis on the signature of international treaties. May (2013) highlights the power that stems from owning IP while May and Sell (2006) trace the history of social conflict and political machinations surrounding it. Landes and Posner (2004) argue that public choice alone cannot provide an explanation of why patent protection is on an ever strengthening path while other forms of regulation have parallely been dismantled. Scotchmer (2004) investigates the incentive respect the principle of national treatment and the incentive to harmonize patent protection.

In this paper, the focus of attention is on representative democracies, where incumbent politicians are supposed to shape policy in response to the general electorate and under the pressure of special interests groups.[6] In a one-country world, the lobby of inventive firms chooses its political contribution while politicians choose the strength of patent protection. Starting from the model of Grossman and Helpman (1994), I obtain the formula characterizing the Subgame-Perfect Nash (SGPN) equilibrium of the two-stage patent-policy game. I also show how the equilibrium policy of patent protection is affected by changes in its underlying parameters, such as the effectiveness of lobbying, the market size and the accountability of politicians. A distinction is drawn between a one-country and a two-country worlds.

[6] From here on, the term "politicians" will be used instead of "incumbent politicians" unless stated otherwise.

1.2 Lobbying in a one-country world

1.2.1 Setup

A one-country world governed by a representative democracy is populated by individuals with identical preferences. Each individual maximizes her utility given by

$$v = x_0 + u(x) \tag{1.1}$$

where x_0 is consumption of the numeraire good 0 with price equal to 1, and x is consumption of the *innovative good*. The sub-utility function $u(\cdot)$ is differentiable, increasing $[u'(x) > 0]$, strictly concave $[u''(x) < 0]$. I assume that the demand curve of the innovative good is convex from above.[7] The price p of the innovation good is affected by the strength of patent protection Ω such that $p'(\Omega) > 0$. Thus, $p \in [p^c, p^m]$, with p^c being the competitive price of x and p^m its monopoly price. The competitive price occurs in the absence of patent protection, while the monopoly price when patent protection is at its strongest. This latter corresponds to the strength of patent protection characterized by infinite duration of patent length, total coverage (all production in the economy is patentable), total enforcement (no piracy is possible) and absence of both working requirements and compulsory licensing. All intermediate prices between the competitive and the monopoly prices correspond to positive levels of patent protection not guaranteeing monopoly but strictly positive profits.[8] Passing from the competitive price to a higher one corresponds to introducing patent protection on the innovation good, while all other upward passages refer to a strengthening of patent

[7]Assuming that the demand curve is convex from above means that $u'''(x) < 0$.

[8]Strictly positive profits not as high as monopoly profits occur in presence of a regime of patent protection lacking at least partially in one of its dimensions (length, coverage, enforcement, working requirements and compulsory licensing). Thus, a certain degree of competition is guaranteed and the price is not set to maximize profits. However, the price is still higher than the marginal cost.

protection.[9] An individual spending an amount A consumes $x = d(p)$ of the innovative good and $x_0 = A - pd(p)$ of the numeraire good. Indirect utility takes the form $I(p, A) = A + s(p)$, with $s(p)$ being the individual consumer surplus. The individual consumer surplus is $s(p) = u[d(p)] - pd(p)$. It follows from the assumption on the convexity from above of the demand curve that $s'(p) < 0$ and $s''(p) > 0$.[10] I assume that good 0 is manufactured by labor alone with constant returns to scale and an input-output coefficient equal to 1. The aggregate supply of labor is large enough to ensure a positive supply of this good. Then the wage rate equals 1 in the competitive equilibrium. Production of the innovative good needs labor and knowledge which is available thanks to previous research efforts of the unique *inventive firm* in the market. The inventive firm has already recovered the research cost generating the knowledge necessary to the production of the innovative good.[11] The competitive equilibrium, that is, the one with no patent protection, the wage rate equal to 1 and knowledge freely available to all firms is characterized by $p^c = 1$.

Since the marginal cost is constant, the remuneration of knowledge for the inventive firm depends on the price of the innovative good. This remuneration of knowledge is denoted by $\pi(p)$. As for the individual consumer surplus, it follows from the assumptions on the demand curve (negative slope and convexity from above) that $\pi'(p) > 0$ and $\pi''(p) < 0$.[12] In other words, the strength of patent protection is an expression of the rent $p - c$ extracted by producers from each sold unit of the innovative good and hence. Then, it follows that, in the competitive equilibrium, $\pi(p^c) = 0$ since imitators

[9] From here on, the expression "strengthening of patent protection" will be used to refer to both ideas.

[10] More precisely, the fact that $s'(p) < 0$ is the consequence of assuming a decreasing demand curve, while $s''(p) > 0$ because the demand curve is assumed convex from above.

[11] In other words, I assume that perfectly competitive inventions are possible. Alternatively, it can be assumed that the knowledge used by the inventive firm to produce the innovative good is generated by the public R&D.

[12] Exactly as for the individual consumer surplus, $\pi'(p) > 0$ is the consequence of assuming a decreasing demand curve, while $\pi''(p) < 0$ because the demand curve is assumed convex from above.

have free access to the knowledge necessary to produce the innovative good. Moreover, since the marginal cost is constant, the supply curve is the horizontal straight line $p = 1$. This implies that the reward of knowledge $\pi(p)$ is also the producer surplus and that, in the competitive equilibrium, the producer surplus is equal to 0.

When patent protection is at its strongest, the inventive firm monopolizes knowledge because the government sets unsurmountable barriers to entry in the commercialization of the innovative good. Since all potential imitators are excluded from the production of the innovative good, the inventive firm gains a monopoly rent, that is, the highest possible difference between the price of the innovative good and its marginal cost. The owner of the inventive firm has a political interest in privatizing knowledge to exclude competitors and gain the highest possible rent. Thus, the owner of the inventive firm decides to pursue her special interest and to influence the policy of patent protection by creating a lobby L. In line with the literature on *collective action*, I assume that consumers and potential competing firms are too numerous to overcome the free-rider problem to conduct joint lobbying activities and remain politically unorganized (Olson, 2009).

The owner of the inventive firm makes a political contribution to politicians in power knowing that a higher political contribution corresponds to a higher price of the innovative good. I define this relationship as $p'(P) = a$ meaning that the lobby knows that a marginal increase in political contribution leads to an increase in the price of the innovative good by the amount $a > 0$. Thus, a is a measure of how effective is the lobbying activity in satisfying its objective. Also, the cost C of the political contribution is increasing in the political contribution such that $C(P) = \frac{1}{2}P^2$. This increasing cost of the political contribution captures the fact that lobbying is more costly at higher political contribution and this for political reasons. In fact, when a lobby spends a high amount of money to buy political support, then further increasing that expenditure not only increases the cost in monetary terms but also in the public image of the lobby that is deteriorated by this activity. Hence, marginally increasing the political contribution when this latter is low is less costly to the lobby than when the political contribution is already high. The gross welfare of the lobby is defined $GW_L(P) = l_o + \pi[p(P)] + s[p(P)]$ while its net welfare as $NW_L(P) = l_o + \pi[p(P)] + s[p(P)] - C(P)$, with l_o being the labor income of the owner of the firm and s being her consumer surplus. Notice that it follows from the assumptions of the demand curve that $GW_L'(p) > 0$ and $GW_L''(p) < 0$. Because of the chain rule $GW_L'(P) = aGW_L'(p) > 00$ while $GW_L''(P) = GW_L''(p) * p''(P) * p''(P) = 0$, given that $p''(P) = 0$. Thus:

$$\text{L} \max_{P} \quad NW_L = GW_L - C \tag{1.2}$$

On the other hand, politicians maximize their welfare W_K with respect to the price of the innovative good that they can influence through changes in the policy of patent protection. The trade-off of politicians in this choice is between the benefit of the political contribution received by the lobby and aggregate welfare AW. The former is $B = pP$ because the benefit of the political contribution is a function of both its amount in monetary terms P and the price of the innovative good. This reflects the fact that if patent protection is absent, then receiving the political contribution benefit politicians only by that amount. There may be different ways in which this is true. For example, politicians might internalise that if they receive the money but do not introduce patent protection, then they will no longer be able to benefit from their trade with the lobby. Aggregate welfare is the gross-of-contributions welfare of this society $AW(p) = l + \pi(p) + Ms(p)$, that is, aggregate income l, plus the remuneration of knowledge, plus aggregate consumer surplus, with M being the market size. The market size is not the population of the country but rather the scale of its demand for the innovative good, that is, the total number of consumers. I assume that $M \geq 2$ meaning that the innovative good is consumed at least by another person which is not the lobbyst (the producer): if there are many lobbyists and producers, then $M \geq$ number of lobbyists (producers) +1. Since wages are fixed at 1, aggregate income = aggregate supply = l. Again, it follows from the assumptions on the demand curve that $AW'(p) \leq 0$ and $AW''(p) < 0$ since the deadweight loss of monopoly increases as price increases. Politicians care about aggregate welfare when choosing the price of the innovative good since consumers vote politicians and might decide to punish them if their consumer surplus is reduced due to patent protection. Thus, defining politicians as K:

$$\text{K} \max_{p} \quad W_K = (1-\alpha)B + \alpha AW \tag{1.3}$$

with $\alpha \in [0,1]$ being a measure of the accountability of politicians. In fact, $\alpha = 0$ means that politicians are interested exclusively in the political contribution, while $\alpha = 1$ that they care only about aggregate welfare.

On the other hand, the lobby maximizes its net gross welfare I am interested in the equilibrium of a two-stage game in which the lobby chooses its political contribution in the first stage and politicians set their preferred policy of patent protection in the second stage. The solution of the game (P^*, p^*) is the political contribution that maximizes the welfare of the lobby, given the choice of politicians that the lobby anticipates. As in Bernheim and Whinston (1986), the solution (P^*, p^*) is a SGPN equilibrium if and only if P^* is feasible, that is, if if $0 \leq P^* \leq l_0 + \pi(p)$, meaning that it's nonnegative and no greater than the aggregate income of the lobby.

1.2.2 Equilibrium

Since the Nash equilibrium is a SGPN equilibrium, this two-stage game can be solved by backward induction. Hence, it is necessary to start from the choice of politicians that choose the price of the innovative good such that:

$$P = -\frac{\alpha}{1-\alpha} AW'(p). \tag{1.4}$$

The optimal strategy of politicians is to set the policy of patent protection that equalizes the marginal benefit $(1-\alpha)P$ and the marginal cost $-\alpha AW'(p)$ of patent protection. At sufficiently low levels of accountability, introducing patent protection certainly makes politicians better off at the expense of aggregate welfare. In general, the more accountable are politicians, the weaker is the patent regime. On the one hand, if politicians are completely accountable ($\alpha = 1$), then the cost of strengthening patent protection is infinite and no strengthening occurs: notice that this happens also for low levels of $AW'(p)$ meaning that if politicians are accountable, there is no patent protection at all. If politicians are completely unaccountable ($\alpha = 0$), then the cost of strengthening patent protection is zero and strengthening always occurs: notice that this happens also for low positive levels of P meaning that if politicians are unaccountable, there is always patent protection.[13]

On the other hand, the lobby sets its political contribution such that:

$$GW'_L(P) = P. \tag{1.5}$$

The lobby sets its political contribution to equalize the marginal benefit $GW'_L(P)$ and the marginal cost P of the political contribution.

[13] In the extreme cases in which aggregate welfare is (not) harmed by patent protection while the political contribution is stricly positive (zero), then patent protection is maximum (zero).

Taking together (1.4) and (1.5), it is possible to find the following equilibrium formula:

$$GW_L'(P) = -\frac{\alpha}{1-\alpha} AW'(p). \tag{1.6}$$

Given that $GW_L'(P) = aGW_L'(p)$, that $GW_L'(p) = \pi'(p) + s'(p)$ and that $AW'(p) = \pi'(p) + Ms'(p)$, then $a[\pi'(p) + s'(p)] = -\frac{\alpha}{1-\alpha}[\pi'(p) + Ms'(p)]$. By rearranging this latter expression, and by defining $\lambda = -\frac{s'(p)}{\pi'(p)}$ it is possible to obtain that

$$\lambda = \frac{(1-\alpha)a + \alpha}{(1-\alpha)a + \alpha M}. \tag{1.7}$$

At this point, a short discussion on the meaning of λ is necessary. First, $\lambda \geq 0$ because both the denominator $\pi'(p)$ and the numerator $-s'(p)$ are positive. Second, $\lambda \leq 1$ because the denominator is always higher than the absolute value of the numerator: if the increase in the reward of knowledge due to patent protection was lower than the decrease in the individual consumer surplus, then the owner of the inventive firm would have no incentive to lobby for patent protection in the first place. Third, $\lambda \geq \frac{1}{M}$ because $AW'(p) = \pi'(p) + Ms'(p) \leq 0$.[14]

Given the assumptions on the demand curve, $\pi''(p) + s''(p)$ is lower than zero. Thus, as the price increases, λ increases, that is, $\lambda'(p) > 0$. Given that $p'(\Omega) > 0$, then we know that as the strength of patent protection increases, then lambda increases too. This means that the only way through which λ can change is through changes of the strength of patent protection. Hence, by studying the comparative statics of λ it is possible to infer whether the strength of patent protection is affected positively or negatively by the parameters related to the accountability of politicians, the market size for the innovative good and the effectiveness of lobbying. More precisely, the effect of

[14] Notice that $\lambda < \frac{1}{M}$ if and only if the price of the innovative good is lower than the competitive price, which is impossible in this model.

these three parameters on the equilibrium strength of patent protection has the same sign as their effect on λ.[15]

Since $\frac{\partial\lambda}{\partial a} = \frac{(1-\alpha)\alpha(M-1)}{[(\alpha-1)a-\alpha M]^2} \geq 0$, $\frac{\partial\lambda}{\partial M} = -\frac{\alpha[\alpha+a(1-\alpha)]}{[\alpha M+a(1-\alpha)]^2} \leq 0$ and $\frac{\partial\lambda}{\partial\alpha} = -\frac{a(M-1)}{[\alpha(M-a)+a]^2} \leq 0$, then it is possible to state that:

Proposition 1

In a one-country world, the equilibrium strength of patent protection is positively affected by the effectiveness of the lobbying activity while it is negatively affected by the accountability of politicians and the market size for the innovative good.[16]

The competitive price maximizes aggregate welfare. In fact, in this model, the aggregate welfare is negatively correlated with the price of the innovative good. This is so because the model is *static* and the inventing process is not taken into account for simplicity. In a *dynamic* context, the relation between the price of the innovative good and aggregate welfare is not monotonic: it is positive until a certain price level and then it becomes negative. This is due to the fact that patent protection might spur inventivity and thus its dynamic benefit more than offsets the static cost at least until a certain price level. Since the equilibrium formula 1.6 deliberately takes aggregate welfare into account, it is not necessary to model the dynamic inventing process to find out that the lobbying activity of inventive firms leads to suboptimal results. If the equilibrium formula considers both the aggregate welfare and the specific interests of the lobby, then the strength of patent protection is higher than the one that would

[15] Since this is an indirect way to study the effects of these parameters on the strength of patent protection, it is possible only to infer their sign but not how large these effects are.

[16] In Grossman and Lai (2004), the optimal strength of patent protection with a Cobb-Douglas research technology is invariant to the market size. This difference is due to the fact that the two authors isolate the effect of the market size interacting with technological factors while I isolate the effect of the market size interacting with political factors. Whether, overall, the market size is correlated negatively with the strength of patent protection is an empirical question.

maximize the former. Hence:

Proposition 2

In a one-country world, the lobbying activity of inventive firms in favor of patent protection leads to a suboptimal outcome from a social welfare point of view. The political activity of the lobby generates a situation of overproduction of patent protection: patent protection is undesirably too strong. The activity of rent-seeking by inventive firms not only redistributes a larger share of total wealth to these firms and not only represents a waste of the money spent in political contributions that could be used otherwise but it also reduces total wealth.

In the absence of patent protection, that is, when the price of the innovative good is competitive, then $\lambda(p^c) = \frac{1}{M}$. Thus, in a representative democracy, patent protection leading to a price of the innovative good higher than its competitive price occurs if $\frac{(1-\alpha)a+\alpha}{(1-\alpha)a+\alpha M} > \frac{1}{M}$, which happens when $\alpha < 1$ and $M > 1$. Since, by definition, the market size is composed by at least two consumers, then it is possibile to formulate the following:

Proposition 3

In a one-country world, some form of patent protection is always in place unless politicians are totally accountable and only care about aggregate welfare.

1.3 Lobbying in a two-country world

1.3.1 Setup

Consider the case of a two-country world constituted by two countries $i = a, b$. In country a there is the unique inventive firm that has generated the knowledge necessary to produce the innovative good. All other firms are imitative. I define a as the inventive country while b as the imitative one. The two countries may engage in international trade of the innovative good. Both countries are governed by a representative democracy and have the same level of productivity. Hence, also in this case, the relationship between the national price of the innovative good and the strength of patent protection is as in the one-country world. Consumers have identical preferences and they maximize utility given by equation 1.1. In the absence of patent protection in both countries, that is, at the competitive equilibrium, knowledge to produce the innovative good is generated in the inventive country and is freely available to all firms regardless their national origin. The principle of national treatment in patent protection is respected. The inventive firm lobbies for patent protection in its own homecountry. Moreover, the inventive firm has also the incentive to lobby for patent protection in the foreign country for two reasons. First, patent protection in the imitative country serves its own exporting interests. Second, patent protection in the imitative country impedes *parallel imports*, namely the possibility of illegally importing the innovative good sold in the imitative country at a lower price. In fact, patent protection in the imitative country renders illegal the imitative production of the innovative good there, thus making parallel imports impossible. In this way, the inventive firm enjoys a positive reward of knowledge in both countries. That is why, in the first stage of the game, the inventive firm lobbies politicians in both countries to strengthen national patent protection. In the second stage of the game, politicians in both countries choose the strength of national patent protection. In this two country-world, the lobby maximizes 1.2 while national politicians maximize 1.3. Since the lobby anticipates the choice of politicians in both countries, the equilibrium formula is 1.6. However, the variables in question are now different from the previous framework. As in the previous framework, the lobby makes a political contribution knownig that $p_i'(P) = a_i$. The gross welfare of the lobby now depends on the price of the innovative good in both countries, such that $GW_L(p_a, p_b) = l_o + \pi(p_a, p_b) + s(p_a)$. The net welfare of the lobby is $NW_L(p_a, p_b) = GW_L(p_a, p_b) - C$, with C being as in the one-country world. Aggregate welfare in the inventive country is $AW_a(p_a, p_b) = \pi(p_a, p_b) + M_a s(p_a)$ while the one in the imitative country is $AW_b(p_b) = M_b s(p_b)$. Notice that aggregate welfare in the imitative country is a function of its national price while aggregate welfare and the reward of knowledge in the inventive country depend on patent protection in both countries. The benefit of politicians from increasing the price of the innovative good is $B_i = p_i P$. On the one hand, the welfare of politicians in the inventive country is $W_{K_a}(p_a, p_b) = (1 - \alpha_a) B_a(p_a) + \alpha_a AW_a(p_a, p_b)$ while, on the other hand, the welfare of politicians in the imitative country is $W_{K_b}(p_b) = (1 - \alpha_b) B_b(p_b) + \alpha_b AW_b(p_b)$. The first and second derivatives of these variable have the same sign as in the previous framework since the demand curves have not changed. The only exception is $AW_b''(p_b) > 0$ because aggregate welfare in the imitative country does not comprise any gain in profits from patent protection.

1.3.2 Equilibrium

The maximization problem of national politicians yields $P = -\frac{\alpha_i}{1-\alpha_i} AW_i'(p_i)$ as in the previous framework. Since $AW_b''(p_b) > 0$ it is necessary to assume that $P \geq AW_b'(p_b^c)$ to guarantee the existence of an equilibrium in the imitative country.

The lobby maximizes its net welfare with respect to the national political contribution yielding $GW_L'(P) = P$. Since the lobby anticipates the choice of politicians in both countries, then the equilibrium formula is:

$$GW_L'(P) = -\frac{\alpha_i}{1-\alpha_i} AW_i'(p_i). \tag{1.8}$$

The choice represented by formula 1.8 is identical to the one in 1.6 but, since the variables are different, the strength of national patent protection changes as well. In fact, by defining $\lambda_i = -\frac{s'(p_i)}{\pi'(p_i)}$ it is possible to obtain the two following SGPN equilibria, one for each country:

$$\lambda_a = \frac{(1-\alpha_a)a_a + \alpha_a}{(1-\alpha_a)a_a + \alpha_a M_a} \tag{1.9}$$

and

$$\lambda_b = \frac{(1-\alpha_b)a_b}{\alpha_b M_b}. \tag{1.10}$$

Formula 1.9 is identical to 1.7 of the one-country world while it differs from 1.10. Openness and national treatment of patent protection have not changed this condition. As in the one-country world, patent protection in both countries is introduced if $\alpha_i < 1$ and $M_i > 1$. Given that $\lambda_i(p^c) = \frac{1}{M_a+M_b}$, patent protection is always set in the inventive country even if its politicians are totally accountable. On the contrary, patent protection in the imitative country is introduced if $\frac{(1-\alpha_b)a_b}{\alpha_b M_b} > \frac{1}{M_a+M_b}$, that is, if $\alpha_b < \frac{a_b(M_a+M_b)}{a_b(M_a+M_b)+M_b}$ meaning that there is a threshold of accountability under which politicians set patent protection. Interestingly, there are also two other thresholds to be considered in the imitative country: one related to the effectiveness of lobbying $a_b > \frac{\alpha_b M_b}{(M_a+M_b)(1-\alpha_b)}$ and the other related to the national market size $M_b < \frac{(M_a+M_b)(1-\alpha_b)a_b}{\alpha_b}$. Also, notice that the comparative statics of λ_i on the three parameters of interests (accountability of politicians, effectiveness of lobbying activity and market size for the innovative good) yields the same sign as in the one-country world. Thus:

Proposition 4

In a two-country world, patent protection in both countries is stronger the less accountable are politicians, the smaller the national market size for the innovative good and the more effective is the lobbying activity. Patent protection is always introduced in the inventive country even if its politicians are totally accountable. Patent protection in the imitative country is introduced if the accountability of politicians or if the market size are below two certain thresholds, or if the effectiveness of lobbying is above a certain threshold.

By comparing 1.9 and 1.10, it is possible to find that if $\frac{(1-\alpha_a)a_a+\alpha_a}{(1-\alpha_a)a_a+\alpha_a M_a} \geq (<) \frac{(1-\alpha_b)a_b}{\alpha_b M_b}$, then patent protection is equal or stronger (weaker) in the inventive than in the imitative country. Patent protection is always stronger in the inventive country if politicians in the imitative country are totally accountable ($\alpha_b = 1$) but it can never occur if these politicians are totally unaccountable ($\alpha_b = 0$), even if politicians in the inventive country are equally unaccountable ($\alpha_a = 0$). Hence:

Proposition 5

Patent protection is always stronger in the inventive country if politicians in the imitative country are totally accountable but this can never occur when these politicians are totally unaccountable, even if politicians in the inventive country are equally unaccountable.

