WORKING PAPER
DIPARTIMENTO DI ECONOMIA PUBBLICA

Working Paper n.122
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Information Gathering, Innovation and Growth

Roma, Giugno 2009
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This version: June 1, 2009

Abstract: In this paper we study the economic implications of IPR protection on corporate intelligence, R&D investment and economic growth. To accomplish this objective, we present a dynamic, scale-invariant Schumpeterian model of growth with information gathering and analyze the steady-state effects of introducing stronger protection for firms’ confidential information. In doing so, we introduce the trade secret into a standard quality-ladder growth model and study the long-run implications of improving the privacy of firms’ data. We find that reducing the set of practices of information gathering is more effective in protecting firms’ privacy than strengthening trade secret.

JEL classification: D9, K4, L5, O32

Keywords: R&D investment, trade secret, information gathering, economic growth.

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Acknowledgments: I would like to thank Raouf Boucekkine, Antonio Minniti, Paul E. Segerstrom, Klaus Wälde and an anonymous referee for their helpful comments and suggestions on previous drafts of this paper. I gratefully acknowledge financial support from the Italian Ministry for the University and Scientific Research (MIUR). Any remaining errors are mine.


1 Introduction

The importance of R&D in technology-intensive sectors has been widely highlighted by the Schumpeterian growth literature (e.g. Grossman and Helpman (1991), and Aghion and Howitt (1992, 1998)). In this literature, patent law - or more generically, intellectual property rights (IPR) protection- plays a primary role in the process of economic development. Thanks to the granting of patents, firms establish a product’s virtual everlasting monopoly, which allows entrepreneurs to recoup the enormous amounts of cash spent on R&D. Yet, it is quite a widespread opinion that collecting and making use of some kind of information about competitors is as crucial an element as R&D for market leadership. However, not all the available practices of information gathering, often called corporate intelligence, are acceptable forms of intelligence gathering and many of them are often considered extreme forms of industrial espionage (or spying).

As we will argue more extensively in the next Section, there is a thin line separating what is actually legal and what is not and very often it not easy to determine at what point information gathering constitutes spying.

This paper deals with R&D and information gathering. Our research objectives are twofold. First, we are interested in studying the long-run effects of corporate intelligence on innovation and growth. Second, we are interested in building a tractable analytical framework to study the long-run implications of IPR protection, corporate intelligence and growth. In order to plug information gathering into the standard Schumpeterian growth model, we introduce two main modifications to the standard Grossman and Helpman’s (1991) quality-ladder scheme. On the one hand, we assume that each R&D race is a two-stage activity, meaning that each R&D firm invests resources to discover the way to produce a higher quality product for first, and then tries to render the discovery useful for business purposes. In the meanwhile, firms apply for trade secret and try to keep any confidential information regarding the new discovery secret from their competitors. On the other, we assume that the trade secret is weakly protected, meaning that the IPR protection system does not provide enough protection against illegitimate practices of corporate intelligence. This assumption allows us to distinguish information gathering from spying and study the long-run effect of stronger IPR on both innovation and growth.

Up to now, economic theory (especially on innovation and growth) has paid much more attention to imitation than information gathering, particularly that on technology transfer and North-South trade (e.g., Helpman (1993), Lai (1998), and Glass and Saggi (2002) among others). Thus far only Cozzi (2001) and Parello (2005) have tried to explore alternative phenomena of misappropriation -such as interim imitation and spying- and their long-run implications for technological change and economic growth.
By introducing a simple modification to the basic Schumpeterian model, Cozzi (2001) finds that the larger the skilled population, the larger the relative incentive to spy. However, even though the model predicts a roughly constant rate of patenting, his model features both a constant patents-per-researcher ratio and time-invariant innovative R&D employment. This result is not consistent with the empirical evidence provided by Jones (1995) and Kortum (1996) that shows that the total amount of resources devoted to R&D in the most important industrial economies has grown dramatically in spite of the roughly constant rate of patenting. Parello (2005) extends Cozzi’s model by including increasing difficulty in R&D along the lines suggested by Segerstrom (1998). His goal is to build a growth model with spying consistent with the aforementioned empirical evidence. He finds that in the long run the economy grows semi-endogenously, meaning that any change occurring in the economy affects only temporarily the steady-state growth rate of the economy. He also finds that for a positive rate of spying to be active in the steady state, the growth rate of R&D difficulty must be no higher than a given threshold.