1.4 Conclusion

The objective of this chapter was to show that a simple model of lobbying is able to provide in itself an explanation to the existence and woldwide diffusion of patent protection. Traditionally, patent protection is defended on the basis of its supposed stimulus to innovation and growth. Although this might be true, the political influence of organized groups of inventive firms is also a sufficient condition to the existence of patent protection. Moreover, even if patent protection increases innovation and aggregate welfare, the lobbying activity of inventive firms leads to suboptimal outcomes from a social welfare point of view. If lobbying is taken into account, the world suffers from an overproduction of patent protection above its most desireable strength, if any. When the effect of the lobbying activity on the strength of patent protection is properly isolated, then this latter is positively affected by the effectiveness of the lobby and negatively by the accountability of politicians and the market size for the innovative good. In this framework, the market size is important because consumers are voters that might punish politicians if their welfare is not properly taken into account. Also, politicians might consider market size because they are honest and do not want to harm their citizens.

In a one-country world, some form of patent protection is always in place unless politicians are totally accountable. On the contrary, in a two-country world, patent protection in the inventive country is always introduced, even when politicians are totally accountable. In the imitative country, patent protection is introduced in consideration of certain levels of accountability of politicians, market size for the innovative good and effectiveness of lobbying. Last but not least, patent protection is always stronger in the inventive country if politicians in the imitative country are totally accountable but this can never occur when these politicians are totally unaccountable, even if politicians in the inventive country are equally unaccountable.

Chapter 2

The fiscal incentives of governments to protect intellectual assets - Theory

2.1 Introduction

Since the real essence of property rights is the right to exclude, then the state is in the best position to specify and enforce them. Violence, by increasing the cost of violating private property, is an effective way to guarantee the respect of private property and, since the state has a comparative advantage in violence, then property rights can be more effectively protected by the state than by other social formations. This is not to say that property rights cannot exist without the state, as proved by the fact that they existed also in anarchic societies, but that the state, by monopolizing violence, is the most apt institution to their specification and enforcement. Thus, theories on the determinants of property rights are inevitably connected to theories of the state.

North (1979) distinguishes two main theories of the state: the *contract* theory and the *predatory* one. On the one hand, the contract theory, largely held by neoclassical economists, offers a public-interest explanation of the birth and essence of the state. On the other hand, the predatory theory, defended primarily by Marxists, political scientists and public choice theorists, argues that the state serves the interests of a certain group or class in society (from now on, the *élite*).

From a contract theory point of view, the state exists because it is beneficial from a social welfare point of view. By reinterpreting this theory from the idea of the *institutional possibility frontier* [Djankov et al. (2003)], citizens or the élite always choose exactly the optimal power of the state that minimizes social losses. The underlying assumption is that citizens are perfectly informed and that the élite is either welfare-maximizing or cast out of the political decision-making if it fails to choose the optimal power of the state: in other words, there is no élite and all political decisions are either directly or indirectly chosen by citizens. In general, the failure of a society to adopt superior institutions, that is, the fact that a society might fall in any point of the institutional possibility frontier is considered to be due to lack of information or coordination's problems of citizens.

From a predatory theory point of view, the state exists to serve the interests of the élite. Its historical birth is explained by the fact that, at a given moment of time, an organized group was able to dominate the other components of society and impose its monopoly of violence. In general, it is argued that only those institutional innovations that benefit the élite are adopted. The underlying assumption is that the élite maximizes its own welfare, even if it is acknowledged that a conflict might arise between its short-term and long-term interests. Under certain conditions, the interest of the élite and the one of the society as a whole coincide but this unanimity of interests is not assumed as in contract theory: in other words, the élite does not automatically choose the power of the state that minimizes social losses but it selects the one that maximizes its own welfare. In general, the fact that a society might fall in any point of the institutional possibility frontier is considered to be due to the interests of the élite. The objective of this paper is to contribute to the 'predatory' literature of the state by studying the behavior of the élite when choosing the strength patent protection. A patent is a set of exclusive rights granted by a sovereign state to an inventor or innovator for a limited period of time in exchange for detailed public disclosure of her invention or innovation [WIPO (2008)].[1] Without a sovereign state enforcing patents, the private monopoly of innovations could not be possible.[2] Hence, patents can be understood from both within the 'contract' and 'predatory' frameworks.

From a 'contract' point of view, patents have been considered as a necessary evil to the quest of innovation. According to the majority of economists, there would not be innovation in a perfect competitive market of ideas. Thus, patents would entail a trade-off between the enhanced incentive to innovate and the static cost of monopoly, the optimal strength of patent protection being the one equalizing the marginal benefit of new knowledge and the marginal cost of a stronger monopoly on that knowledge.

A more recent strand of literature on the economics of innovation has raised two objections to this traditional trade-off: first, perfectly competitive innovation could be possible and most innovations would be created under competition [Boldrin and Levine (2008a, 2008b)]; second, patents could increase the cost of the innovation process and entail dynamic costs [Heller (1998)]; [Bessen and Maskin (2009)]. Therefore, if patents cannot be justified as a necessary evil to stimulate innovation, and more efficient alternatives are available, such as perfectly competitive innovation or public R&D, it

[1] An invention is a solution to a specific technological problem of a product or a process introduced for the first time while an innovation occurs if someone improves on or makes a significant contribution to an existing product, process or service. Although an invention is not an innovation, we will use the latter term to refer to both throughout this paper.

[2] The analysis does not apply to other forms of intellectual property such as trademarks but it fits with copyrights which are similar in nature to patents.

would be interesting to formulate a 'predatory' explanation to the existence of patent protection. A possible 'predatory' answer to this question is connected with the concept of *rent-seeking*, that is, the attempt to increase one's share of existing wealth to the expense of others. From this perspective, patent protection would not be used to stimulate innovation but to defend the monopolistic interests of innovative firms: government regulation of innovation would be *captured* by powerful organized groups which *buy* protection at the expenses of consumers. Although it is largely documented that politicians around the world received pressures from lobbies of technological corporations to protect intellectual assets, I identify here another possible channel able to explain why state officials have always been particularly interested in patent protection along history. If, on the one hand, the 'political capture' explanation depicts politicians and, more in general, political power, in the hands of corporate (economic) interests, on the other hand, the reverse might also be taking place, from the political to the economic interests. By identifying this complementary channel, and by combining this latter with the 'political capture' explanation, it is possible to show the existence of a *state-corporate nexus*, a complementarity between the political interests of politicians and the economic interests of producers in the protection of intellectual assets. This is the first causality which has already been studied in the literature:

Corporate interests to protect intellectual assets (higher profits) →political capture of politicians (lobbies buy politicians) → intellectual property rights

while this is the second causality that I identify and test econometrically in Chapter 3:

Political interests to protect intellectual assets (higher tax revenue: in-

creased provision of public goods and probability of gaining elections and hold power) $\rightarrow$ use of the economic competitiveness of national firms for political purposes $\rightarrow$ intellectual property rights.

Together, these two causalities form a complementarity, the state-corporate nexus in the protection of intellectual assets. Hence, a 'predatory' explanation of patent protection based on this state-corporate nexus is provided as follow.

2.2 Model

2.2.1 One-country world

The objective of this subsection is to show how the strength of patent protection $\Omega \in [0,1]$ is chosen in a one-country world. While $\Omega = 0$ indicates total absence of patent protection, $\Omega = 1$ corresponds to the fictitious strength of patent protection characterized by infinite duration of the patent length, total coverage (all production in the economy is patentable), total enforcement (no piracy is possible) and absence of both working requirements and compulsory licensing.
The equilibrium strength of patent protection in a one-country world is different according to whether politicians K act to maximize the social welfare SW or if they maximize their own welfare W_K. This is the difference between which strength of patent protection we *should* have as a society and the strength of patent protection we *actually* have. In other words, a distinction between the normative and positive analysis of the strength of patent protection is put forward. In both normative and positive analysis and, as more precisely explained in Chapter 3, the strength of patent protection is a composed index based on patent coverage, membership to international

intellectual property (IP) treaties, enforcement, loss of protection and duration.[3]

Also, in both normative and positive analysis, I denote by $R \in [0,1]$ the economy's total expenditure on research and development (R&D) to generate new inventions. These new inventions can be both in *product* or *process*. The distinction between invention and innovation is omitted for sake of simplicity. Notice that $R = 1$ means that the integrity of this economy's output is dedicated to the R&D, while $R = 0$ indicates that no resources are dedicated to the production of inventions. Thus, R can be thought as a continuum of inventions ranging from zero inventions until the maximum number of producible inventions given the resources of the economy.

Normative analysis of maximum social welfare

In a world of politicians that act to maximize social welfare, it is already known since at least Nordhaus (1969) that the strength of patent protection should be chosen at the level that maximizes the difference between the *dynamic benefit* and the *static cost*.

On the one hand, the dynamic benefit of patent protection corresponds to the enhanced incentives of private agents to invest in R&D. In theory [Arrow (1962)], there can be no investment in R&D and hence no inventions at all without patent protection since private agents would not be able to recover the fixed cost necessary to produce them.

On the other hand, the static cost of patent protection is connected to the ineffiency of *monopoly pricing*. Therefore, the *benevolent dictator* chooses the strength of patent protection in which the marginal dynamic benefit equals the marginal static cost.

Since at least Heller et al. (1998), it is known that patent protection may generate dynamic cost, that is, it might actually decrease the production of inventions in the economy. Hence, it would be more correct to define the dynamic benefit, net of the dynamic cost. Nevertheless, for the purpose of this analysis, it is not relevant to

[3]For a detailed discussion of each one of these categories, please refer to Chapter 3.

make the distinction between dynamic benefit and cost and hence I assume, for sake of simplicity, that the dynamic benefit is already the *net dynamic benefit*, net of its dynamic cost.

Figures 1 and 2 in the Appendix show the *trade-off* between dynamic benefit and static cost of patent protection in the cases, respectively, of an invention in product and an invention in process. In the first case, the invention of a higher-quality product shifts the demand curve from the red to the green line. It is clear that this shift in the demand curve represents an increase in social welfare for both producers and consumers. The black dotted line between the red and green ones represents the new demand curve that would have occurred without patent protection. This means that, without patent protection, an invention in product would have appeared but of a lesser quality than the one enabled by patent protection. The benevolent dictator maximizes the difference between the net dynamic benefit and the static cost which are, respectively, the area $C_3 + P_3$ and the deadweight loss on the part of producers DWL_1 plus the one on the part of consumers DWL_2. The strength of patent protection that maximizes social welfare is the one that makes the economic rent π equal to the fixed cost of the invention f, that is, the R&D. Notice that, in the case represented in Figure 1, there might be a conflict between consumers and producers over the share of the surplus given that the benefit of patent protection is higher for consumers than for producers ($C_3 > P_3$). In the second case, the invention of a more productive process shifts the supply curve from the red to the green line. Again, it is clear that this shift in the supply curve represents an increase in social welfare for both producers and consumers. The black dotted line between the red and green ones represents the new supply curve that would have occurred without patent protection. This means that, without patent protection, an invention in process would have appeared but of a less cost-effective than the one enabled by patent protection. The benevolent dictator maximizes the difference between the net dynamic benefit and the static cost which leads to the same result as in Figure 1. The only difference between these two outcomes is that, in Figure 2, the benefit of patent protection is higher for producers than for consumers ($C_3 < P_3$).

Politicians strengthen patent protection until the optimal level, by maximizing the following *social welfare function*. I define the simple equations of the model as follow: 1) $R(\Omega) = \Omega I$, meaning that the investment in R is at its maximum level when patent protection is at its strongest, that is, when $\Omega = 1$, 2) $C(R) = cR$, meaning that the consumer surplus C increases the most when $R = 1$, 3) $P(R) = pR$, meaning that the producer surplus increases the most when $R = 1$, 4) $DWL(\Omega) = \frac{1}{2}(d^C + d^P)\Omega^2 = \frac{1}{2}d\Omega^2$, with $d = d^C + d^P$, meaning that the deadweight loss both on the part of consumers d^C and on the part of producers d^P increases the most when $\Omega = 1$. The underlying assumption that motivates 2) and 3) is that a higher R always leads to more inventions and hence more social surplus. Thus, politicians maximize social welfare with respect to the strength of patent protection:

$$\text{K} \max_{\Omega} \quad SW = C + P - DWL \tag{2.1}$$

yielding the following first-best condition (Appendix for Proof 1):

$$\Omega^*_{SW} = \frac{(c+p)I}{d} \tag{2.2}$$

In other words, patent protection is strengthened until the sum of the increases in consumer surplus C and in producer surplus P brought about by the increase in private R&D (incentivized by the strengthening of Ω) is equal to the increase in the deadweight loss DWL brought about this same strengthening of Ω. Thus (Appendix for Proof 2):

Proposition 1

With politicians maximizing social welfare, patent protection is strengthened if the marginal dynamic benefit $(c + p)I$ *is higher than the marginal static cost* $d\Omega$. *More precisely, the optimal strength of patent protection* Ω^*_{SW} *is an increasing function of* c, p *and* I *but a decreasing function of* d^C *and* d^P.

An analysis of how and why c, p, I, d^C and d^P change requires a study of demand and supply curves of the technological goods embodying inventions. Although it is not an objective of this paper to delve into the optimal first-best conditions of patent protection, it is possible to argue that, in general, the optimal strength of patent protection increases if one or more of the following events occurs: 1) the increase in consumer surplus C brought about by an increase in R becomes higher, that is, c increases, meaning that higher-quality or more cost-effective inventions for consumers are generated with the same R&D expenditure, 2) the increase in producer surplus P brought about by an increase in R becomes higher, that is, p increases, meaning that higher-quality or more cost-effective inventions for producers are generated with the same R&D expenditure, 3) the increase in R brought about by a strengthening of Ω becomes higher, that is, I increases, meaning that the R&D becomes more reactive to the same changes of patent protection.

Positive analysis of maximum net tax revenue

A one-country world is governed by rational politicians that act to maximize their collective welfare, that is, they act as an *élite*. The élite needs to choose the strength of patent protection that maximizes the net tax revenue. To choose the optimal strength of patent protection, the élite faces a *trade-off* between the patent-induced tax revenue

T and the cost C of providing patent protection.[4] Both revenue and cost increase as the chosen patent protection is strengthened. The following short discussion provides an explanation of why this might be so.

On the one hand, strengthening patent protection leads to a stronger monopolization of profits for inventive firms owning inventions. In other words, as patent protection is strengthened along one or more of its dimensions, inventive firms are able to extract more economic rents from their inventions. These economic rents are taxed at the tax rate $t^m \in [0, 1]$. Since IP is a highly profitable economic activity, then t^m represents the Effective Average Tax Rate (EATR) on highly profitable activities in the economy.

On the other hand, strengthening patent protection leads to higher state expenditure. This is due to the fact that patent protection, in all its forms, needs an infrastructure, both physical and intellectual, composed of efficient patent offices, prepared bureaucrats, highly-skilled legal personnel (lawyers and judges), police officers and others. The provision of this infrastructure is expensive and it is the more so, the stronger the supplied patent protection.

I define π^m as the sum of discounted aggregate monopoly profits that firms appropriates from inventions at the maximum strength of patent protection ($\Omega = 1$) and at the maximum production of inventions ($R = 1$). Each invention can be commercially exploited, either competitively in the absence of patent protection or monopolistically, in the presence of patent protection. I introduce a distinction between highly profitable competitive profits π^{cH} and not highly competitive profits π^{cL}. The former indicates the sum of discounted aggregate highly profitable competitive profits that firms appropriates from inventions when there is no patent protection ($\Omega = 0$) and at the maximum production of inventions ($R = 1$). The latter indicates the sum of discounted aggregate

[4] Notice that, in this case, *optimal* refers to the welfare of the élite and not total social welfare. In other words, the strength of patent protection is *optimal* with respect the objective of the agent K, irrespective of *allocative efficiency*.

lowly profitable competitive profits that firms appropriates from inventions when there is no patent protection ($\Omega = 0$) and at the maximum production of inventions ($R = 1$). Highly profitable competitive profits are taxed at the effective average tax rate (EATR) on highly profitable activities t^m while lowly competitive profits π^{cL} are taxed at the lower rate $t^c \in [0, 1]$, which represents the EATR on lowly profitable activities.

Notice that competitive profits in Arrow (1962) are zero because they are *economic profits* and trade secrets are not considered in his analysis. Thus, the marginal cost to produce another unit of the same invention is zero and the price of the technological good embodying this invention is equal to its marginal cost. On the contrary, Boldrin and Levine (2008) define as competitive those profits extracted thanks to the *first-mover advantage* allowed by trade secrets guaranteeing a price of technological goods higher than their marginal cost. In this latter case also, competitive profits, although positive, are studied in *economic* terms. Since the focus of this paper is on the fiscal interest of politicians to set patent protection, what counts here is not whether profits are positive or equal to zero from an economic perspective but rather what is their total amount. In other words, I am interested in *accounting profits*. In a one-country world, the sum of discounted aggregate monopoly profits is always higher than the sum of discounted aggregate highly competitive profits by definition, that is, $\pi^m - \pi^{cH} > 0$. However, this does not mean that the aggregate profits of the economy when the strength of patent protection is at its maximum ($\Omega = 1$) are higher than the aggregate profits when there is no patent protection ($\Omega = 0$). That is, we do not know whether $\pi^m \geq \pi^{cH} + \pi^{cL}$ or $\pi^m < \pi^{cH} + \pi^{cL}$. In theory, it is always possible that the monopolization of profits, although increasing the profits (both economically and accountingly) of the single producer with respect to her situation in a competitive market, leads to a reduction of aggregate profits in accounting terms (although not economically, since aggregate competitive economic profits are zero while aggregate monopolistic economic profits are positive). In an even more complex situation, it might occur that, if inventions are concentrated in the production of intermediary inputs used in following production processes, then strengthening patent protection induces a reduction in profits of final goods producers higher than the increase (if anything) in profits of intermediate goods producers. To study all these scenarios it is necessary to undertake a general equilibrium analysis. Nevertheless, for the purpose of this analysis in a one-country world, what counts is that $\pi^m - \pi^{cH} > 0$, which is true by definition given the fact that maximum patent protection increases the profitability of inventions for inventors with respect to a situation of trade secrets.

If the objective of the élite is to maximize the net tax revenue, that is, T net of C, then it has an incentive to appropriately consider both the amount and the type of profits at each exogenously given levels of t^m and t^c. Given that, in the real world, profit tax rates are usually an important electoral issue while patent protection is usually not one due to the shroudedness of its effects on social welfare, then the exogeneity of both tax rates is a plausible assumption. If this is, then this model identifies a possible *causal* channel going from the tax rates to the strength of patent protection. Further studies might endogenize the tax rates and show the conditions under which a *complementarity* between the two variables can arise.

There might be two types of élite, one *forward-looking* and *patient* while the other *myopic* and *impatient*. The difference between the two is that the forward-looking élite realises that the strength of patent protection has an effect on the private level of investment in R&D and that this feedbacks on the level of taxable profits in the long-run. Therefore, for the forward-looking élite, the private R&D is endogenous with respect to the strength of patent protection. On the other hand, a myopic élite does not consider the effect of patent protection on the R&D, considering that this effect might occur (if anything, due to the possible dynamic cost) so far in the future that it might not be in power anymore or simply discounting it at a zero discount rate. The discussion on under which conditions and institutions it is possible that élites consider their long-run interest or the long-run interest of the entire society is well-studied in the literature of political economy.

Here, I am interested in myopic élites that maximize the net tax revenue taking the private R&D expenditure as an exogenous parameter and I will therefore add the following assumption.

Assumption 1: the élite is myopic, that is, not interested in the long-run positive effect of the strength of patent protection on the level of private R&D expenditure.

In other words, R is exogenous in models with policians maximizing the net tax revenue. Given all the above, I present the equations of the model as follow. A strengthening of patent protection leads to: 1) higher fiscal revenue from monopoly profits taxable at the EATR on highly profitable activities $t^m R \pi^m \Omega$, 2) lower fiscal revenue from highly profitable competitive profits generated by free-riding on inventions and taxable at the EATR on highly profitable activities $t^m R \pi^{cH}(1-\Omega)$, 3) lower fiscal revenue from lowly profitable competitive profits generated by free-riding on inventions and taxable at the EATR on lowly profitable activities $t^c R \pi^{cL}(1-\Omega)$, 4) higher cost of providing patent protection $\frac{1}{2}\Omega^2$.

Politicians will make the following choice with respect to the strength of patent protection:

$$\text{K} \max_{\Omega} \quad W_K = T - C \tag{2.3}$$

yielding the following equilibrium strength of patent protection (Appendix for Proof

3):

$$\Omega^*_{W_K} = R[t^m(\pi^m - \pi^{cH}) - t^c\pi^{cL}]. \tag{2.4}$$

Given that, by the definition of patent protection, the sum of discounted aggregate monopoly profits is higher than the sum of discounted aggregate highly competitive profits ($\pi^m - \pi^{cH} > 0$), a simple comparative statics of (4) suggests that the equilibrium strength of patent protection is correlated in the following ways with its underlying parameters (Appendix for Proof 4): 1) positively (or unaffected when $R = 0$) with the EATR on highly profitable activities, 2) either positively, negatively or unaffected with the private R&D expenditure,[5] 3) negatively (or unaffected when $R = 0$) with the EATR on lowly profitable activities decreases, 4) positively (or unaffected when $R = 0$ or $t^m = 0$) with monopoly profits, 5) negatively (or unaffected when $R = 0$ or $t^m = 0$) with highly profitable competitive profits, 6) negatively (or unaffected when $R = 0$ or $t^c = 0$) with lowly profitable competitive profits. It is important to underline that, in this model, the effect of the private R&D expenditure on the strength of patent protection is not direct, as proposed in previous studies [Ginarte and Park (1997)] but it is mediated by the fiscal interests of politicians. It is therefore possible to state that:

Proposition 2

With politicians maximizing the net tax revenue in a one-country world, the strength of patent protection increases as the EATR on highly profitable activities increases. This effect is stronger, the higher the private expenditure in R&D, the higher the rent that can be extracted from protected inventions and the lower the profitability of highly profitable competitive profits on unprotected inventions. Thus, the effect of the private R&D expenditure on the strength of patent protection is not direct but it is mediated by

[5] Positively at sufficiently high t^m and π^m or sufficiently low π^{cH}, t^c and π^{cL}. Negatively in the opposite case. Unaffected in neither case.

the fiscal interests of politicians.

Notice also that results 5) and 6) are in line with previous findings in the literature showing that, if the first-mover advantage is an effective way to appropriate returns from an invention, then the patent system becomes less necessary for firms to finance their private R&D [Khan (2008)]. Nevertheless, what is highlighted here is a *complementary* explanation to the one already provided in previous studies: if the first-mover advantage is an effective way to appropriate returns from an invention, then the patent system becomes less necessary for the state to finance its fiscal revenue.

The way in which the production process is actually carried out is important for the correct interpretation of these last two results, both in traditional explanations [Khan (2008)] and in this model. In fact, the more extended mechanization of the production process has progressively rendered the knowledge and application of natural sciences more compelling. When engineers substitute artisans, handcrafters and manufacturers in the elaboration of knowledge necessary to carry out the production process, this latter becomes more heavily reliant on codifiable rather than tacit knowledge. The transformation brought about by mechanical industry from tacit and personified knowledge into a codifiable and disembodied one rendered the first-mover advantage less effective to appropriate the returns from inventions. This is why, the world has experienced an historical reduction in the profitability of competitive profits. Therefore, this model identifies that, given the historical reduction in profitability of competitive profits that the world has experienced since the First Industrial Revolution, patent protection might be more widely used today not only to finance the private R&D but also to finance the state. This leads us to the following:

Proposition 3

If the profitability of competitive profits decreases, then patent protection becomes more compelling not only to finance the private R&D (as highlighted in previous studies) but also to finance the state.

For a graphical representation of the importance of the EATR on highly profitable activities when setting patent protection, please refer to Figures 3 and 4 in the Appendix. If the objective of using patent protection is not to finance the private R&D expenditure but to finance the state, then the yellow area in Figure 3 will be maximized (net of the cost of providing patent protection, not represented graphically). Hence, only the blue area will remain available to finance the private R&D, which means that a weaker patent protection would have obtained the same objective of financing that invention (in process in both images). Thus, as shown in Figure 4, the green area represents the welfare loss, the upper green area being the welfare loss on the part of consumers and the lower green area being the welfare loss of producers.

2.2.2 Two-country world

The objective of this subsection is to show how the strength of patent protection is chosen in a two-country world, composed by two countries i, with $i = 1, 2$, each one governed by a national élite. The two countries are identical and they can only differ in the parameters under scrutiny, namely the R&D expenditure and the EATR on highly profitable activities. Patent protection respects the principle of *national treatment*, that is, equal treatment of national and foreign inventions. I exclude the possibility of counterfeiting and *parallel imports*. There are no multinational firms (MNCs) that might shift profits from one country to another.

Normative analysis of maximum national social welfare

In this two-country world, politicians are benevolent and they maximize the national social welfare SW_i. Hence, assumption 1 on the exogeneity of R_i is relaxed since these benevolent politicians take into consideration the long-run positive effect of patent protection on the level of investment in R&D. I add the two following assumptions:

Assumption 2: the élites do not cooperate to reach the joint maximum social welfare, even if this latter would be higher than the sum of the two national maximums.

Assumption 3: neither élite has the political power to impose a certain strength of patent protection on the other.

I modify the equations of the model presented in 2.1.1 to take into account the effect of foreign patent protection on national parameters. Here as follow, I present the equations of the model with a brief explanation for each:
1) $R_i(\Omega_i, \Omega_{-i}) = \frac{1}{2} I \Omega_i \Omega_{-i}$. This means that the private investment in R&D realized in one country depends on the strength of patent protection in both countries. Notice that the private expenditure in R&D in one country is zero if at least one of the two countris has no patent protection (mathematically, $R_i = 0$ if $\Omega_i = 0$, for all $i = 1, 2$). Thus, firms in one country also consider potential free-riding opportunities by firms in the other countries. This is one of the consequences of the *immateriality* of knowledge that, in the absence of protection, spreads all over the world as a free gift to all those firms that did not bear the cost to generate it. This is a remarkable difference from the case of a one-country world: in this latter case, by definition, patent protection is homogenously applied in all corners of the country and hence national firms do not need to internalize the positive externality of their investment in R&D on foreign

competitors.

2) $C(R_i, R_{-i}) = \frac{1}{2}c(I\Omega_i\Omega_{-i})$ (Appendix for Proof 5).

The dynamic benefit of patent protection on consumers is a linear function of the sum of the private expenditures in R&D in both countries. Thus, as in the one-country model, the effect of patent protection on consumer surplus is indirect and it passes through its effect on the R&D expenditure. The consumer surplus depends *equally* on the private expenditure in R&D in both countries because it is assumed for simplicity that there are no transportation costs of products from one country to the other and that consumers do not have either nationalistic or xenophilic preferences.

3) $P(R_i, R_{-i}) = \frac{1}{4}p[\frac{1}{2}I\Omega_i\Omega_{-i}(2 + \Omega_i + \Omega_{-i}) + \frac{1}{2}I\Omega_i\Omega_{-i}(2 - \Omega_i - \Omega_{-i})]$ (Appendix for Proof 6).

The dynamic benefit of patent protection on producers is more complex than in the one-country world. In fact, it is necessary to take into account here whether producers have access to foreign knowledge. The formula can be justifies as follow:

- if $\Omega_i = 1$ for all $i = 1, 2$, then $P(R_i, R_{-i}) = \frac{1}{2}pI$ (Appendix for Proof 7). This means that maximum patent protection in both countries leads firms in one country to gain half of the producer surplus that would be generated in a one-country world with maximum patent protection.

- if $\Omega_i = 0$ for all $i = 1, 2$, then $P(R_i, R_{-i}) = 0$ (Appendix for Proof 8). This means that absence of patent protection in both countries leads all firms to zero producer surplus.

4) $DWL_i(\Omega_i, \Omega_{-i}) = \frac{1}{2}\left[\frac{(d^C_{ii}+d^P_{ii})\Omega_i^2+(d^C_{i-i}+d^P_{i-i})\Omega_{-i}^2}{2}\right]$, with $d^C_{ii} + d^P_{ii} = d_{ii}$. This means that the deadweight loss in one country brought about by patent protection in both countries depends on the deadweight loss on national consumers due to national patent protection (d^C_{ii}), on the deadweight loss on national producers due to national patent

protection (d_{ii}^P), on the deadweight loss on national consumers due to foreign patent protection (d_{i-i}^C) and on the deadweight loss on national producers in country due to foreign patent protection (d_{i-i}^P).

Given the equations of the model, politicians in each country maximize the national social welfare with respect to the national strength of patent protection:

$$\mathrm{K}_i \max_{\Omega_i} SW_i(\Omega_i) = C + P - DWL_i \tag{2.5}$$

yielding the following first-best condition (Appendix for Proof 9):

$$\Omega^*_{SW_i} = \frac{(c+p)I}{d_{ii}}\Omega_{-i} \tag{2.6}$$

A similar comparative statics analysis applies to formula (2) and formula (6). However, formula (6) differs from (2) because the strength of national patent protection here depends also on the strength of foreign patent protection. As shown in Proof 10 in the Appendix, the global outcome is either maximum patent protection in both countries or no patent protection at all. This result is driven by the fact that firms in one country not only consider national patent protection but also foreign firms' free-riding on national inventions, when choosing their level of investment in R&D. As the strength of foreign patent protection increases, the free-riding by foreign firms on national inventions is reduced because of the principle of *national treatment*. In general, this result is the consequence of both the *nonrivalrous* nature of knowledge that trespasses borders freely and of the principle of national treatment: these two characteristics of the country-based international system of patent protection always forces firms to consider free-riding opportunities for foreign competitors; also, these characteristics oblige national consumers to buy products from real inventors regardless their nationality, thus modifying what producers can gain from trade.[6] If the consumer surplus or the producer surplus are particularly sensitive to inventions (high c or p), the investment in R&D sufficiently high (high I), or the national deadweight loss particularly sensitivie to patent protection (high d_{ii}), then the global equilibrium is of maximum patent protection. In the opposite case, the global equilibrium is of no patent protection. Therefore, it is possible to state that:

Proposition 4

In a noncooperative two-country world with politicians maximizing national social welfare and with no country more politically powerful than any other, all countries are either forced to adopt the strongest patent protection possible or they are forced out of patent protection altogether. Whether one equilibrium or the other obtains depends on the value of the parameters c, p, I and d_{ii}. This result is driven by the nonrivalrous nature of inventions and the principle of national treatment. These latter modify national producer surplus and push firms to take into account opportunities for foreign firms to free-ride on national inventions.

Positive analysis of maximum national net tax revenue

In this two-country world, the élite in each country chooses the strength of patent protection that maximizes the national net tax revenue W_{K_i} by solving the trade-off between the gross tax revenue and the cost of providing patent protection. The three previously stated assumptions hold, plus an additional one:

Assumption 4: country 1 spends in R&D and generates national inventions *more*

[6] Although outside the scope of this study, it can be shown that the free-riding problem worsens as the number of interacting countries increases, thus leading to a faster suppression of patent protection in all countries.

than a critical threshold z that I define as $z = \frac{\pi^{cH}}{\pi^{m}}(R_1 + R_2)$; on the contrary, country 2 spends in R&D and generates national inventions *less* than z. This implies country 1 is more inventive than country 2, that is $R_1 > R_2$.

Assumption 4 makes the two otherwise identical countries different only in their level of expenditure in R&D and production of inventions.

The one-country world framework needs to be modified to take into account that competitive profits, both the highly profitable and the not highly profitable ones, can be generated by copying both national but also *foreign* inventions. In this way, a strengthening of patent protection in one country leads to: 1) higher fiscal revenue from monopoly profits taxable at the EATR on highly profitable activities $t^m R_i \pi^m \Omega_i$, as in the one-country world, 2) lower fiscal revenue from highly profitable competitive profits generated by free-riding on national inventions and taxable at the EATR on highly profitable activities $t^m R_i \pi^{cH}(1-\Omega_i)$, as in the one-country world, 3) lower fiscal revenue from lowly profitable competitive profits generated by free-riding on national inventions and taxable at the EATR on lowly profitable activities $t^c R_i \pi^{cL}(1-\Omega_i)$, as in the one-country world, 4) lower fiscal revenue from highly profitable competitive profits generated by free-riding on foreign inventions and taxable at the EATR on highly profitable activities $t^m R_{-i} \pi^{cH}(1-\Omega_i)$, 5) lower fiscal revenue from lowly profitable competitive profits generated by free-riding on foreign inventions and taxable at the EATR on lowly profitable activities $t^c R_{-i} \pi^{cL}(1-\Omega_i)$, 6) higher cost of providing patent protection $\frac{1}{2}\Omega_i$.

Points 4) and 5) modify this framework in non-trivial ways with respect to the one-country world. Taking the potential free-riding on foreign inventions into account, the élite in each country maximizes the national net tax revenue by considering the following trade-off:

$$\mathrm{K}_i \max_{\Omega} W_{K_i}(\Omega_i) = T_i - C_i \tag{2.7}$$

which leads to (Appendix for Proof 11):

$$\Omega^*_{W_{K_i}} = t^m[R_i\pi^m - \pi^{cH}(R_i + R_{-i})] - t^c\pi^{cL}(R_i + R_{-i}). \tag{2.8}$$

By looking at equation (8) a simple comparative statics suggests that the equilibrium strength of national patent protection is correlated in the following ways with its underlying parameters (Appendix for Proof 12): 1) positively (negatively) with the EATR on highly profitable activities if and only if the national expenditure in R&D is higher (lower) than the critical threshold z; it is unaffected if $R_i + R_{-i} = 0$ or if the national expenditure in R&D is equal to the critical threshold, 2) either positively, negatively or unaffected with the national private R&D expenditure,[7] 3) negatively with the foreign private R&D expenditure, 4) negatively (or unaffected when $R_i + R_{-i} = 0$) with the EATR on lowly profitable activities decreases, 4) positively (or unaffected when $R_i + R_{-i} = 0$ or $t^m = 0$) with monopoly profits, 5) negatively (or unaffected when $R_i + R_{-i} = 0$ or $t^m = 0$) with highly profitable competitive profits, 6) negatively (or unaffected when $R_i + R_{-i} = 0$ or $t^c = 0$) with lowly profitable competitive profits. As in the case of one-country world, the effect of the national R&D expenditure on the strength of patent protection is not direct but it is mediated by the fiscal interests of politicians. However, an important difference should be emphasized: the sign of the change in the strength of patent protection due to an increase in the national R&D expenditure is ambiguous and depends on the parameters while higher foreign R&D expenditure always induces a weakening in patent protection. This is the

[7] As in the one-country world, positively at sufficiently high t^m and π^m or sufficiently low π^{cH}, t^c and π^{cL}. Negatively in the opposite case. Unaffected in neither case.

consequence of national firms increasing competitive profits by free-riding on foreign inventions. As long as this free-riding creates opportunities to increase the national fiscal revenue, then politicians will positively take it into account and weaken patent protection. Notice also another important fact. If national expenditure in R&D is lower than the critical threshold, then there is no trade-off in setting patent protection: the only rational choice for politicians is to set no patent protection at all. However, more complex and realistic models might show that the welfare of politicians is not only a function of the net tax revenue but also of money m spent by lobbies in favor of patent protection. This is a well-known fact in the literature and a formalization of it is provided in Chapter 1. Instrumental to this analysis is the idea that the money coming from these lobbies increases as the strength of patent protection increases too, such that $m'(\Omega_i) > 0$ and $m''(\Omega_i) < 0$. This means that modifying equation (7) so that $W_{K_i} = m + T_i - C_i$ always provides a trade-off even when the R&D expenditure is lower than the critical threshold. In this way, equation (8) becomes $\Omega^*_{W_{K_i}} = m' + t^m[R_i\pi^m - \pi^{cH}(R_i + R_{-i})] - t^c\pi^{cL}(R_i + R_{-i})$ and equation (7) always reflects the choice of politicians maximizing a value function, even if the gross tax revenue decreases at higher strength of patent protection. This modification permits us to study the effect of the EATR on highly profitable activities on the strength of patent protection for all countries, both inventive (spending in R&D more than the critical threshold) and imitative (spending in R&D less than the critical threshold). It is therefore possible to state that:

Proposition 5

With politicians noncooperatively maximizing the national net tax revenue in a two-country world, the strength of national patent protection increases (decreases) as the EATR on highly profitable activities increases if and only if the national expenditure *in R&D is higher than a critical threshold. This effect is stronger, the higher the national expenditure in R&D, the higher the rent that can be extracted from protected inventions and the lower the profitability of highly profitable competitive profits on unprotected inventions. As in the case of one-country world, the effect of the national R&D expenditure on the strength of patent protection is not direct but it is mediated by the fiscal interests of politicians. While an increase in the national R&D expenditure does not systematically induce a strengthening of national patent protection, a higher foreign R&D expenditure always leads to a weakening in patent protection. This is the consequence of a higher fiscal revenue brought about by larger competitive profits of national firms free-riding on foreign inventions.*

A self-evident logical consequence of Proposition 5 and Assumption 4 is that, if the two countries start from two different strengths of patent protection such that $\Omega_1 > \Omega_2$, then a decrease (increase) in the EATR on highly profitable activities in both countries leads to a weakening of patent protection in 1 and to its strengthening in 2, eventually yielding patent *harmonization* (*divergence*). Hence:

Corollary of Proposition 5

If one country is more inventive than the other and if this this starts from a weaker patent protection, then a decrease (increase) in the EATR on highly profitable activities leads to patent harmonization (divergence).

Two other interesting results can be summarized as follow: 1) two otherwise identical countries that only differ in the level of R&D expenditure (as stated in Assumption 4) will set their national strength of patent protection such that the more inventive country is more protective than the less inventive one, 2) if politicians maximize the net tax revenue, the equilibrium strength of patent protection is lower (or equal) in a two-country world than in a one-country world because of the positive effect that copying foreign knowledge has on national competitive profits and hence on tax revenue (Appendix for Proof 13). The political unification of these two countries would lead to a strengthening of patent protection even if all the other characteristics of the economy are unaffected. Therefore:

Proposition 6

In a noncooperative two-country world composed by two identical countries that differ only in the R&D expenditure levels and with politicians maximizing the net tax revenue, then patent protection is stronger in the more inventive country. Moreover, patent protection is stronger in a one-country world than in a two-country world: the political unification of this latter leads to less free-riding on foreign inventions and hence on less fiscal interest to weaken patent protection.

Normative analysis with political power

In a two-country world, politicians are benevolent (Assumption 1 does not hold) and country F is politically able to impose its preferred strength of patent protection on country W (Assumption 3 does not hold). I also relax Assumption 4, that is, the two countries differ only in their relative political power and not in the level of R&D expenditure. By looking at the framework in 2.2.1, it is possible to show that the élite in country F faces a different trade-off when choosing the strength of patent protection in country W since it cares about the national deadweight loss realized abroad and not the one realized nationally. In fact, the same equation as in 2.2.1 are valid here but

Hence, politicians in the powerful country maximize the national social welfare

SW_F with respect to the foreign strength of patent protection:

$$\mathrm{K}_F \max_{\Omega_W} SW_F = C + P - DWL_F \tag{2.9}$$

thus leading to the equilibrium strength of the weak country's patent protection that maximizes the social welfare in the powerful country $\Omega^*_{SW_{F_W}}$ (Appendix for Proof 14):

$$\Omega^*_{SW_{F_W}} = \frac{(c+p)I}{d_{FW}}\Omega_F \tag{2.10}$$

By comparing equations (6) with (10), it is possible to see that the same comparitive statics applies to both (with the difference that now d_{ii} is substituted by d_{FW} and that Ω_{-i} is substituted by Ω_F). However, introducing political power in the two-country world governed by politicians maximizing the more politically powerful country's social welfare changes the final outcome. In fact, politicians now consider the national deadweight loss realized abroad and not the one relized internally. More complex models might show that if the national deadweight loss is higher when brought about by national rather than foreign patent protection ($d^C_{FW} + d^P_{FW} < d^C_{FF} + d^P_{FF}$), then the probability that the final outcome is maximum global patent protection increases with respect to the case in 2.2.1. For example, if trade is realized nationally more than internationally (which is empirically true), then the national deadweight loss is higher when brought about by national rather than foreign patent protection. This would lead to a higher probability that $\frac{(c+p)I}{d_{FW}} = 1$, thus leading also to a higher probability that the final outcome is maximum global patent protection. More complex models might also show that the pace of dropping patent protection until it is eliminated altogether is slower in this case than in 2.2.1.

Proposition 7

In a noncooperative two-country world with a powerful country setting global patent protection to maximize its own national welfare, Proposition 4 holds. However, if the national deadweight loss realized nationally is smaller than the one realized abroad, then: 1) the probability that global patent protection is at its maximum increases, 2) in the case of the two countries being forced out of patent protection, the pace of this occurence is slower.

Positive analysis with political power

The framework is identical to the one in 2.2.3 but now Assumption 1 holds. The powerful country imposes its preferred strength of patent protection to the weak country. Although, as explained below the equations of the model are different, the trade-off is identical to the one proposed in 2.2.2: stronger patent protection in the weak country leads to higher fiscal revenue and higher cost of providing patent protection for the powerful country. Notice that here the cost of providing patent protection in the weak country is paid by the powerful country. This is empirically true given all the interests that hegemons of the international system have always had in foreign patent protection, the USA, for example, providing police, administrative and legal aid to developing countries not entirely able to operate the patent system on their own.

Since competitive profits, both the highly profitable and the lowly profitable ones, can be generated by copying national and foreign inventions, a strengthening of patent protection in the weak country leads to the following effects to politicians in the powerful country: 1) higher fiscal revenue from monopoly profits on exports by firms in F and taxable at the EATR on highly profitable activities $t_F^m \pi_{FW}^m$, 2) lower fiscal revenue from competitive profits on exports generated by free-riding on national inventions, both the one taxed at the EATR on highly profitable activities $t_F^m R_F \pi_{FW}^{cH}$ and the ones taxed at the EATR on lowly profitable activities $t_F^c R_F \pi_{FW}^{cL}$, 3) lower fiscal revenue from competitive profits on exports generated by free-riding on foreign inventions, both the one taxed at the EATR on highly profitable activities $t_F^m R_W \pi_{FW}^{cH}$ and the ones taxed at the EATR on lowly profitable activities $t_F^c R_W \pi_{FW}^{cL}$. Thus, the élite in the powerful country maximizes the national net tax revenue with respect to the strength of patent protection in the weak country:

$$\mathrm{K}_F \max_{\Omega_W} W_{F_K} = T_F - C_F \tag{2.11}$$

which leads to (Appendix for Proof 15):

$$\Omega^*_{W_{F_W}} = t_F^m [R_F \pi_{FW}^m - \pi_{FW}^{cH}(R_F + R_W)] - t_F^c \pi_{FW}^{cL}(R_F + R_W) \tag{2.12}$$

The comparative statics of equation (12) is identical to the one of equation (8), with the difference that now all profits are from exports and that the EATRs that count when choosing the strength of patent protection in the weak country are those implemented in the powerful country. Again, the effect of the national R&D expenditure on the strength of patent protection in the weak country is not direct but it is mediated by the fiscal interests of politicians. However, contrary to the case in 2.2.2, the sign of the change in the strength of patent protection in the weak country due to an increase in the national R&D expenditure is not ambiguous anymore but it always induces a weakening in patent protection. This is the consequence of the fact that only the fiscal interests of politicians in the powerful country are taken into account. On the contrary, the effect of increasing the R&D expenditure in the powerful country on the strength of patent protection in the weak one is ambiguous. If the R&D expenditure in the powerful country is lower than the critical threshold, then there is no trade-off in setting patent protection: the only rational choice for politicians is to set no patent protection at all. The same discussion on the paramter m representing the money received by lobbies applies here as well. It is therefore possible to state that:

Proposition 8

We are in a two-country world with political power and with politicians in the powerful country maximizing their net tax revenue with respect to the strength of patent protection in the weak country. Then, this latter increases (decreases) as the EATR on highly profitable activities in the powerful country increases if and only if the R&D expenditure in the powerful country is higher than a critical threshold. This effect is stronger, the higher the R&D expenditure in the powerful country, the higher the rent that can be extracted from protected inventions and the lower the profitability of highly profitable competitive profits on unprotected inventions exported to the weak country. As in the case of one-country world, the effect of the national R&D expenditure on the strength of patent protection is not direct but it is mediated by the fiscal interests of politicians. While an increase in the R&D expenditure in the powerful country does not systematically induce a strengthening of patent protection in the weak one, a higher R&D expenditure in the weak country always leads to a weakening in patent protection there.

2.3 Appendix

2.3.1 Proof 1

K $\max_{\Omega} SW = C + P - DWL$ **yields** $\Omega^*_{SW} = \frac{(c+p)I}{d}$.

1. $SW = C + P - DWL$ can be rewritten as $SW(\Omega) = C(R(\Omega)) + P(R(\Omega)) - DWL(\Omega) = c\Omega I + p\Omega I - \frac{1}{2}d\Omega^2$.

2. By maximizing this latter expression with respect to Ω, it is possible to obtain

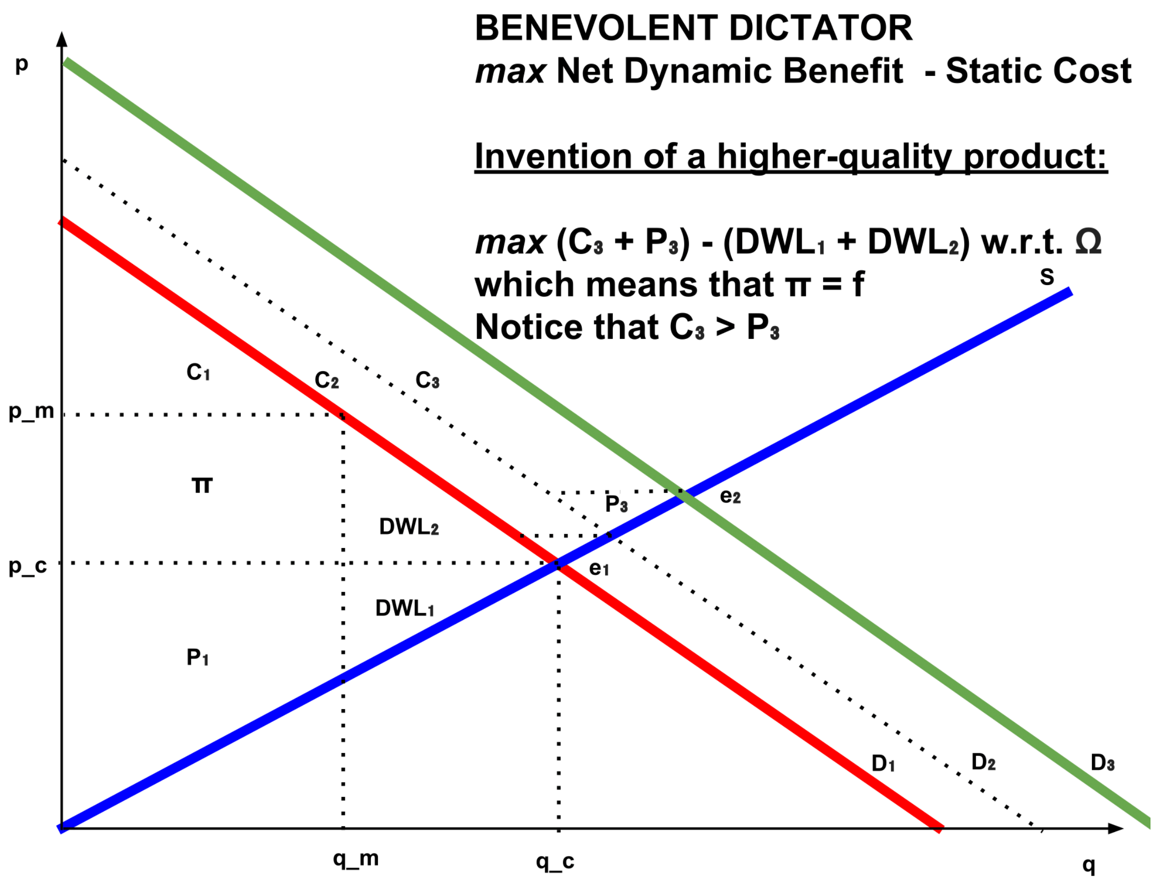

Figure 2.1: Net dynamic benefit and static cost of patent protection in the case of an invention in product

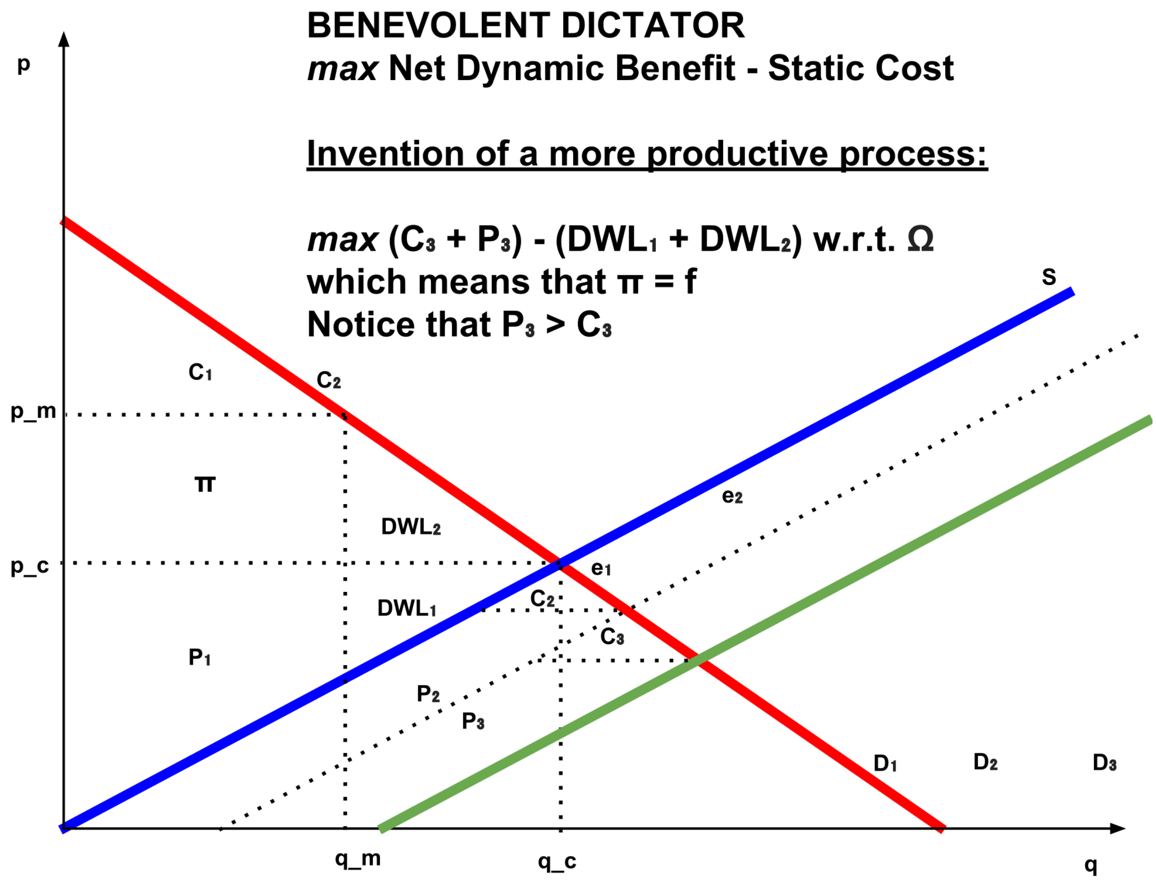

Figure 2.2: Net dynamic benefit and static cost of patent protection in the case of an invention in process

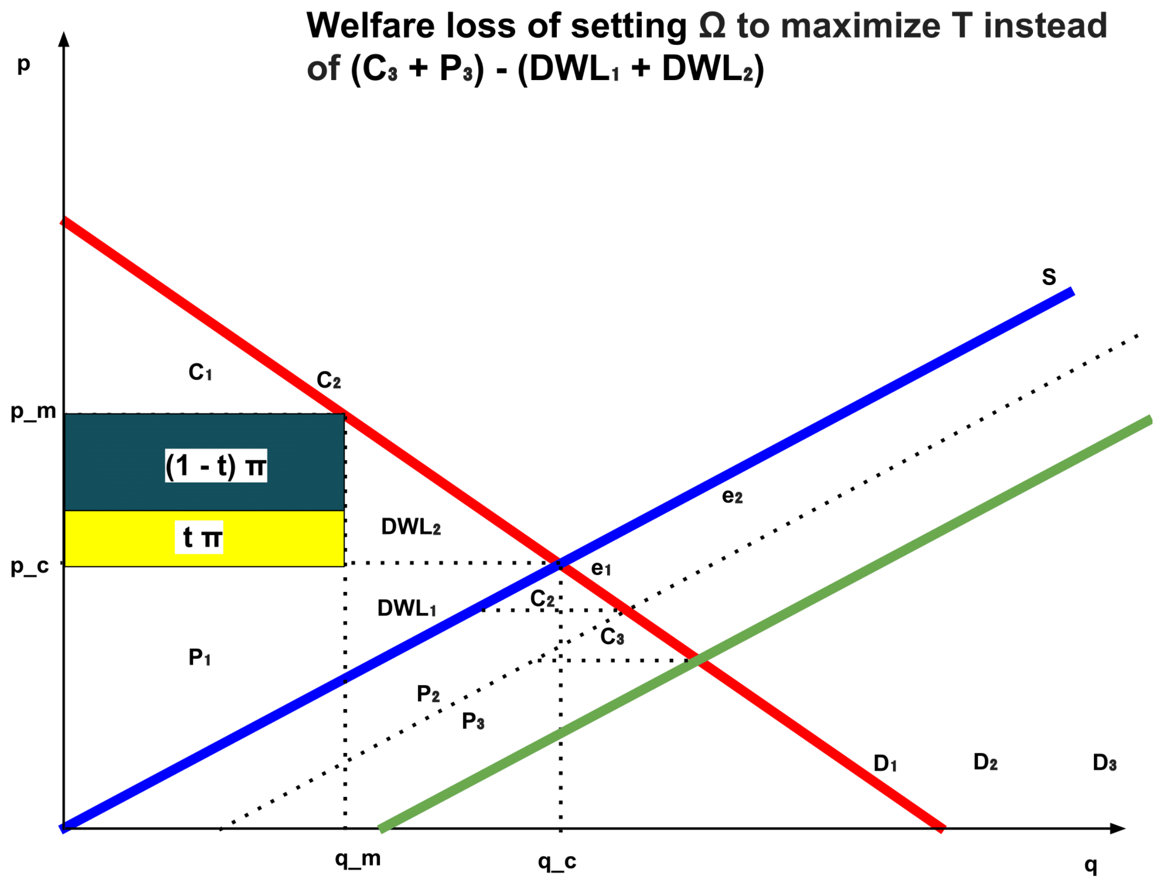

Figure 2.3: Welfare loss of setting patent protection to maximize the net tax revenue in the presence of an invention in process.

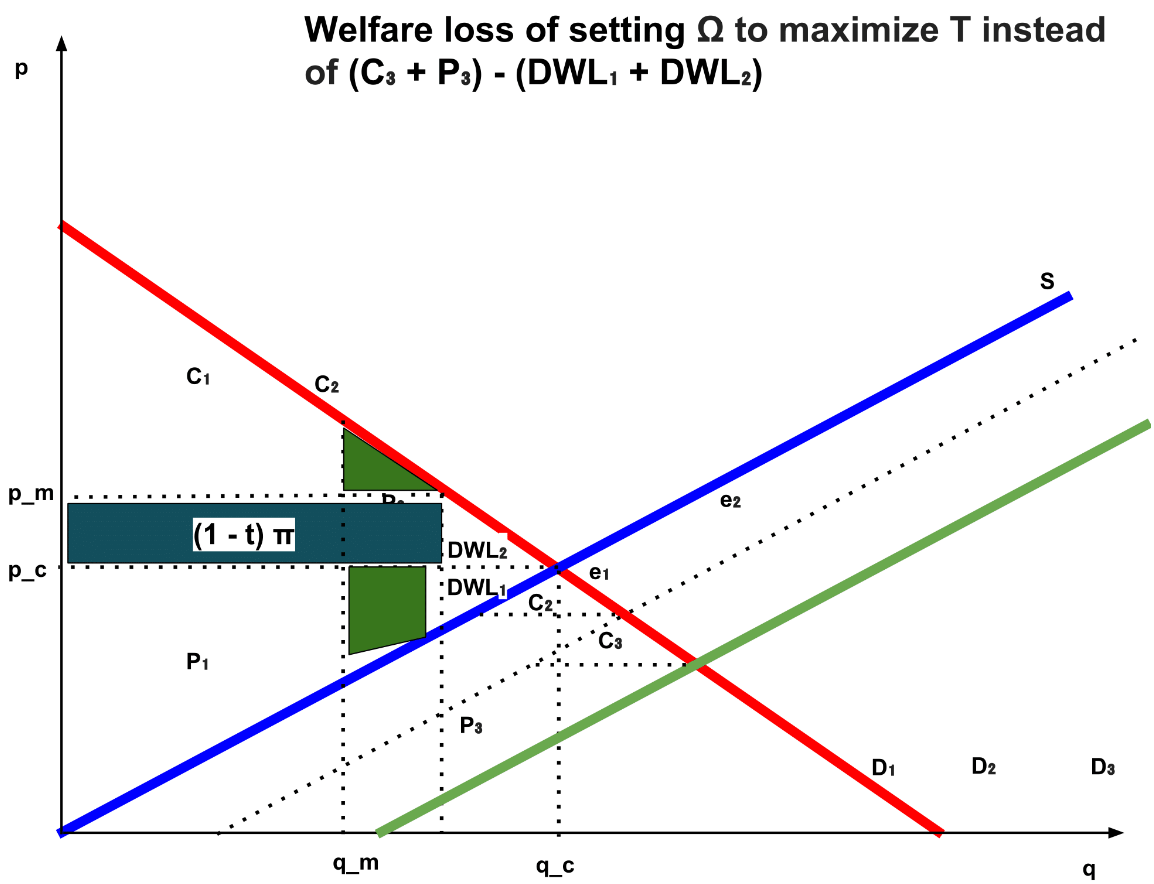

Figure 2.4: Welfare loss of setting patent protection to maximize the net tax revenue in the presence of an invention in process.

the following first-order condition (FOC): $cI + pI - d\Omega = 0$.

3. By rearranging this latter, I obtain $d\Omega = cI + pI$.

4. By rearranging this latter, I obtain $d\Omega = (c+p)I$.

5. Thus, $\Omega^*_{SW} = \frac{(c+p)I}{d}$.

2.3.2 Proof 2

Comparative statics of $\Omega^*_{SW} = \frac{(c+p)I}{d}$ on its parameters.

1. $\frac{\partial\Omega^*_{SW}}{\partial c} = \frac{\partial\frac{(c+p)I}{d}}{\partial c} = \frac{I}{d} \geq 0$.

2. $\frac{\partial\Omega^*_{SW}}{\partial p} = \frac{\partial\frac{(c+p)I}{d}}{\partial p} = \frac{I}{d} \geq 0$.

3. $\frac{\partial\Omega^*_{SW}}{\partial I} = \frac{\partial\frac{(c+p)I}{d}}{\partial I} = \frac{c+p}{d} \geq 0$.

4. $\frac{\partial\Omega^*_{SW}}{\partial d^C} = \frac{\partial\frac{(c+p)I}{d^C+d^P}}{\partial d^C} = -\frac{(c+p)I}{(d^C+d^P)^2} \leq 0$.

5. $\frac{\partial\Omega^*_{SW}}{\partial d^P} = \frac{\partial\frac{(c+p)I}{d^C+d^P}}{\partial d^P} = -\frac{(c+p)I}{(d^C+d^P)^2} \leq 0$.

2.3.3 Proof 3

K $\max\limits_{\Omega}$ $W_K = T - C$ leads to $\Omega^*_{W_K} = R[t^m(\pi^m - \pi^{cH}) - t^c\pi^{cL}]$.

1. $W_K = T - C$ can be rewritten as $W_K(\Omega) = T(\Omega) - C(\Omega) = t^m R\pi^m\Omega + t^m R\pi^{cH}(1-\Omega) + t^c R\pi^{cL}(1-\Omega) - \frac{1}{2}\Omega^2 = t^m[R\pi^m\Omega + R\pi^{cH}(1-\Omega)] + t^c R\pi^{cL}(1-\Omega) - \frac{1}{2}\Omega^2 = R\left\{t^m[\pi^m\Omega + \pi^{cH}(1-\Omega)] + t^c\pi^{cL}(1-\Omega)\right\} - \frac{1}{2}\Omega^2$.

2. By maximizing this latter expression with respect to Ω, it is possible to obtain the following FOC: $t^m(R\pi^m - R\pi^{cH}) - t^c R\pi^{cL} - \Omega = 0$.

3. By rearranging this latter, I obtain $\Omega^* = t^m(R\pi^m - R\pi^{cH}) - t^c R\pi^{cL}$.

4. Thus, $\Omega^*_{W_K} = R[t^m(\pi^m - \pi^{cH}) - t^c\pi^{cL}]$.

2.3.4 Proof 4

Comparative statics of $\Omega^*_{W_K} = R[t^m(\pi^m - \pi^{cH}) - t^c\pi^{cL}]$ **on its parameters**.

1. $\frac{\partial\Omega^*_{W_K}}{\partial t^m} = R(\pi^m - \pi^{cH}) \geq 0$.

2. $\frac{\partial\Omega^*_{W_K}}{\partial R} = t^m(\pi^m - \pi^{cH}) - t^c\pi^{cL} \lesseqgtr 0$ depending on the values of the underlying parameters.

3. $\frac{\partial\Omega^*_{W_K}}{\partial t^c} = -R\pi^{cL} \leq 0$.

4. $\frac{\partial\Omega^*_{W_K}}{\partial \pi^m} = Rt^m \geq 0$.

5. $\frac{\partial\Omega^*_{W_K}}{\partial \pi^{cH}} = -Rt^m \leq 0$.

6. $\frac{\partial\Omega^*_{W_K}}{\partial \pi^{cL}} = -Rt^c \leq 0$.

2.3.5 Proof 5

$C(R_i, R_{-i})$ **is equal to** $\frac{1}{2}c(I\Omega_i\Omega_{-i})$.

$C(R_i, R_{-i}) = C(R_i(\Omega_i, \Omega_{-i}), R_{-i}(\Omega_i, \Omega_{-i})) = \frac{1}{2}c(R_i + R_{-i}) = \frac{1}{2}c(\frac{1}{2}I\Omega_i\Omega_{-i} + \frac{1}{2}I\Omega_i\Omega_{-i}) = \frac{1}{2}c(I\Omega_i\Omega_{-i})$.

2.3.6 Proof 6

$P(R_i, R_{-i})$ **is equal to** $\frac{1}{4}p[\frac{1}{2}I\Omega_i\Omega_{-i}(2 + \Omega_i + \Omega_{-i}) + \frac{1}{2}I\Omega_i\Omega_{-i}(2 - \Omega_i - \Omega_{-i})]$.

$P(R_i, R_{-i}) = P(R_i(\Omega_i, \Omega_{-i}), R_{-i}(\Omega_i, \Omega_{-i})) = \frac{1}{4}[pR_i + pR_i\Omega_i + pR_{-i}(1 - \Omega_i) + pR_{-i}(1 - \Omega_{-i}) + pR_i + pR_i\Omega_{-i}] = \frac{1}{4}p[R_i(2 + \Omega_i + \Omega_{-i}) + R_{-i}(2 - \Omega_i - \Omega_{-i})] = \frac{1}{4}p[\frac{1}{2}I\Omega_i\Omega_{-i}(2 + \Omega_i + \Omega_{-i}) + \frac{1}{2}I\Omega_i\Omega_{-i}(2 - \Omega_i - \Omega_{-i})]$.

2.3.7 Proof 7

If $\Omega_i = 1$ for all $i = 1, 2$, then $P(R_i, R_{-i}) = \frac{1}{2}pI$.

$\frac{1}{4}p[\frac{1}{2}I\Omega_i\Omega_{-i}(2+\Omega_i+\Omega_{-i})+\frac{1}{2}I\Omega_i\Omega_{-i}(2-\Omega_i-\Omega_{-i})] = \frac{1}{4}p[\frac{1}{2}I*1*1*(2+1+1)+\frac{1}{2}I*1*1*(2-1-1)] = \frac{1}{4}p(\frac{1}{2}I*1*4+\frac{1}{2}I*1*0) = \frac{1}{4}p(\frac{4}{2}I) = \frac{1}{2}pI.$

2.3.8 Proof 8

If $\Omega_i = 0$ for all $i = 1, 2$, then $P(R_i, R_{-i}) = 0$.

$\frac{1}{4}p[\frac{1}{2}I\Omega_i\Omega_{-i}(2+\Omega_i+\Omega_{-i})+\frac{1}{2}I\Omega_i\Omega_{-i}(2-\Omega_i-\Omega_{-i})] = \frac{1}{4}p[\frac{1}{2}I*0*0*(2+0+0)+\frac{1}{2}I*0*0*(2-0-0)] = \frac{1}{4}p(\frac{1}{2}I*0*2+\frac{1}{2}I*0*2) = 0+0 = 0.$

2.3.9 Proof 9

K_i $\max_{\Omega_i}$ $SW_i(\Omega_i) = C + P - DWL_i$ leads to $\Omega^*_{SW_i} = \frac{(c+p)I}{d_{ii}}\Omega_{-i}$.

1. $SW_i(\Omega_i) = C+P-DWL_i$ can be rewritten as $SW_i(\Omega_i) = \frac{1}{2}cI\Omega_i\Omega_{-i}+\frac{1}{4}p[\frac{1}{2}I\Omega_i\Omega_{-i}(2+\Omega_i+\Omega_{-i})+\frac{1}{2}I\Omega_i\Omega_{-i}(2-\Omega_i-\Omega_{-i})] - \frac{1}{2}\left[\frac{(d^C_{ii}+d^P_{ii})\Omega_i^2+(d^C_{i-i}+d^P_{i-i})\Omega_{-i}^2}{2}\right]$.

2. By maximizing this latter expression with respect to Ω_i, it is possible to obtain the following FOC: $-\frac{(d^C_{ii}+d^P_{ii})\Omega+(-cI-pI)\Omega_{-i}}{2} = 0$.

3. By multiplying both sides by -2 I obtain $(d^C_{ii}+d^P_{ii})\Omega_i + (-cI-pI)\Omega_{-i}$.

4. By rearranging this latter, I obtain $(d^C_{ii}+d^P_{ii})\Omega_i = -(-cI-pI)\Omega_{-i}$.

5. Thus, $(d^C_{ii}+d^P_{ii})\Omega_i = (cI+pI)\Omega_{-i}$.

6. Hence, $(d^C_{ii}+d^P_{ii})\Omega_i = (c+p)I\Omega_{-i}$

7. Finally, $\Omega^*_{SW_i} = \frac{(c+p)I}{d^C_{ii}+d^P_{ii}}\Omega_{-i} = \frac{(c+p)I}{d_{ii}}\Omega_{-i}$.

2.3.10 Proof 10

Comparative statics of $\Omega^*_{SW_i} = \frac{(c+p)I}{d^C_{ii}+d^P_{ii}}\Omega_{-i} = \frac{(c+p)I}{d_{ii}}\Omega_{-i}$ **on its parameters**.

1. $\frac{\partial\Omega^*_{SW_i}}{\partial c} = \frac{I}{d_{ii}}\Omega_{-i} \geq 0.$

2. $\frac{\partial\Omega^*_{SW_i}}{\partial p} = \frac{I}{d_{ii}}\Omega_{-i} \geq 0.$

3. $\frac{\partial\Omega^*_{SW_i}}{\partial I} = \frac{c+p}{d_{ii}}\Omega_{-i} \geq 0.$

4. $\frac{\partial\Omega^*_{SW_i}}{\partial d^C_{ii}} = -\frac{(c+p)I}{(d^C_{ii}+d^P_{ii})^2}\Omega_{-i} \leq 0.$

5. $\frac{\partial\Omega^*_{SW_i}}{\partial d^P_{ii}} = -\frac{(c+p)I}{(d^C_{ii}+d^P_{ii})^2}\Omega_{-i} \leq 0.$

6. $\frac{\partial\Omega^*_{SW_i}}{\partial\Omega_{-i}} = \frac{(c+p)I}{d_{ii}} \geq 0.$ A strengthening (weakening) of patent protection abroad leads to a strengthening (weakening) of patent protection nationally.

7. if $\Omega_{-i} = 1$, then $0 \leq \Omega^*_{SW_i} = \frac{(c+p)I}{d_{ii}} \leq 1$ which, in a repeated interaction, would lead to $\Omega_{-i} = \left[\frac{(c+p)I}{d_{-i-i}}\right]^2 \leq \frac{(c+p)I}{d_{ii}} \leq 1$, until the only two possible global equilibrium points are either $\Omega^*_{SW_i} = \Omega^*_{SW_{-i}} = 0$ if $0 \leq \frac{(c+p)I}{d_{ii}} < 1$ or $\Omega^*_{SW_i} = \Omega^*_{SW_{-i}} = 1$ if $\frac{(c+p)I}{d_{ii}} = 1$.

2.3.11 Proof 11

$\mathbf{K}_i$ $\max\limits_{\Omega_i}$ $W_{K_i} = T_i - C_i$ **leads to** $\Omega^*_{W_{K_i}} = t^m[R_i\pi^m - \pi^{cH}(R_i + R_{-i})] - t^c\pi^{cL}(R_i + R_{-i})$.

1. $W_{K_i} = T_i - C_i$ can be rewritten as $W_{K_i}(\Omega_i) = T_i(\Omega_i) - C_i(\Omega_i) = t^m R_i\pi^m\Omega_i + t^m R_i\pi^{cH}(1-\Omega_i) + t^c R_i\pi^{cL}(1-\Omega_i) + t^m R_{-i}\pi^{cH}(1-\Omega_i) + t^c R_{-i}\pi^{cL}(1-\Omega_i) - \frac{1}{2}\Omega_i^2 = t^m[R_i\pi^m\Omega_i + (R_i + R_{-i})\pi^{cH}(1-\Omega_i)] + t^c(R_i + R_{-i})\pi^{cL}(1-\Omega_i) - \frac{1}{2}\Omega_i^2.$

2. By maximizing this latter expression with respect to Ω, it is possible to obtain the following FOC: $t^m[R_i\pi^m - (R_i + R_{-i})\pi^{cH}] - t^c(R_i + R_{-i})\pi^{cL} - \Omega_i = 0.$

3. By rearranging this latter, I obtain $\Omega^*_{W_{K_i}} = t^m[R_i\pi^m - (R_i + R_{-i})\pi^{cH}] - t^c(R_i + R_{-i})\pi^{cL}$.

2.3.12 Proof 12

Comparative statics of $\Omega^*_{W_{K_i}} = t^m[R_i\pi^m - (R_i + R_{-i})\pi^{cH}] - t^c(R_i + R_{-i})\pi^{cL}$ **on its parameters**.

1. $\frac{\partial\Omega^*_{W_{K_i}}}{\partial t^m} = R_i\pi^m - (R_i + R_{-i})\pi^{cH} \geq 0$ if and only if $R_i \geq z = \frac{\pi^{cH}}{\pi^m}(R_i + R_{-i})$.

2. $\frac{\partial\Omega^*_{W_{K_i}}}{\partial R_i} = t^m(\pi^m - \pi^{cH}) - t^c\pi^{cL} \lesseqgtr 0$ depending on the values of the underlying parameters.

3. $\frac{\partial\Omega^*_{W_{K_i}}}{\partial R_{-i}} = -t^m\pi^{cH} - t^c\pi^{cL} \leq 0$.

4. $\frac{\partial\Omega^*_{W_{K_i}}}{\partial t^c} = -(R_i + R_{-i})\pi^{cL} \leq 0$.

5. $\frac{\partial\Omega^*_{W_{K_i}}}{\partial \pi^m} = R_i t^m \geq 0$.

6. $\frac{\partial\Omega^*_{W_{K_i}}}{\partial \pi^{cH}} = -(R_i + R_{-i})t^m \leq 0$.

7. $\frac{\partial\Omega^*_{W_{K_i}}}{\partial \pi^{cL}} = -(R_i + R_{-i})t^c \leq 0$.

2.3.13 Proof 13

Prove that $\Omega^*_{W_{K_1}} > \Omega^*_{W_{K_2}}$ **if** $R_1 > R_2$**.**

Since $\Omega^*_{W_{K_1}} = t^m[R_1\pi^m - \pi^{cH}(R_1 + R_2)] - t^c\pi^{cL}(R_1 + R_2)$ and $\Omega^*_{W_{K_1}} = t^m[R_2\pi^m - \pi^{cH}(R_1 + R_2)] - t^c\pi^{cL}(R_1 + R_2)$, then:

1. $t^m[R_1\pi^m - \pi^{cH}(R_1+R_2)] - t^c\pi^{cL}(R_1+R_2) > t^m[R_2\pi^m - \pi^{cH}(R_1+R_2)] - t^c\pi^{cL}(R_1+R_2)$.

2. By adding $t^c\pi^{cL}(R_1+R_2)$, I obtain $t^m[R_1\pi^m - \pi^{cH}(R_1+R_2)] > t^m[R_2\pi^m - \pi^{cH}(R_1+R_2)]$.

3. By adding $t^m\pi^{cH}(R_1+R_2)$, I obtain $t^m R_1\pi^m > t^m R_2\pi^m$.

4. By dividing $t^m\pi^m$, I obtain $R_1 > R_2$.

Prove that $\Omega^*_{W_K} \geq \Omega^*_{W_{K_i}}$.

1. $R[t^m(\pi^m - \pi^{cH}) - t^c\pi^{cL}] \geq t^m[R_i\pi^m - \pi^{cH}(R_i+R_{-i})] - t^c\pi^{cL}(R_i+R_{-i})$.

2. The one-country world maybe considered as the two-country world that had unified. Hence $R = R_i + R_{-i}$.

3. By substituting $R = R_i + R_{-i}$, I obtain $(R_i+R_{-i})[t^m(\pi^m - \pi^{cH}) - t^c\pi^{cL}] \geq t^m[R_i\pi^m - \pi^{cH}(R_i+R_{-i})] - t^c\pi^{cL}(R_i+R_{-i})$.

4. This leads to $t^m(R_i+R_{-i})\pi^m \geq t^m R_i\pi^m$.

5. Hence, by diving by $t^m\pi^m$, I obtain $R_i + R_{-i} \geq R_i$.

6. By substracting R_i, the result is $R_{-i} \geq 0$ which is true by the definition of the model.

2.3.14 Proof 14

$\mathbf{K}_F \max\limits_{\Omega_W}$ $SW_F = C + P - DWL_F$ **leads to** $\Omega^*_{SW_{F_W}} =$.

1. $SW_F = C+P-DWL_F$ can be rewritten as $SW_F(\Omega_W) = C(R_F(\Omega_F,\Omega_W), R_W(\Omega_F,\Omega_W)) + P(R_F(\Omega_F,\Omega_W), R_W(\Omega_F,\Omega_W)) - DWL_F(\Omega_W) = \frac{1}{2}cI\Omega_F\Omega_W + \frac{1}{4}p[\frac{1}{2}I\Omega_F\Omega_W(2+\Omega_F+\Omega_W) + \frac{1}{2}I\Omega_F\Omega_W(2-\Omega_F-\Omega_W)] - \frac{1}{2}\left[\frac{(d^C_{FF}+d^P_{FF})\Omega_F^2+(d^C_{FW}+d^P_{FW})\Omega_W^2}{2}\right]$

2. By maximizing this latter expression with respect to Ω_W, it is possible to obtain the following FOC: $-\frac{(d^C_{FW}+d^P_{FW})\Omega_W+(-cI-pI)\Omega_F}{2} = 0$.

3. By multiplying both sides by -2 I obtain $(d^C_{FW} + d^P_{FW})\Omega_W + (-cI - pI)\Omega_F$.

4. By rearranging this latter, I obtain $(d^C_{FW} + d^P_{FW})\Omega_W = -(-cI - pI)\Omega_F$.

5. Thus, $(d^C_{FW} + d^P_{FW})\Omega = (cI + pI)\Omega_W$.

6. Hence, $(d^C_{FW} + d^P_{FW})\Omega = (c + p)I\Omega_W$

7. Finally, $\Omega^*_{SW_{F_K}} = \frac{(c+p)I}{d^C_{FW}+d^P_{FW}}\Omega_P = \frac{(c+p)I}{d_{FW}}\Omega_F$.

2.3.15 Proof 15

$\mathbf{K}_F$ $\max\limits_{\Omega_W}$ $W_{F_W} = T_F - C_F$ **leads to** $\Omega^*_{W_{F_W}} = t^m_F[R_F\pi^m_{FW} - \pi^{cH}_{FW}(R_F + R_W)] - t^c_F\pi^{cL}_{FW}(R_F + R_W)$.

1. $W_{F_W} = T_F - C_F$ can be rewritten as $W_{F_W}(\Omega_W) = T_F(\Omega_W) - C_F(\Omega_W) = t^m_F R_F \pi^m_{FW}\Omega_W + t^m_F R_F \pi^{cH}_{FW}(1 - \Omega_W) + t^c_F R_F \pi^{cL}_{FW}(1 - \Omega_W) + t^m_F R_W \pi^{cH}_{FW}(1 - \Omega_W) + t^c_F R_W \pi^{cL}_{FW}(1 - \Omega_W) - \frac{1}{2}\Omega^2_W = t^m_F[R_F\pi^m_{FW}\Omega_W + (R_W + R_F)\pi^{cH}_{FW}(1 - \Omega_W)] + t^c_F(R_F + R_W)\pi^{cL}_{FW}(1 - \Omega_W) - \frac{1}{2}\Omega^2_W$.

2. By maximizing this latter expression with respect to Ω_W, it is possible to obtain the following FOC: $t^m_F[R_F\pi^m_{FW} - (R_F + R_W)\pi^{cH}_{FW}] - t^c_F(R_F + R_W)\pi^{cL}_{FW} - \Omega_W = 0$.

3. By rearranging this latter, I obtain $\Omega^*_{W_{F_W}} = t^m_F[R_F\pi^m_{FW} - \pi^{cH}_{FW}(R_F + R_W)] - t^c_F\pi^{cL}_{FW}(R_F + R_W)$.

Chapter 3

The fiscal incentives of governments to protect intellectual assets - Empirical Tests

3.1 Abstract

Chapter 3 is dedicated to test the main propositions related to the fiscal incentives to protect intellectual assets of Chapter 2. I find that the tax rate on profits is a statistically significant covariate of the strength of patent protection, even when controlling for all other relevant variables, thus suggesting that governments might have a fiscal incentive to strengthen patent protection and to sign intellectual property treaties.

3.2 Introduction

The objective of Chapter 3 is to present some evidence of the predictions of the model formulated in Chapter 2. I am interested in testing the propositions regarding the fiscal incentives of patent protection, thus leaving the benchmark framework of politicians maximizing social welfare untested. To test the main propositions of Chapter 2, I provide evidence using data and regression analysis when available. When data is not available, qualitative analysis such as brief case studies are put forward to test the hypothesis. In general, special care is taken in controlling for other alternative explanations of the determinants of the strength of patent protection.

3.3 Proposition 2

Proposition 2 states the following: " *With politicians maximizing the net tax revenue in a one-country world, the strength of patent protection increases as the EATR on highly profitable activities increases. This effect is stronger, the higher the private expenditure in R&D, the higher the rent that can be extracted from protected inventions and the lower the profitability of highly profitable competitive profits on unprotected inventions. Thus, the effect of the private R&D expenditure on the strength of patent protection is not direct but it is mediated by the fiscal interests of politicians.*".

Since Proposition 2 deals with the case of a one-country world, it is necessary to test it controlling for the movement of factors of production and final products between countries. The Middle Ages and the modern era until the First Industrial Revolution appear as a good case study since that historical period was characterized by low levels of international trade, foreign investments and migrations in comparison to the world that started with industrial capitalism. On the contrary, the historical period that starts with the First Industrial Revolution and the rise of industrial capitalism around 1760 cannot be used as a valid case study for Proposition 2 since the economic and political transformations that the world underwent in that period makes it necessary to relax the assumption of a one-country world. In fact, with the rise of modern industry, the weakening and final abolition of guilds, the intensification of international trade and migrations of wage labour, politicians governing industrial states started to take into consideration what occurred abroad before deciding their preferred patent policy. The propositions elaborated in the two-country model of Chapter 2 try to extend the analysis valid exclusively until 1760 to the new world that emerged with the First Industrial Revolution.

3.3.1 The Middle Ages

It is a well-known fact in economic history that patent protection was used by European monarchs in the Middle Ages as a way to tax their subjects. Until at least the modern period that started with the discovery of the Americas, feudal states were characterized by low fiscal capacity and lack of both legal and military means to systematically tax their subjects. It is only in the modern era that states started to exercise a complete fiscal control on all economic activities performed under their jurisdiction. In the absence of the necessary *monopoly of violence* (Weber) to tax all economic activities and extract the stream of resources to finance the state, feudal monarchs needed to come to agreements with local lords and landowners. Thus, *letters patent* were used as a way through which monarchs tried to raise fiscal revenue. Letters patent were a legal instrument in the form of a published written order granting privileges such as an office, right, monopoly, title, or status to favored persons. The functioning of letters patent was fairly simple and feudal monarchs would use them to concentrate revenue in the few hands of privileged lords in order to be able to less costly tax it. Hence, in the Middle Ages clearly, the objective was not to protect technical knowledge and spur inventivity but to raise fiscal revenue. More precisely, lords obtaining these privileges were able to concentrate revenue in their hands because of the economic rents generated by the monopolization of commodities such as salt. In exchange for these privileges, lords had to pay a share of their total revenue to the monarch. The system can be thought as a private deal between monarchs and lords to their mutual benefit. This *de facto outsourcing of fiscal capacity* was necessary to monarchs because these were still unable to monopolize the violence necessary to tax all economic activities under their jurisdiction. The political alliance between monarchs and lords was a fiscal deal in which the share going to the former of the total revenue of the latter can be considered a *tax rate*. Since letters patent often were used to concede monopolies on commercial activities, this tax rate was a *de facto corporate tax rate ante litteram* and can be represented as the parameter t^m of Chapter 2. The higher the share that monarchs were able to gain from their private deals with privileged lords, the stronger their incentive to concede these same privileges. It is an historical fact that where monarchs were so politically powerful to impose on privileged lords the payment of large proportions of the revenue coming from letters of patent, the monopolization of the economy was stronger. Proposition 2 is therefore consistent with this correlation between the political strength of monarchs (to be thought of as a *proxy* for the unavailable data of the proportion of revenue that monarchs were able to extract from privileged lords) and the monopolization of the economy caused by the number and stringency of letters patent.

Hence, I claim that the case of letters patent in the Middle Ages does not falsify proposition 2.

3.3.2 The Modern Era: 1624 - 1760

In the modern era, letters patent were not an instrument to competitively and privately tax economic resources since modern states had already acquired the fiscal capacity to tax these resources directly. Nevertheless, I claim that letters patent were still used as a way to indirectly increase the fiscal revenue and this despite the fact that they could be used only to protect inventions rather than to give monopolies to favored lords who would pay for them. For example, in England the idea that letters patent had to be used to protect inventions rather than to concede privileges to favored persons was sanctioned by the Statute of Monopolies passed on 25 May 1624. The Statute of Monopolies was the result of the political struggle between the Crown and Parliament, in which this latter prevailed and was able to curtail the power of the monarch. Nevertheless, although the Statute of Monopolies represents a paradigmatic shift in the history of patent law, the monopolization of inventions still allowed the monarch to less costly tax the monopolized commercialization of those inventions. Hence, even if monarchs had to find other means to tax the activities not covered by letters patent, these latter still offered an easy way to raise fiscal revenue from the monopolization of inventions. Proposition 2 is consistent with the fact that, as in the Middle Ages, the monopolization of inventions was positively correlated with the power of the Crown. Hence, although the new declared objective of letters patent in the modern era was the protection of inventors and the incentivization of the ingenuity of the country, modern patent laws were still used by monarchs to raise fiscal revenue from inventors and the more so the higher was t^m.

3.3.3 The literature

Proposition 2 is in line with previous research showing that the fiscal capacity of the state is positively correlated with the protection of property rights [Besley and Persson (2009)]. The main difference with this literature is that, in the theoretical model presented in Chapter 2, the fiscal and legal capacities are not complements driven by other variables but the first is one direct *determinant* of the second. In other words, a *causal* channel is identified from the tax system to the protection of intellectual assets,

showing that the élite might have a fiscal incentive to introduce patent protection. In theory, the opposite causal channel from the protection of intellectual assets to the corporate tax rate could also exist but, at this stage, by assuming an exogenous tax rate, only the first causal channel is identified. Further historical evidence might shed light on the existence or not of the potential complementarity between the stringency of letters patent and the corporate tax rate extracted from monopolies. If the historical evidence provides proofs that the monopolization of the economy had an effect on the share of revenue extracted by monarchs, then the theoretical model should be modified accordingly and allow for the endogeneity of the corporate tax rate.
Another interesting fact that can be deduced logically from the theoretical model presented in Chapter 2 and the preceding empirical literature on related subjects is the consequence of the following well-known stylized facts: 1) as the GDP per capita of a country increases then its R&D expenditure per capita increases too, 2) as the R&D expenditure per capita increases, the strength of patent protection increases too [Ginarte and Park (1997)]; the two variables of this last correlation (or causation for several authors) are also positively correlated with the inventiveness of the economy, 3) as the GDP per capita of a country increases, then its fiscal capacity (the tax revenue as a percentage of GDP) increases too [Besley and Persson (2009)], 4) as the fiscal capacity of the state increases, then the tax revenue becomes increasingly more reliant on income and profits taxes and less on tariffs [Baunsgaard and Keen (2010)], 5) the GDP per capita is positively correlated with political freedom and democracy [Barro (1996)], 6) political freedom and democracy is positively correlated with the respect of intellectual property [Lerner (2002)].

First of all, by combininig stylized facts 1, 2 and 5, it is possible to deduce the two following well-known relations:

***Relation 1* - GDP per capita** $\uparrow (\downarrow) \rightarrow$**R&D expenditure per capita** $\uparrow (\downarrow) \rightarrow \boldsymbol{\Omega} \uparrow (\downarrow)$

,

***Relation 2* - GDP per capita** $\uparrow (\downarrow) \rightarrow$**democracy** $\uparrow (\downarrow) \rightarrow \boldsymbol{\Omega} \uparrow (\downarrow)$.

Whether and in which direction the strength of patent protection affects the GDP per capita or the R&D expenditure per capita is empirically controversial and hence I omit this possibility.

Second, the combination of stylized facts 3, 4 and 5 with Proposition 2 leads to the two following relations:

***Relation 3* - GDP per capita** $\uparrow (\downarrow) \rightarrow$**fiscal capacity** $\uparrow (\downarrow) \rightarrow \mathbf{t} \uparrow (\downarrow) \rightarrow \boldsymbol{\Omega} \uparrow (\downarrow)$.

***Relation 4* - Democracy** $\uparrow (\downarrow) \rightarrow$**fiscal capacity** $\uparrow (\downarrow) \rightarrow \mathbf{t} \uparrow (\downarrow) \rightarrow \boldsymbol{\Omega} \uparrow (\downarrow)$.

These two last relations might provide the following insights: 1) richer countries might set stronger patent protection than poorer ones not (only) because of the effect of the R&D expenditure per capita or the effect of democracy but (also) due to the effect of the corporate tax rate as indicated in Relation 3, 2) more democratic countries might set stronger patent protection than less democratic ones due to the effect of the corporate tax rate as indicated in Relation 4.

In general, it is possible that controlling for the corporate tax rate when regressing the strength of patent protection on democracy and R&D expenditure per capita makes the effect of the last two variables insignificant. It is therefore possible to state the following:

Corollary of Proposition 2

With politicians maximizing the net tax revenue, the strength of patent protection is higher in richer countries not (only) because these latter spend more intensively in R&D or because they are more democratic and respectful of private property but (also) because they rely more heavily on higher corporate tax rates to finance the state.

3.4 Proposition 5

The first part of Proposition 5 states the following: "*With politicians noncooperatively maximizing the national net tax revenue in a two-country world, the strength of national patent protection increases (decreases) as the EATR on highly profitable activities increases if and only if the national expenditure in R&D is higher than a critical threshold. (...)*".

Contrary to the test of Proposition 2, I will use here regression analysis. In particular I am interested in the following regression:

$$PR = constant + \beta_1 t + \beta_2 Rt + controls + error \tag{3.1}$$

in which PR is the strength of patent protection, t is the EATR of highly profitable activities, R is the total national R&D expenditure over GDP and the controls are the GDP per capita, the political institutions, the secondary educational attainment and whether the country is open or not to international trade. Since Proposition 4 does not only state that the EATR of highly profitable activities is correlated with the strength of patent protection but also that this correlation interacts with the national private expenditure in R&D, it is necessary to control for the interaction term Rt when regressing PR on t.

In a second stage, the strength of patent protection will be decomposed to verify whether the correlation with the corporate tax rate is verified for different ways of measuring how strongly innovations are protected. Also, a distinction will be drawn between national public, national private and foreign private expenditure in R&D over GDP.

3.4.1 Data

For this analysis, I use the Ginarte and Park database which collects panel data on the strength of patent protection for 122 countries, every 5 years, from 1960 until 2010. This particular dataset has been used by others in the literature such as Maskus (2000); Grossman and Lai (2004); Bessen and Meurer (2008) due the numerous of questions that can be raised when studying the determinants of the strength of patent protection. As already mentioned, a decomposition of the Ginarte and Park database will also be used to test the correlation under study between the strength of patent protection and the corporate tax rate. More precisely, when using the decomposition of the Ginarte and Park database, the following distinct measures of how strongly inventions are protected will be under scrutiny:

- *coverage*: also called *breadth*, this category measures the strength of patent protection by whether the seven following subcategories are patentable or not: 1) pharmaceuticals, 2) chemicals, 3) food, 4) plant and animal varieties, 5) surgical products, 6) microorganisms, 7) utility models. To be precise, the number assigned to this category by Ginarte and Park represents the following fraction:

$$\frac{\text{number of the seven subcategories which are patentable or not declared unpatentable}}{7}$$

To verify whether the subcategories are patentable or not, the Ginarte and Park database is based on the scrutiny of the most recent patent law for each country.

- *membership in international patent agreements*: this category measures the willingness of countries to respect the principle of *national treatment* which asserts the nondiscriminatory treatment of foreign inventions. To provide a measure of the respect of the principle of national treatment, the Ginarte and Park database concentrates on the three following international patent treaties: 1) the Paris Convention of 1883 (and subsequent revisions) imposing the principle of national treatment on foreign inventions to all signatory countries, 2) the Patent Cooperation Treaty (PCT) of 1970 harmonizing and simplifying administrative procedures by allowing, for example, the filing of a single patent application that is effective in any of the member countries, 3) the International Convention for the Protection of New Varieties of Plants (UPOV) of 1961 giving plant breeders a protection similar to a patent and harmonizing standards across signatory countries. To be precise, the number assigned to this category by Ginarte and Park represents the following fraction:

$$\frac{\text{number of signed international patent treaties}}{3}$$

- *provisions for loss of protection*: since inventors holding a patent can face the risk of being deprived of protection, this category provides a measure of to what extent this risk is high. To calculate this risk, Ginarte and Park study to what extent inventors are protected against losses deriving from the three following cases: 1) *working requirements* indicating whether inventions have to be put into practice or not; for example, a country might impose that a product using the piece of information protected by a patent is manufactured or, if the patent holder is a foreigner, that the product is imported; in general, the absence of working requirements represents an advantage for patentees who might not be financially able to work their inventions or when working is not at that point economically profitable, 2) *compulsory licensing* establishing that patentees share the use of their inventions with third parties, thus reducing the profits that inventors are able to appropriate, primarily when this requirement applies within a short period of time after a patent is granted, 3) revocation of patents that might apply for non-working. To be precise, the number assigned to this category by Ginarte and Park represents the following fraction:[1]

$$\frac{\text{number of protection from potential losses}}{3}$$

- *enforcement mechanisms*: since patent laws and thus also patent laws require adequate mechanisms of enforcement, this category measures whether countries provide the following legal instruments: 1) preliminary injunctions, that is pre-trial actions that require individuals to cease an alleged infringement; this instrument is a way of temporarily protecting patentees from infringement until the final decision is promulgated by the Court, 2) contributory infringement pleadings alluding to actions by third-party participants that do not directly infringe a patent but that indirectly provoke infringement, such as the supplying of inputs

[1]Notice that, for compulsory licensing, Ginarte and Park attribute a value of 1/3 if a country does not impose it within 3 or 4 years from the date of patent grant or application, the time frame stipulated by the Paris Treaty [World Intellectual Property Organization (1988)] and and recommended by the U.S. Chamber of Commerce [Gadbaw-Gwynn (1988)].

essential to the working of a patented invention, 3) burden of proof reversals shifting the burden of proof in processes of patent infringement from the patentee to the alleged infringer; thanks to this enforcement mechanism, if a good is produced by another party, it is assumed that it was manufactured by using the patented invention; since it is difficult for inventors to prove that another party is infringing on their patents, then this shift in burden of proof is a step in favor of their interests against potential infringers. To be precise, the number assigned to this category by Ginarte and Park represents the following fraction:

$$\frac{\text{number of enforcement mechanisms}}{3}$$

- *duration of protection*: also called length, this category measures the strength of patent protection by counting for how many number of years it can last; since countries differ in defining when the patent term starts, either from the date of application or the date of grant, Ginarte and Park established the two following measures:

$$\frac{\text{number of years of protection from the date of the application (grant)}}{20\ (17)}$$

The World Bank dataset on the GDP per capita from 1960 until 2015 accounts for the gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in costant U.S. dollars.

The UNESCO dataset on the expenditure in R&D as a share of the national GDP from 1980 until 2016 accounts for the current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. In general, R&D covers basic research, applied research, and experimental development. As already mentioned, I also use a decomposition of this dataset in which it is possible to distinguish between national public, national private and foreign private expenditures.

The Political Rights Index from Freedom House ranging from 1972 until 2016 includes the freedom to vote and run for office. The original index varies so that lower numbers reflect greater liberties. Here the index is converted to a scale from 10 (least free) to 70 (most free). In this way, positive coefficients will be associated with positive influences on patent rights.

The Opennes Index represents the value of trade as a percentage of GDP such as reported in the World Bank database from 1960 until 2015.

The Secondary Education Attainment Index from 1950 until 2010 is taken from Barro and Lee's database.

The Oxford University Center for Business Taxation (CBT) dataset on corporate income tax rates from 1979 until 2017 accounts for the statutory and effective marginal rates on the profits of corporations and on capital gains, whether realized or not, on land, securities, and other assets. The statutory corporate tax rates are of two types: 1) the top corporate tax rate at central government level, excluding eventual surcharges, 2) the total statutory corporate tax rate, which is the arithmetical average of all the top statutory tax rates on corporate income that exist in a given country, in a given year, including surcharges and local taxes.

An important point is whether this dataset provides a measure of what has been defined as the Effective Average Tax Rate (EATR) on highly profitable activities in Chapter 2. Here, I follow Griffith, Miller and O'Connell (2014) that use the total statutory corporate tax rate as a proxy for the EATR on highly profitable activities. This is due to the fact that: "*returns from intellectual property are expected to be sufficiently high that deductions such as capital allowances are relatively unimportant, so that the effective tax rate faced by the firm is approximately the statutory tax rate*"[Griffith, Miller and O'Connell (2014)]. For a proof of the fact that both the effective marginal and average tax rate asymptote to the statutory tax rate as profitability increases, please refer to Figure 1 in Devereux and Griffith (2003). The discussion of whether the total statutory corporate tax rate approximates the EATR on highly profitable activities is also connected to the question of IP box regimes. These latter are fiscal schemes set in some countries to tax patent revenues at a lower rate than other commercial revenues. In fact, starting from the early 1970s, some developed countries of the OECD introduced the first tax schemes to incentivize the private R&D by deducing part of the corporate income deriving from patents and by taxing it a lower preferential rate. Again, as explained in Griffith, Miller and O'Connell (2014), if the asset is particularly profitable, then capital allowances, such as the IP box regimes, are relatively unimportant so that the total statutory corporate tax rate is a good proxy for the EATR on income of inventive firms.

The names of the variables used in the regressions are as follow: PR is the strength of patent protection, R is the R&D expenditure over the GDP, E is the level of secondary education attainment, P is the political rights index, O is the openness index, t is the EATR on highly profitable activities and Rt is the interaction variable between the R&D expenditure over the GDP and the EATR on highly profitable activities.

3.4.2 Tests

First of all, it is necessary to decide whether the estimation of equation (1) should be performed by using Ordinary Least Squares (OLS) or other techniques. To make this decision, I run the Breusch-Pagan test for the presence of heteroskedasticity and I find that the nul hypothesis of constant variance is to be rejected, as shown in Figure 1 in the Appendix. The result shows that the OLS is not appropriate and that the Generalized Least Square (GLS) estimation method is to be preferred to take into account the heteroskedasticity of the error terms.

Second, it is necessary to decide whether a random effects or a fixed effects GLS is to be used. To choose whether the former or the latter estimation technique is to be preferred, I run the Hausman test and I find that the nul hypothesis of non-systematic difference in coefficients between the random effects and the fixed effects models is rejected, as shown in Figure 2 in the Appendix.

The results show that the GLS with fixed effects is the appropriate model for this dataset. To double check this conclusion, I run also the Mundlak test that rejects as well the nul hypothesis of non-systematic difference in coefficients between the random effects and the fixed effects models is rejected, as shown in Figure 3. The results of the Hausman and Mundlak tests indicate that the idiosyncratic errors are correlated with the two coefficients of interests β_1 and β_2 of equation (1).

3.4.3 Results

Baseline results

Before running a GLS with fixed effects to estimate the two coefficients of interest β_1 and β_2 of equation (1), I am interested in showing that the correlation between the strength of patent protection and the EATR on highly profitable activities is hidden in the data. In fact, a simple scatterplot showing the correlation between PR and t without control variables appears negative, as shown in Figure 4 in the Appendix.

It is certainly incorrect to deduce from Figure 4 that the correlation between the two variables of interest is negative, since Proposition 5 moves from a *ceteris paribus* assumption. It is therefore necessary to control for all differences among countries that might affect the strength of patent protection and to make such distinct cases such as Brazil in 1995 and Japan in 2010 comparable. Figure 5 in the Appendix shows that the correlation between PR and t changes sign (from negative to slightly positive) when we move to a *ceteris paribus* scenario.

I run a GLS with fixed effects to estimate the two coefficients of interest β_1 and β_2 of equation (1). When combining all the available data for this baseline regression, the balanced panel dataset is constituted by 182 observations for 43 countries each 5 year from 1980 until 2010. Figure 4 in the Appendix shows the results.

The first column estimates the coefficients of the control variables Y, R, E, P and O on PR. This is the classical analysis of the effects of relevant variables that the literature has already shown to be correlated with the strength of patent protection. In line with Ginarte and Park (1997), I find that the GDP per capita, the R&D expenditure over GDP, the level of secondary education attainment and the openness index are all positively correlated with the strength of patent protection at a 99.9% confidence interval (p-value < 0.001).

The second column estimates the same variables as before plus the EATR on highly profitable activities that is, as already explained, the top statutory marginal corporate tax rate. Unsurprinsingly, this latter variable is not statistically significant in the explanation of the strength of patent protection. On the contrary, it appears that introducing t in the regression reduces the significance of Y and R, from the p-value < 0.001 to p-value < 0.01, although the significance of E and O is unaffected. Hence, it seems that introducing t in the regression creates a mispecification and that this variable should be dropped.

Nevertheless, the third column estimates equation (1) that, in line with the explanation provided by the theoretical model in Proposition 4 of Chapter 2 and in contrast with respect to the previous literature, shows the correlation between the EATR on highly profitable activities and the strength of patent protection at different levels of R&D expenditure over GDP. More precisely: 1) when controlling for Rt, t appears to be negatively correlated with PR at a 99.9% confidence interval (p-value < 0.001), 2) when controlling for t, Rt appears to be positively correlated with PR at a 99.9% confidence interval (p-value < 0.001), 3) Y and E are still positively correlated at a 99.9% confidence interval (p-value < 0.001), 4) R is not significant anymore.

This result suggests three main points.

First of all, contrary to the previous literature, the R&D expenditure over GDP is not a predictor of the strength of patent protection when the effect of the EATR on highly profitable activities is accounted for. This indicates that previous work showing the existence of a positive correlation between the R&D expenditure over GDP and the strength of patent protection might have been driven by the hidden effect of the EATR on highly profitable activities. The R&D expenditure over GDP has an effect on the strength of patent protection only in interaction with the EATR on highly profitable activities and when this latter is controlled for. Therefore, as shown in Proposition 4, the R&D expenditure over GDP is an important element in the determination of the strength of patent protection only because of the *conflicting fiscal incentives* it generates, that is, the fiscal incentive to strengthen patent protection at high level of R&D and the fiscal incentive to weaken it at low levels of R&D. This result is in contrast with the usually suggested idea in the previous literature that governments have an incentive to protect inventors when their investments in R&D is sufficiently high and that there is a threshold of R&D expenditure above which governments act to protect them. If this result is not falsified in following analysis, it might show that an R&D threshold actually exists but for fiscal reasons and not to protect inventors *per se*. Hence, the study of the strength of patent protection needs an attentive scrutiny of how governments use it to finance their fiscal revenue rather than to simply protect investors financing the R&D.

Second, a comparison of column 2 and column 3 of Figure 4 shows that the EATR on highly profitable activities appears to be uncorrelated with the strength of patent protection if its interaction with the expenditure in R&D over GDP is not appropriately considered. The insignificance of t in column 2 hides its significance at different levels of R&D expenditure over GDP.

Third, the correlation of the EATR on highly profitable activities and the strength of patent protection significantly changes sign with 95% confidence interval from negative to positive. This change of sign is produced at sufficiently high expenditure in R&D over GDP, thus not falsifying Proposition 4 of Chapter 2. It is possible to see a graphical representation of this change of sign in Figure 5 in the Appendix.

Last but not least, Y, E and O are confirmed to be important explanatory variables of PR, confirming thus the results of previous work on this matter.

But, how strong is the effect of t on PR? As already explained, this effect depends also on R. The two following examples will provide a measure of the magnitude of the effect under study. In Indonesia, in 2000, we have the following data: R=0.0677% of GDP, t = 30% of high profits and PR= 2.4667. If there had been an increase *ceteris paribus* in the EATR on highly profitable activities such that the new t was 35%, then the estimates shown in Figure suggest that the new PR would be equal to 2.2176, a small but relevant weakening.[2] Hence, due to the particularly low R&D expenditure

[2] Based on the estimates from column 3 of Figure 6, for a country with the level of R&D expenditure over GDP equal to 0.0677%, a 5-point increase in the EATR on highly profitable activities would

over GDP in Indonesia, an increase in t induces a weakening of patent protection.

In Korea, in 2010, we have the following data: R=3.4659% of GDP, $t = 24.2\%$ of high profits and $PR = 4.3333$. If there had been an increase *ceteris paribus* in the EATR on highly profitable activities such that the new t was 29.2% of high profits, then the estimates shown in Figure suggest that the new PR would be equal to 4.5221, a small but relevant strengthening.[3] Hence, due to the particularly high R&D expenditure over GDP in Korea, an increase in t induces a strengthening of patent protection.

Other results

First, I regress equation (1) accounting for the decomposition of the index of the strength of patent protection. The objective is to verify whether the baseline results are valid for all measures of the strength of patent protection, namely the coverage, membership in international treaties, loss of protection, enforcement and duration.[4] The results of these five regressions can be looked at in Figure 6 in the Appendix and they can be summarized as follow: 1) t and Rt have the same sign and the same significance level at 99.9% confidence interval (p-value < 0.001) as in the baseline model for coverage and membership, 2) t and Rt have the same sign but a lower significance level at 95% confidence interval (p-value < 0.05) than the baseline model for enforcement, 3) t and Rt are insignificant for loss and duration, 4) the significant change of sign with 95% confidence interval of the correlation between t and the dependent variable occurs only in the case of coverage and membership but not for enforcement, as shown

change PR in 2000 by $5 * (-0.0482 + 0.0248 * 0.0677) = -0.2326$. Thus, the strength of patent protection in Indonesia in 2000 would have decreased from 2.4667 to 2.2176

[3] Based on the estimates from column 3 of Figure 6, for a country with the level of R&D expenditure over GDP equal to 3.4659%, a 5-point increase in the EATR on highly profitable activities would change PR in 2010 by $5*(-0.0482+0.0248*3.4659) = 0.1888$. Thus, the strength of patent protection in Korea in 2010 would have increased from 4.3333 to 4.5221.

[4] The names of the variables in the regressions are respectively coverage, membership, loss, enforcement and duration.

in Figure 7, 8 and 9 respectively.[5]

Second, I regress equation (1) accounting for the decomposition of the R&D expenditure over GDP, namely the one coming from private firms, government, foreign private firms operating in the country, higher education institutions and non-profit organizations.[6] The results of these five regressions can be looked at in Figure 10 in the Appendix and they can be summarized as follow: 1) t has the same sign and the same significance level with 99.9% confidence interval (p-value < 0.001) as in the baseline model when controlling for R_ent (and R_ent_t), 2) t has the same sign and the significance level with 95% confidence interval (p-value < 0.05) for R_gov (and R_gov_t) and for R_for (and R_for_t), 3) the only significant interaction term (with 95% confidence interval and p-value < 0.05) is R_ent_t, 4) in neither case there is a significant change of sign with 95% confidence interval.

Third, I regress equation (1) accounting for the decomposition of both the index of the strength of patent protection and the R&D expenditure over GDP. The results of these twenty-five regressions can be looked at in Figure 11, 12, 13, 14 and 15 in the Appendix and they can be summarized as follow: 1) for coverage t is negative with 99.9% confidence interval (p-value < 0.001) in the case of controlling for R_ent and R_ent_t which is also significant positive (with 99% confidence interval and p-value < 0.01), 2) for membership t is negative with 99% confidence interval (p-value < 0.01) in the case of controlling for R_ent and R_ent_t which is also significant positive (with 99.9% confidence interval and p-value < 0.001), 3) only in this last case there is a significant change of sign with 95% confidence interval, as shown in Figure 16 in the Appendix.

Hence, it appears that when the descompositions of PR and R are taken into account,

[5] Since t and Rt are not significant for loss and duration, it is self-evident that there can be no significant change of sign in these cases.

[6] The names of the variables in the regressions are respectively R_ent, R_gov, R_for, R_high and R_nopr, while the interaction term is respectively R_ent_t, R_gov_t, R_for_t, R_high_t and R_nopr_t.

the fiscal incentives of governments such as they are presented in Chapter 2 may be operating in the case of signing international IP treaties at different levels of private R&D expenditure over GDP. But, at the same time, the econometric tests also shows that, the same mechanism is in place for the patent system as a whole, regardless its specific application, when all the expenditure in R&D in the country and not only the private one is taken into account. To summarize: 1) governments have conflicting fiscal incentives to use patent protection for all inventions regardless the source of their financing, 2) governments have conflicting fiscal incentives to sign international IP treaties only for inventions coming from the private sector. Thus, it appears that, whether inventions are provided by private firms, governments, foreigners or non-profit organizations is important only for the conflicting fiscal incentives of politicians to join international treaties but that, in general, it is the availability of inventions *per se* that affects the conflicting fiscal incentives of governments to protect them through the patent system. Why this might be so needs further investigation but the following intuition might be put forward. In fact, private firms are often able to *directly* patent or to *patent around* inventions provided by the public system through the R&D financed by governments. This means that private firms are often able to extract economic rents from inventions generated by governments. Hence, it is intuitively important that also the public R&D affects the fiscal incentive of governments to strengthen or weaken patent protection. An econometric test that concentrates only on the private R&D risks excluding an important aspect of how economic rents are extracted by private firms and, therefore, of how taxable profits are affected by the decision to strengthen or weaken patent protection and how their relative tax rates affect this decision. At this stage, I claim that all the national R&D and not only the private one should be considered when studying the conflicting fiscal incentives of governments to set patent protection. The fact that the existence of conflictive fiscal incentives of governments in the case of signing international IP treaties exist at different levels of private R&D expenditure over GDP might simply means that, for *membership*, the private R&D is not only a necessary but also a sufficient condition to their existence. However, the statistical significance of these conflictive fiscal interests is higher when we consider all the R&D and not only the private one, as it appears from comparing column 2 of Figure with column of Figure .

3.4.4 Robustness checks

Although the regressions with the descompositions of PR and of R may be considered as a way to check the robustness of the baseline results, I here run three further robustness checks.

The first is to exclude the possibility that the baseline results is driven by a time trend. In fact, patent protection has received a strong push forward at a global level with the signature of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) in 1994. The upward time trend of patent protection might therefore have an effect on the correlation of interest and it is necessary to control for time fixed effect. I re-run the regression of equation (1) with both country and time fixed effect. As shown in Figures and , the baseline results are robust to this new specification of the model.

The second robustness check is to verify whether the baseline result occurs also for fiscal variables other than the EATR on highly profitable actvities. As explained in Chapter 2, the total statutory corporate tax rate and hence the EATR on highly profitable activities affects the strength of patent protection. Here, I run equation (1) twice, the first time by substituting the EATR on highly profitable activities with the EATR on all corporate profits and the second time with the Effective Marginal Tax Rate (EMTR). The first and third columns of Figure in the Appendix show that the significancy of the interaction between EATR and R is not robust to time fixed effects while the second and forth columns show that there is no significant interaction between EMTR and R. Thus, as expected, the correlation between these two last variables and the strength of patent protection appears weak if anything. For a correlation to be taking place in these two last cases, patent protection should increase aggregate profits for the whole economy, which is something that might not systematically happen and that might be too hard for politicians to measure. Thus, in line with Proposition 4, governments might only limiting themselves to strengthen patent protection when the top statutory marginal corporate tax rate increases since patent protection increases by definition the size of profits taxable at that rate. In fact, patent protection, by guaranteeing a high profitability on intellectual property, generates a shift of aggregate profits from being taxed at a lower to being taxed at the top rate. Nevertheless, as explained in Chapter 2, this shift occurs only when the country is sufficiently inventive otherwise the opposite effect is in place due to the loss of profitable activities from copying foreign inventions. Further investigation is needed to elucidate under which circumstances governments use can use patent protection to increase the aggregate profits of the economy and not only the portion of them taxed at the top statutory marginal rate.

The third robustness check is to exclude that the results are driven by the fact that the dependent variable PR (Figure) and membership (Figure) assume categorical values. The rule of thumb in these cases is usually to consider a dependent variable that assumes more than 7 distinct categorical values as continuous rather than discrete. The variable PR assumes 115 distinct values, some of which repeat themselves to generate 288 observations, while the variable membership assumes 6 distinct variables for a total of 286 observations. Although running an ordered probit with country fixed effects instead of a GLS with fixed effects is certainly incorrect for PR (and probably also for membership) the results of these regressions are shown respectively in Figures and .[7] The results are confirmed for the regression of PR on R but not for membership on R_ent. The outcome of this last robustness check can possibly mean that either it is incorrect to use an ordered probit model in these cases or that the baseline results cannot be extended to the specific case of signing international IP treaties when the private R&D is taken into account. Although it might be incorrect to use the ordered probit for membership, no more can be added at this stage and further investigation is needed to shed light on this somewhat contradictory result.

3.4.5 The Corollary of Proposition 5

The corollary of Proposition 5 suggests that: "*If one country is more inventive than the other and if this this starts from a weaker patent protection, then a decrease (increase) in the EATR on highly profitable activities leads to patent harmonization (divergence).*

In other words, the Corollary of Proposition 4 states the conditions under which a change in the EATR on highly profitable activities leads to international patterns of harmonization or divergence in patent protection. Empirically, it is a fact that the EATR on highly profitable activities has decreased worlwide. As shown in Figure , the world's average EATR for the available countries in the dataset provided by CBT has passed from a value of 0.53 to a value of 0.25 during the period 1979 - 2017. Since the developed world more strongly protects patent protection than developing countries, then this progressive world reduction in the EATR on highly profitable activities represents a force driving towards a more harmonized and homogeneous global patent system. Intuitively, the opposite trend towards a divergent global patent system occurs if the EATR on highly profitable activities increases globally, as happened in the period

[7]Notice that since it is impossible to command an ordered probit with fixed effects, I had to introduce them manually by adding the variable i which is the country dummy variable.

from 1945 until 1979 (although data is not available for this period).

If the Corollary of Proposition 5 is correct, it provides an explanation of why the international system tends toward patent harmonization and divergence based on the fiscal incentives of government. Although this is certainly not the only force that drives these patterns (and the historical cycles of harmonization followed by divergence and viceversa), I claim that the fiscal interests of governments might be an important element in their understanding.

3.4.6 The problem of endogeneity

Unfortunately, the econometric test of Proposition 5 is based solely on correlations and not on well-identified causal mechanisms. Further investigation should address the problem of both the endogeneity of t and of R.

Nevertheless, controlling for the endogeneity of t and R in the determination of PR should not intuitively change the results presented above. In fact, both theoretically and empirically: 1) t and R are negatively correlated because: a) increasing the EATR on highly profitable activities reduces the incentives of private actors to invest in R&D, b) high levels of R&D expenditure over GDP increase the political power of inventive firms that more strenously lobby governments in favor of reductions in corporate tax rates; 2) R and PR and positively correlated due also to the political power of inventive firms in lobbying governments for patent protection. Hence, at higher levels of R, we should find lower levels of t and higher levels of PR which would make the correlation between t and PR negative. Since I have proposed an explanation of why, at a sufficiently high level of R, the correlation between t and PR becomes positive and given that the empirical test cannot reject this hypothesis, then controlling for the issue of endogeneity should make my results even more significative. In fact, given that the endogeneity pushes in favor of a negative correlation between t and PR, controlling for this issue should make the change of sign occur at lower levels of R and it should make it sharper. In other words, the line in the figures where the change of sign of the correlation between t and PR is represented should be steeper and it should cross the x-axis at a lower R.

However, further investigation is needed to show that controlling for the problem of endogeneity might render the results more significative instead of falsifying them.

3.5 Discussion and Conclusion

The general idea is that the élite ruling in a given country may increase its own fiscal revenue by modifying the system of patent protection.

On the one hand, an increase in the EATR on highly profitable activities raises the strength of patent protection that maximizes the net fiscal revenue in countries not open to foreign inventions. When testing this hypothesis with a short case study of the Middle Ages and the Modern Era, it appears that it cannot be falsified. This should be of interest to economic historians studying tax systems and patent rights before the First Industrial Revolution, which I have arbitrarily considered as the date starting from which the international mobility of knowledge (and hence the possibility of imitation) increased. Future analysis testing this idea (Proposition 2 in Chapter 2) should make use of data and quantitative analysis. Natural experiments able to identify and estimate the causal relationship from the EATR on highly profitable activities to the strength of patent protection would represent a more stringent test than those I was able to provide in this Chapter. Unfortunately, finding data on both tax rates and patent protection for the Middle Ages and the Modern Era is a hard task.

On the other hand, in an international system of countries interconnected through trade, migrations and mobility of knowledge, an increase in the EATR on highly profitable activities raises the strength of patent protection in inventive countries while it reduces the strength of patent protection in imitative countries. Hence, there is a threshold in the R&D expenditure over GDP above which a country becomes inventive, a technological world leader able to concentrate at the top tax rate more taxable income from protecting national inventions than the one it loses from copying foreign knowledge. On the contrary, under this R&D threshold, a country becomes imitative and a technological world follower able to concentrate at the top tax rate more taxable income from copying foreign inventions than the one it loses from protecting national knowledge.

3.6 Appendix

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: Y R E P O t

         chi2(6)      =    31.81
         Prob > chi2  =   0.0000
```

Figure 3.1: Breusch-Pagan test

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fe           re          Difference          S.E.
-------------+----------------------------------------------------------------
           Y |   .0000258     .0000125        .0000133        7.88e-06
           R |    .355746       .34021         .015536        .0818021
           E |   .0273547     .0238483        .0035064        .0050219
           P |   .0134775     .0064916        .0069859        .0097615
           O |   .0128127     .0003763        .0124364        .0031006
           t |  -.0119311    -.0252455        .0133145        .0048985
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       32.04
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Figure 3.2: Hausman test

```
. eststo: test mean_Y mean_R mean_E mean_P mean_O mean_t

 ( 1)  mean_Y = 0
 ( 2)  mean_R = 0
 ( 3)  mean_E = 0
 ( 4)  mean_P = 0
 ( 5)  mean_O = 0
 ( 6)  mean_t = 0

           chi2(  6) =   35.22
         Prob > chi2 =    0.0000
```

Figure 3.3: Mundlak test

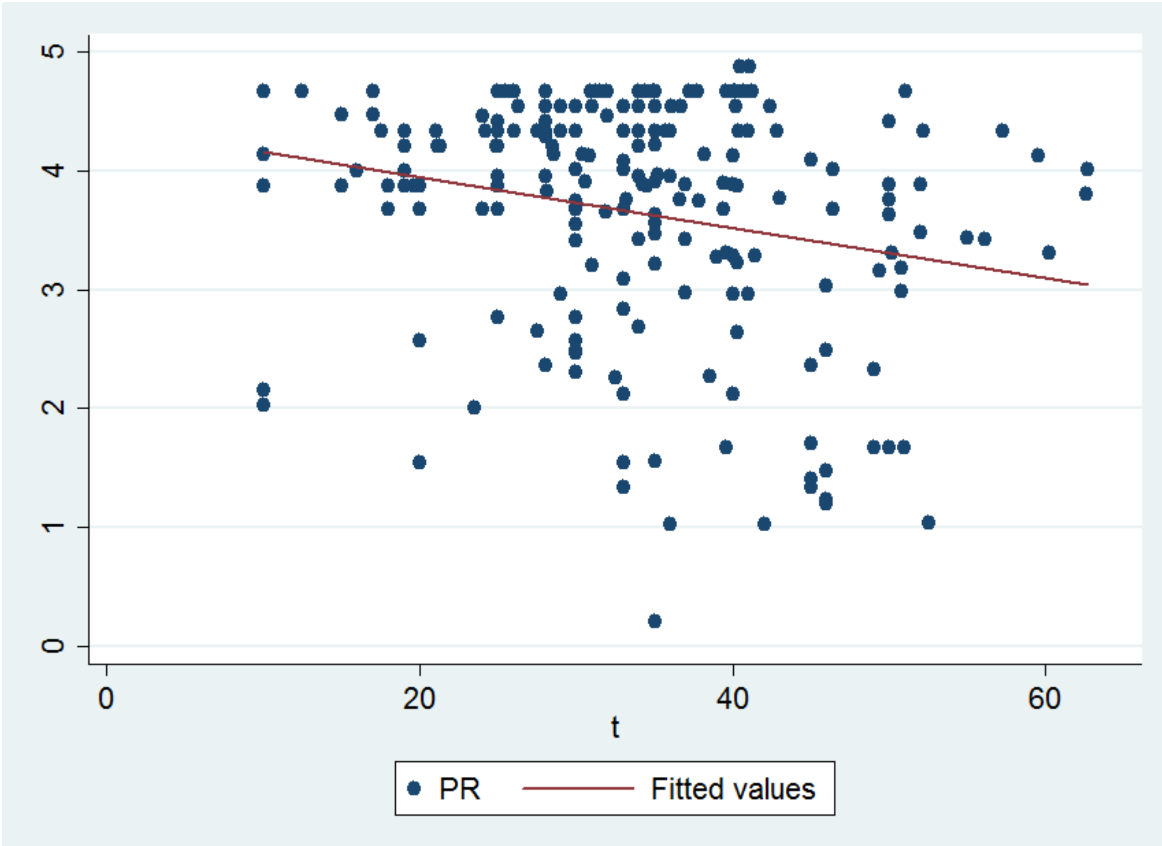

Figure 3.4: Correlation between PR and t without controls

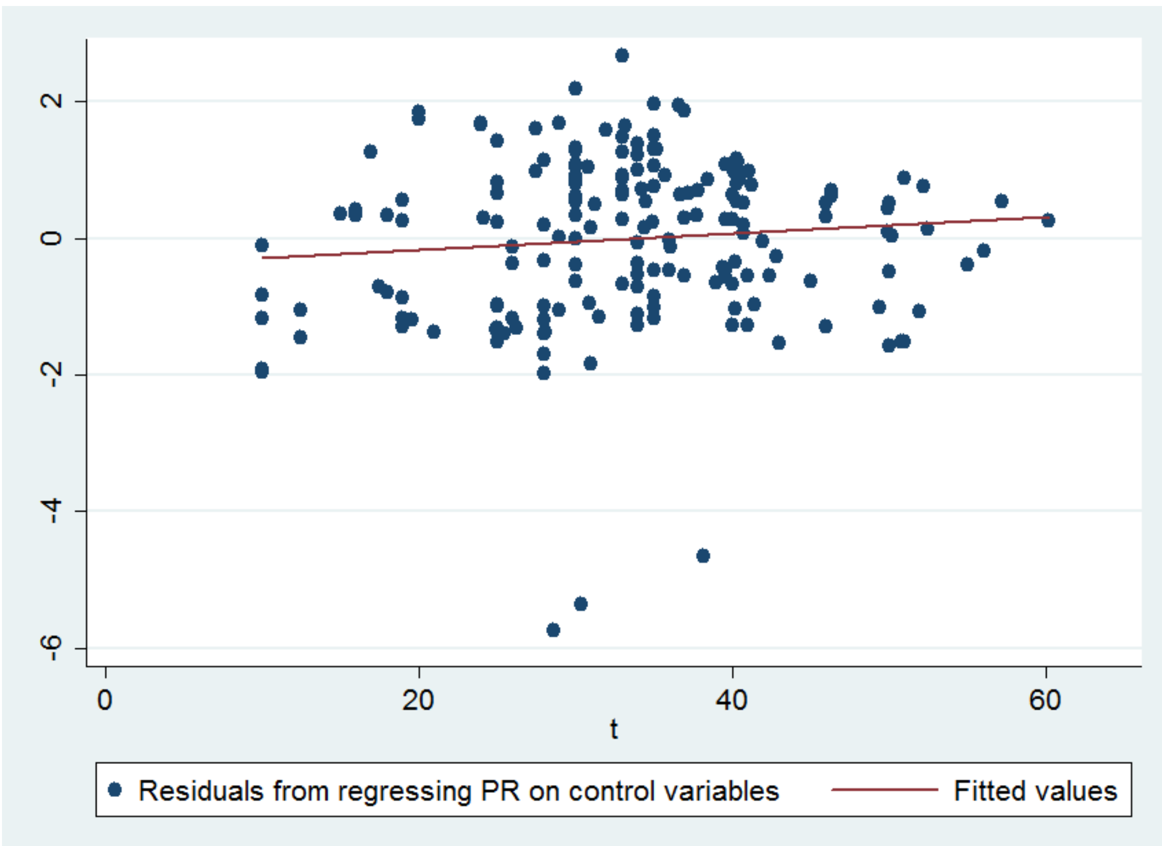

Figure 3.5: Correlation between PR and t with controls

	(1)	(2)	(3)
	PR	PR	PR
Y	0.0000278***	0.0000258**	0.0000339***
	(3.44)	(2.81)	(3.74)
R	0.401***	0.356**	-0.365
	(3.84)	(3.06)	(-1.63)
E	0.0324***	0.0274***	0.0246***
	(5.64)	(3.97)	(3.71)
P	0.0115	0.0135	0.0132
	(1.22)	(1.23)	(1.26)
O	0.0161***	0.0128***	0.0122***
	(4.64)	(3.54)	(3.54)
t		-0.0119	-0.0482***
		(-1.60)	(-3.98)
Rt			0.0248***
			(3.71)
_cons	-1.091	-0.195	0.786
	(-1.87)	(-0.22)	(0.88)
N	200	182	182

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.6: Baseline results

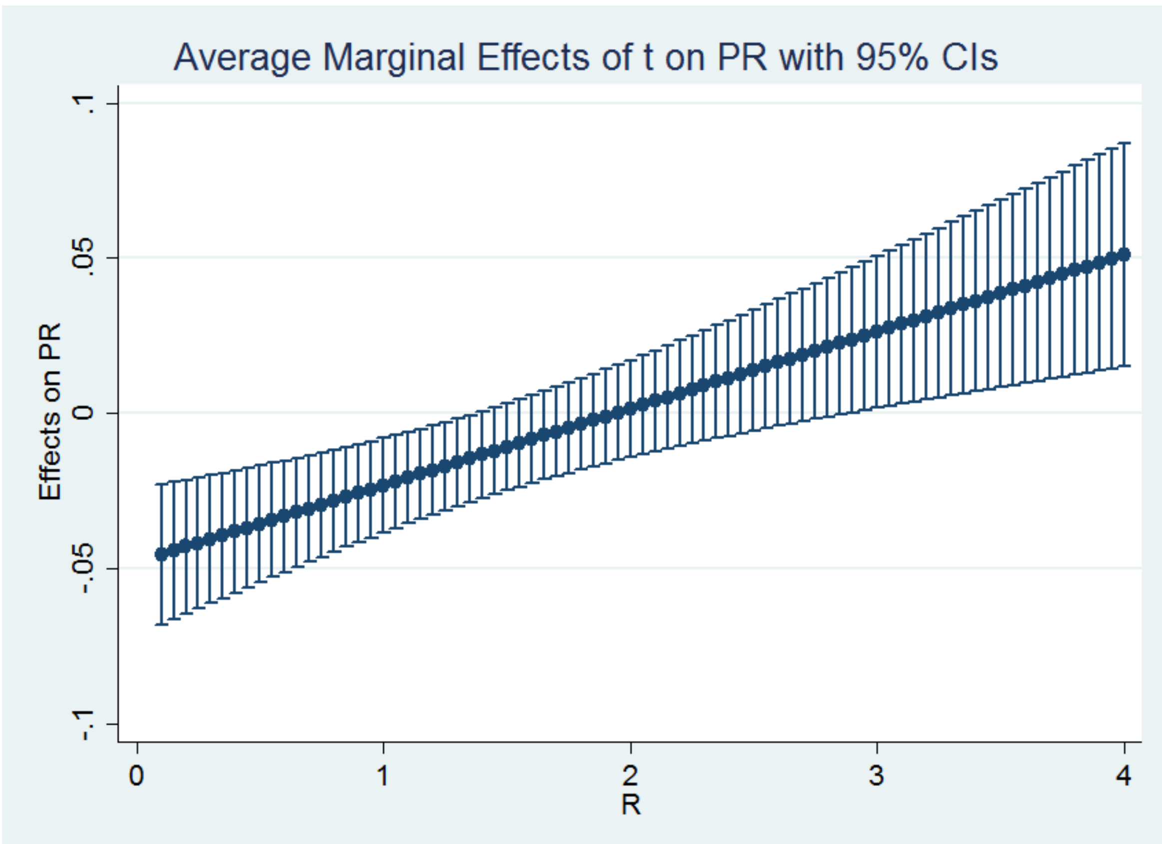

Figure 3.7: Significant change of sign of the correlation between t and PR at different levels of R

	(1) coverage	(2) membership	(3) loss	(4) enforcement	(5) duration
Y	0.0000101***	0.0000145***	0.00000852***	-0.00000104	0.00000186
	(4.21)	(4.60)	(4.67)	(-0.25)	(1.27)
R	-0.0632	-0.118	-0.0142	-0.148	-0.0210
	(-1.07)	(-1.52)	(-0.32)	(-1.45)	(-0.58)
E	0.00784***	0.00361	0.00551***	0.00691*	0.000678
	(4.48)	(1.57)	(4.14)	(2.28)	(0.64)
P	0.00404	0.00595	0.0000441	-0.00166	0.00481**
	(1.47)	(1.64)	(0.02)	(-0.35)	(2.87)
O	0.00210*	0.00124	-0.000915	0.00887***	0.000951
	(2.29)	(1.03)	(-1.32)	(5.61)	(1.71)
t	-0.0136***	-0.0167***	-0.000993	-0.0142*	-0.00269
	(-4.25)	(-3.97)	(-0.41)	(-2.57)	(-1.38)
Rt	0.00644***	0.00886***	0.00160	0.00655*	0.00133
	(3.65)	(3.81)	(1.19)	(2.14)	(1.24)
_cons	-0.0967	0.0431	-0.0311	0.306	0.565***
	(-0.41)	(0.14)	(-0.17)	(0.75)	(3.95)
N	182	182	182	182	182

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.8: Results with decomposition of PR

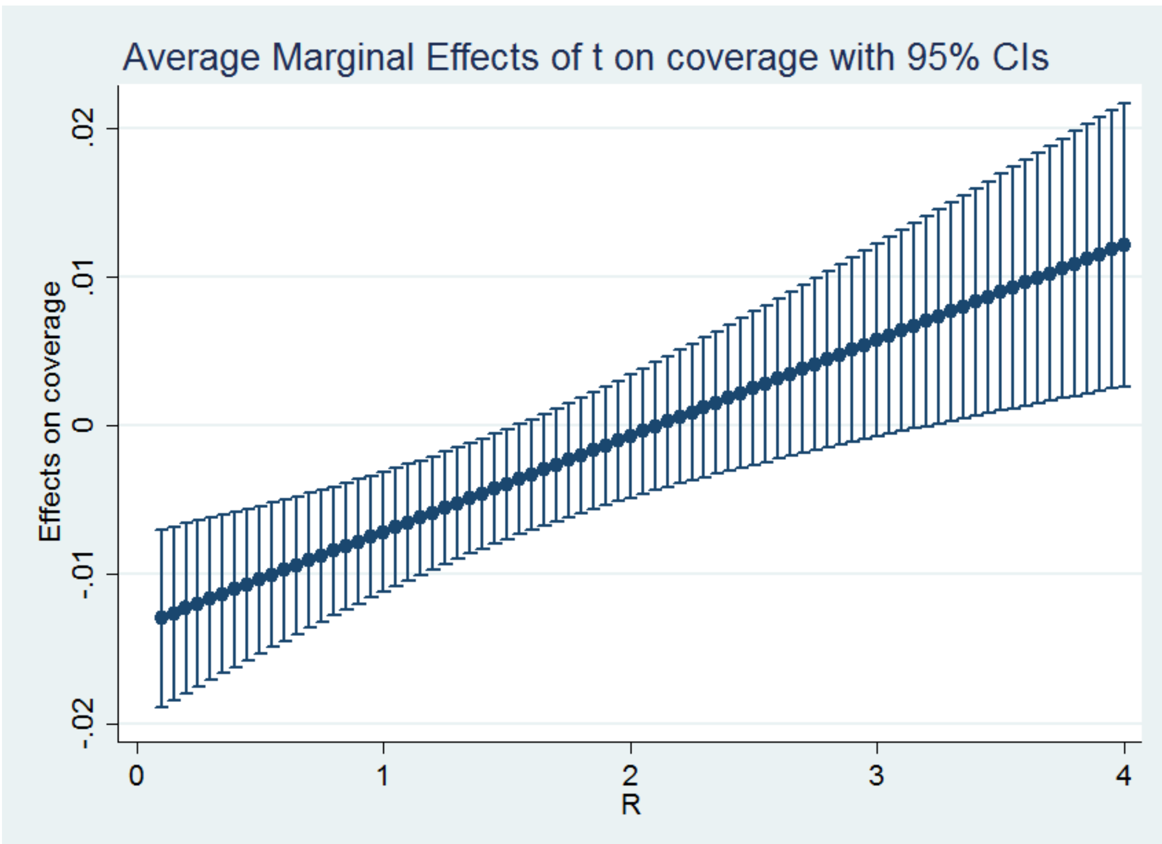

Figure 3.9: Significant change of sign of the correlation between t and coverage at different levels of R

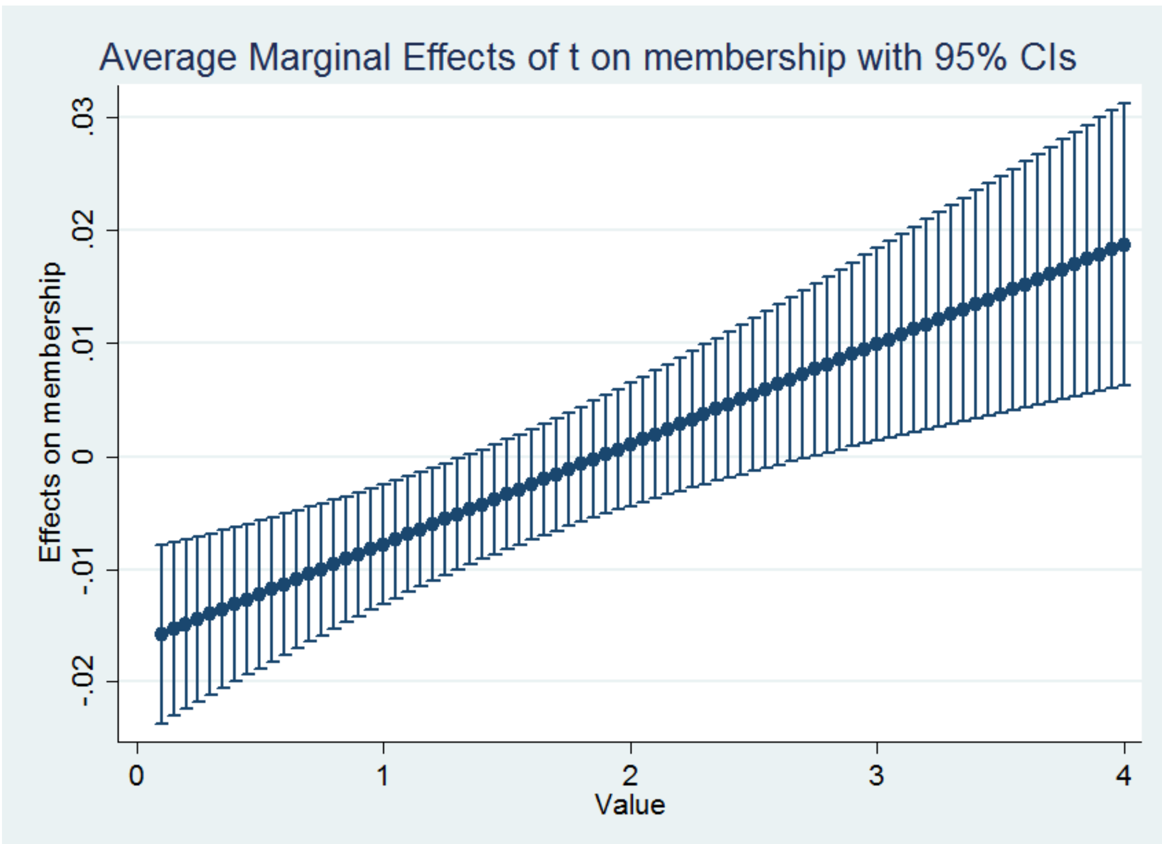

Figure 3.10: Significant change of sign of the correlation between t and membership at different levels of R

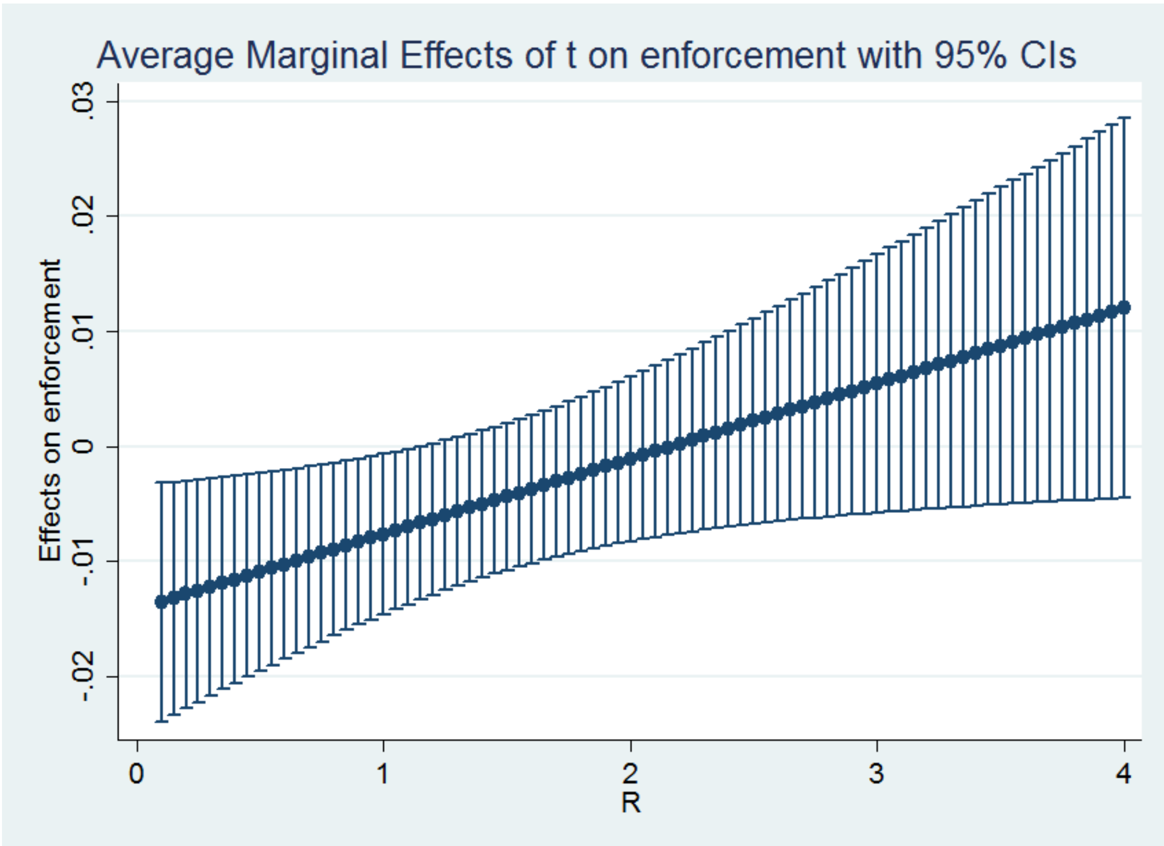

Figure 3.11: Not significant change of sign of the correlation between t and enforcement at different levels of R

	(1)	(2)	(3)	(4)	(5)
	PR	PR	PR	PR	PR
Y	0.0000367**	0.0000363**	0.0000369**	0.0000378**	0.0000227
	(3.25)	(2.85)	(3.06)	(3.14)	(1.39)
R_ent	-0.400				
	(-1.13)				
E	0.0190**	0.0176*	0.0161*	0.0148	0.00220
	(2.87)	(2.26)	(2.15)	(1.74)	(0.37)
P	-0.00276	0.0160	0.00290	-0.00637	0.00499
	(-0.22)	(1.22)	(0.21)	(-0.48)	(0.59)
O	0.00483	0.00568	0.00423	0.0138**	0.0106***
	(1.42)	(1.47)	(1.15)	(3.14)	(3.52)
t	-0.0353***	-0.0361*	-0.0226*	-0.00891	-0.0144
	(-3.48)	(-1.99)	(-2.49)	(-0.82)	(-1.36)
R_ent_t	0.0262*				
	(2.56)				
R_gov		-0.482			
		(-0.50)			
R_gov_t		0.0274			
		(0.98)			
R_for			-1.548		
			(-1.64)		
R_for_t			0.0598		
			(1.64)		
R_high				11.08*	
				(2.24)	
R_high_t				-0.225	
				(-1.54)	
R_nopr					-5.944
					(-0.64)
R_nopr_t					0.0340
					(0.13)
_cons	2.459*	1.475	2.217*	1.660	2.743**
	(2.50)	(1.18)	(2.06)	(1.60)	(3.18)
N	136	137	126	110	91

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.12: Results with decomposition of R on PR

	(1) coverage	(2) coverage	(3) coverage	(4) coverage	(5) coverage
Y	0.0000114***	0.0000104**	0.0000111***	0.0000134***	0.00000691
	(4.00)	(3.14)	(3.42)	(4.37)	(1.58)
R_ent	-0.109				
	(-1.22)				
E	0.00644***	0.00667**	0.00577**	0.00442*	0.00171
	(3.85)	(3.30)	(2.87)	(2.04)	(1.07)
P	-0.00246	0.00238	-0.00133	-0.00361	-0.00136
	(-0.77)	(0.70)	(-0.36)	(-1.06)	(-0.60)
O	0.000855	0.00108	0.000688	0.00268*	0.00200*
	(1.00)	(1.08)	(0.70)	(2.39)	(2.47)
t	-0.0109***	-0.00730	-0.00711**	-0.00499	-0.00213
	(-4.27)	(-1.55)	(-2.93)	(-1.80)	(-0.75)
R_ent_t	0.00809**				
	(3.14)				
R_gov		0.0956			
		(0.38)			
R_gov_t		0.00183			
		(0.25)			
R_for			-0.422		
			(-1.67)		
R_for_t			0.0177		
			(1.81)		
R_high				1.835	
				(1.46)	
R_high_t				0.00176	
				(0.05)	
R_nopr					1.708
					(0.68)
R_nopr_t					-0.0702
					(-1.00)
_cons	0.462	0.0858	0.440	0.319	0.595*
	(1.86)	(0.26)	(1.53)	(1.20)	(2.57)
N	136	137	126	110	91

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.13: Results with decomposition of R on coverage

	(1) membership	(2) membership	(3) membership	(4) membership	(5) membership
Y	0.0000210***	0.0000207***	0.0000173***	0.0000191***	0.00000267
	(5.20)	(4.69)	(3.83)	(4.16)	(0.53)
R_ent	-0.237				
	(-1.88)				
E	-0.000581	-0.000609	0.000169	0.0000191	-0.000568
	(-0.25)	(-0.23)	(0.06)	(0.01)	(-0.31)
P	0.00647	0.00859	0.00680	0.00177	0.00513
	(1.43)	(1.89)	(1.31)	(0.35)	(1.98)
O	-0.000679	-0.000712	-0.00136	0.00127	0.000643
	(-0.56)	(-0.53)	(-0.98)	(0.76)	(0.69)
t	-0.0122**	-0.0123	-0.00694*	0.00312	-0.00257
	(-3.36)	(-1.95)	(-2.04)	(0.75)	(-0.79)
R_ent_t	0.0125***				
	(3.42)				
R_gov		-0.290			
		(-0.86)			
R_gov_t		0.0132			
		(1.36)			
R_for			-0.718*		
			(-2.03)		
R_for_t			0.0326*		
			(2.38)		
R_high				7.817***	
				(4.16)	
R_high_t				-0.208***	
				(-3.74)	
R_nopr					2.569
					(0.89)
R_nopr_t					-0.139
					(-1.72)
_cons	0.182	0.131	0.218	0.000314	0.636*
	(0.52)	(0.30)	(0.54)	(0.00)	(2.39)
N	136	137	126	110	91

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.14: Results with decomposition of R on membership

	(1) loss	(2) loss	(3) loss	(4) loss	(5) loss
Y	0.00000943***	0.00000927***	0.00000926***	0.00000930***	.
	(3.90)	(3.84)	(3.63)	(4.09)	.
R_ent	-0.0477				
	(-0.63)				
E	0.00505***	0.00545***	0.00559***	0.00475**	.
	(3.55)	(3.69)	(3.53)	(2.96)	.
P	0.000160	0.000879	-0.000133	-0.00100	.
	(0.06)	(0.35)	(-0.05)	(-0.40)	.
O	-0.00156*	-0.00170*	-0.00149	-0.000249	.
	(-2.15)	(-2.32)	(-1.92)	(-0.30)	.
t	0.00120	0.00152	0.00176	0.00497*	.
	(0.55)	(0.44)	(0.92)	(2.42)	.
R_ent_t	0.00216				
	(0.99)				
R_gov		0.0119			
		(0.06)			
R_gov_t		0.00225			
		(0.43)			
R_for			-0.174		
			(-0.88)		
R_for_t			0.00308		
			(0.40)		
R_high				1.639	
				(1.76)	
R_high_t				-0.0183	
				(-0.66)	
R_nopr					.
					.
R_nopr_t					.
					.
_cons	-0.0275	-0.117	-0.0250	-0.166	0.495
	(-0.13)	(-0.49)	(-0.11)	(-0.84)	.
N	136	137	126	110	91

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.15: Results with decomposition of R on loss

	(1) enforcement	(2) enforcement	(3) enforcement	(4) enforcement	(5) enforcement
Y	-0.00000480	-0.00000464	-0.00000201	-0.00000436	0.0000136
	(-0.77)	(-0.73)	(-0.32)	(-0.68)	(1.07)
R_ent	-0.102				
	(-0.53)				
E	0.00671	0.00564	0.00363	0.00485	0.000960
	(1.84)	(1.45)	(0.93)	(1.07)	(0.21)
P	-0.00779	-0.00306	-0.00417	-0.00402	0.00127
	(-1.12)	(-0.47)	(-0.58)	(-0.57)	(0.19)
O	0.00668***	0.00702***	0.00700***	0.0103***	0.00806**
	(3.57)	(3.64)	(3.65)	(4.41)	(3.43)
t	-0.0129*	-0.0155	-0.00858	-0.0115	-0.00933
	(-2.31)	(-1.71)	(-1.82)	(-2.00)	(-1.14)
R_ent_t	0.00524				
	(0.93)				
R_gov		-0.291			
		(-0.60)			
R_gov_t		0.00911			
		(0.65)			
R_for			-0.142		
			(-0.29)		
R_for_t			0.00384		
			(0.20)		
R_high				-1.668	
				(-0.63)	
R_high_t				0.0305	
				(0.39)	
R_nopr					-11.25
					(-1.55)
R_nopr_t					0.266
					(1.31)
_cons	0.958	0.818	0.687	0.582	-0.00117
	(1.78)	(1.31)	(1.23)	(1.06)	(-0.00)
N	136	137	126	110	91

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.16: Results with decomposition of R on enforcement

	(1) duration	(2) duration	(3) duration	(4) duration	(5) duration
Y	-0.000000289	0.000000562	0.00000121	0.000000404	-0.000000424
	(-0.21)	(0.27)	(0.92)	(0.38)	(-0.38)
R_ent	0.0956*				
	(2.19)				
E	0.00141	0.000429	0.000919	0.000729	0.000103
	(1.72)	(0.34)	(1.12)	(0.97)	(0.25)
P	0.000851	0.00722***	0.00174	0.000496	-0.0000451
	(0.54)	(3.41)	(1.15)	(0.42)	(-0.08)
O	-0.000459	-0.0000147	-0.000609	-0.000195	-0.0000872
	(-1.09)	(-0.02)	(-1.52)	(-0.50)	(-0.42)
t	-0.000492	-0.00262	-0.00170	-0.000487	-0.000323
	(-0.39)	(-0.90)	(-1.72)	(-0.50)	(-0.45)
R_ent_t	-0.00182				
	(-1.43)				
R_gov		-0.00855			
		(-0.05)			
R_gov_t		0.00103			
		(0.23)			
R_for			-0.0920		
			(-0.89)		
R_for_t			0.00260		
			(0.65)		
R_high				1.452**	
				(3.31)	
R_high_t				-0.0313*	
				(-2.41)	
R_nopr					1.026
					(1.61)
R_nopr_t					-0.0236
					(-1.33)
_cons	0.885***	0.557**	0.897***	0.924***	1.019***
	(7.28)	(2.77)	(7.64)	(10.03)	(17.33)
N	136	137	126	110	91

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.17: Results with decomposition of R on duration

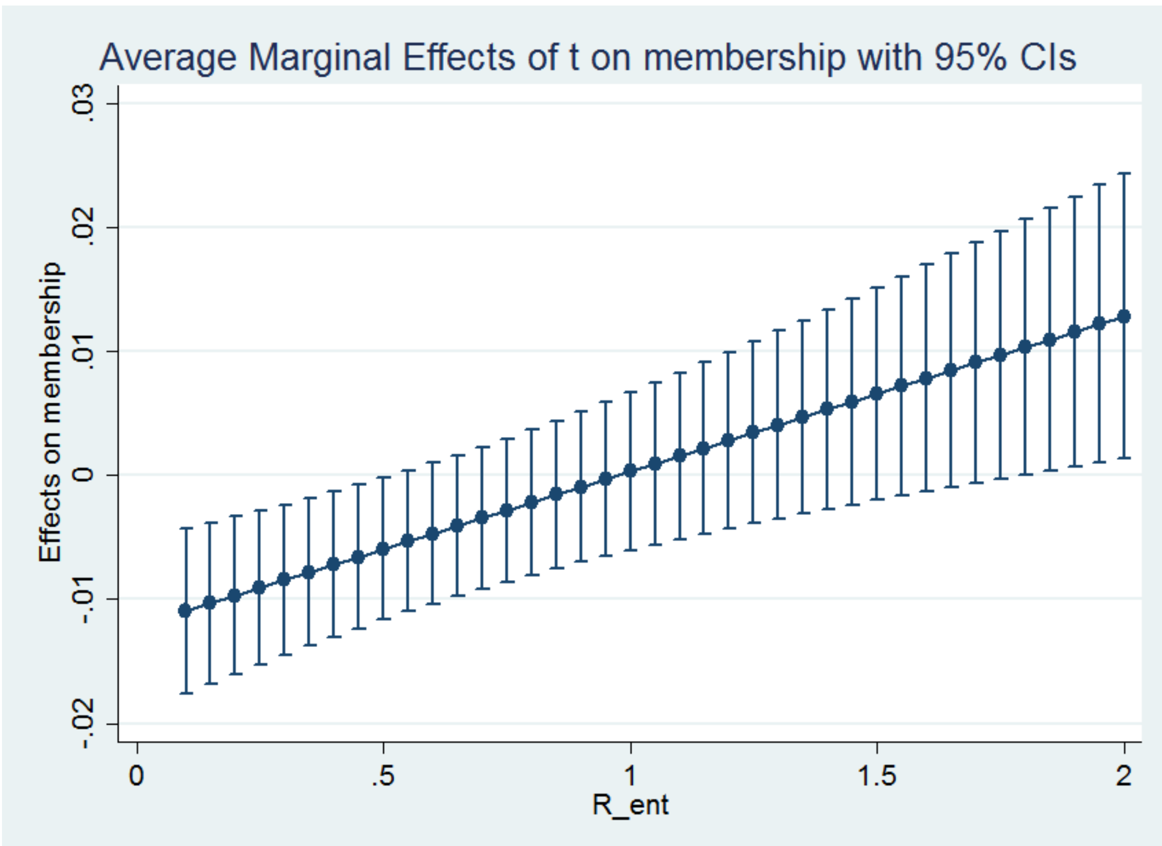

Figure 3.18: Significant change of sign of the correlation between t and membership at different levels of R_ent

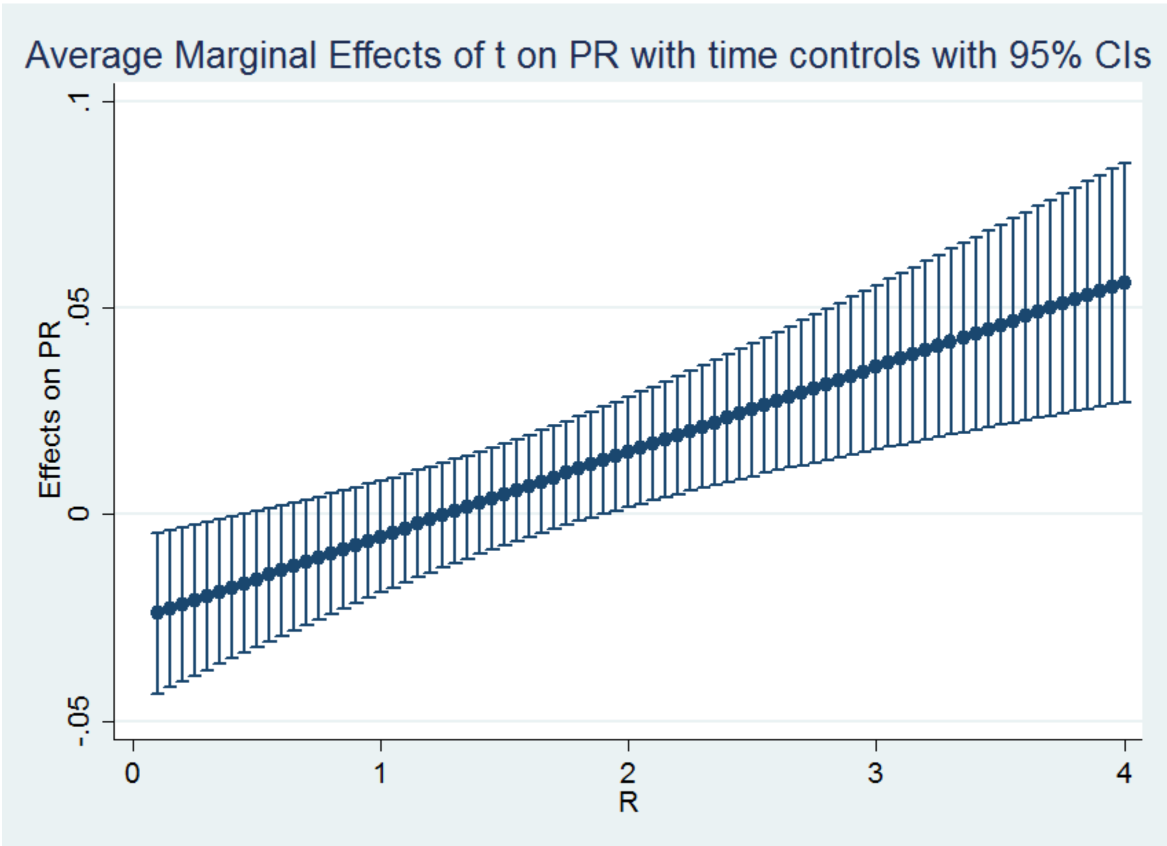

Figure 3.19: Significant change of sign of the correlation between t and PR with time controls at different levels of R

	(1) PR	(2) PR	(3) PR
Y	-0.0000315***	-0.0000330**	-0.0000217*
	(-3.44)	(-3.03)	(-2.01)
R	0.211*	0.270**	-0.320
	(2.50)	(2.87)	(-1.79)
E	0.0138**	0.0153*	0.0144*
	(2.72)	(2.58)	(2.55)
P	-0.00374	0.00250	0.00251
	(-0.51)	(0.28)	(0.30)
O	0.0114***	0.0109***	0.0111***
	(3.81)	(3.46)	(3.69)
1980bn.year	.		
	.		
1985.year	0.182	.	.
	(1.14)	.	.
1990.year	0.451*	0.420**	0.387**
	(2.55)	(3.02)	(2.92)
1995.year	1.222***	1.089***	1.058***
	(6.53)	(7.28)	(7.43)
2000.year	1.576***	1.459***	1.362***
	(7.54)	(7.77)	(7.55)
2005.year	1.734***	1.640***	1.514***
	(7.29)	(7.12)	(6.84)
2010.year	1.686***	1.604***	1.474***
	(6.71)	(6.39)	(6.11)
t		0.00534	-0.0260*
		(0.81)	(-2.50)
Rt			0.0205***
			(3.80)
_cons	1.779**	1.270	1.933**
	(3.10)	(1.70)	(2.65)
N	200	182	182

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Figure 3.20: Robustness check with time fixed effects

```
Ordered probit regression                         Number of obs   =        182
                                                  LR chi2(8)      =     134.00
                                                  Prob > chi2     =     0.0000
Log likelihood = -605.75471                       Pseudo R2       =     0.0996
```

PR	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Y	.0000256	6.17e-06	4.15	0.000	.0000135	.0000377
R	-.1992629	.3407867	-0.58	0.559	-.8671925	.4686667
E	.026822	.0063035	4.26	0.000	.0144673	.0391767
P	.0094199	.0053421	1.76	0.078	-.0010505	.0198902
O	-.0047224	.002255	-2.09	0.036	-.009142	-.0003027
t	-.0647589	.01794	-3.61	0.000	-.0999208	-.0295971
Rt	.0218683	.0099131	2.21	0.027	.002439	.0412975
i	.0123843	.0063473	1.95	0.051	-.0000562	.0248249

Figure 3.21: Robustness check on PR with ordered probit and country fixed effects

```
Ordered probit regression                         Number of obs   =        136
                                                  LR chi2(8)      =     100.70
                                                  Prob > chi2     =     0.0000
Log likelihood = -105.40142                       Pseudo R2       =     0.3233
```

membership	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Y	-.0000126	.0000106	-1.19	0.235	-.0000334	8.19e-06
R_ent	1.416463	.883496	1.60	0.109	-.3151579	3.148083
E	.041329	.0103383	4.00	0.000	.0210663	.0615918
P	.0309697	.0091186	3.40	0.001	.0130975	.0488419
O	-.0052154	.0033462	-1.56	0.119	-.0117738	.0013431
t	-.0992011	.0237131	-4.18	0.000	-.1456779	-.0527242
R_ent_t	-.005671	.0226875	-0.25	0.803	-.0501376	.0387957
i	.0247031	.0096392	2.56	0.010	.0058105	.0435956

Figure 3.22: Robustness check on membership with ordered probit and country fixed effects

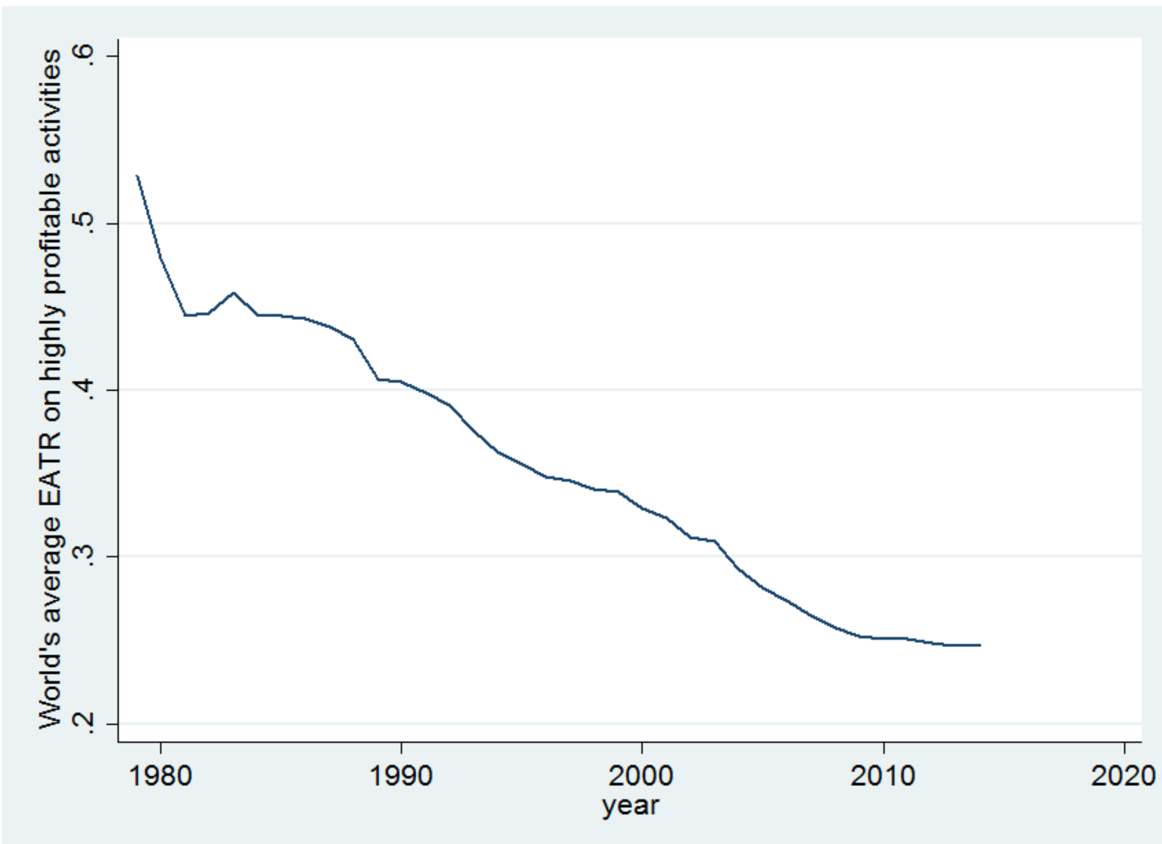

Figure 3.23: World's average EATR on highly profitable activities (1979 - 2017)

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