Our model differs from those of Cozzi (2001) and Parello (2005) in at least two respects. First, our model plugs trade secret into the standard quality-ladder model and focuses on information gathering rather than spying. Second, the model makes the intensity of information gathering an endogenous variable. The reasons why we opt for information gathering rather than spying is that in the real world there is little incentive either for errant companies or those that have been the victim of intelligence breaches to make their problems public. This makes spying a hidden phenomenon, with the result that when an incident is made public this does not mean that spies have been successful in spying but, rather, that they have failed to steal confidential information. If society is really protecting proprietary information, a steady-state equilibrium with a positive rate of spying, such as that found by Cozzi (2001) and Parello (2005), substantially gives a measure of something that people consider illegal. Information gathering is, in contrast, something that is globally accepted as legitimate tactics of competitive intelligence in contrast to the ‘illegitimate’ practice of spying.

The model is solved for the steady-state equilibrium and then used to study the long-run implications of a stronger IPR protection regime. We find that a steady-state equilibrium with information gathering exists only to the extent to which the degree of IPR protection is not very high. Specifically, we find that when the economy starts with a degree of IPR protection that is high enough to discourage corporate intelligence, the economy has no room for information gathering and works as a standard fully-endogenous growth model without scale effect; in contrast, when the economy starts with a low degree of IPR protection, corporate intelligence becomes more attractive to firms and the economy has room for information gathering. When the latter occurs, we find
that strengthening IPR protection - in terms of introducing a new trade secret protection scheme that is more sensitive to confidential information - leads to a permanent increase in steady-state rate of innovation and to a permanent decrease in the steady-state per capita consumption expenditure.

The paper is organized as follows. Section 2 gives some anecdotal evidence on how thin the line separating acceptable and unacceptable corporate intelligence practices is. Section 3 sets up the model and presents the main differences between it and standard R&D-based growth model. Section 4 solves the model for the steady-state equilibrium and analyzes its long-run properties. Section 5 analyzes the steady-state equilibrium effect of stronger IPR protection. Section 6 discusses the main results of the model and tries to provide a possible policy interpretation of them. Finally, Section 6 concludes.

2 Some anecdotal evidence.

In this Section we report on three cases of corporate intelligence in which the thin line between the legitimate tactics of competitive intelligence gathering and the ‘illegitimate’ practice of spying emerges. We start with two enlightening examples illustrating how information gathering can turn into spying because of the tensions caused by intense competition between rivals. Then, we provide another example showing how spying can escalate into national security concerns.

To start with, we consider an incident of spying that involved the branded-goods companies Procter & Gamble and Unilever. The espionage scandal exploded in 2001 when it was made public that professional spies, appointed by Procter & Gamble in the US to find out more about its competitor’s hair care business, were alleged to have disguised themselves as market analysts and sifted through rubbish bins outside Unilever’s offices in search of confidential information. The objective of the intelligence activity was to uncover operations that would have been of particular concern to Unilever, coming when the two companies were involved in an auction for the Clairol hair care brand – an auction which Procter & Gamble ultimately won (Edgecliffe-Johnson 2001).

Although not necessarily illegal – different countries have different rules on the legal status of rubbish (Burns 2002; Skapinker and Edgecliffe-Johnson 2001), Unilever accused Procter & Gamble’s tycoons of industrial espionage and threatened legal action against the company. Procter & Gamble’s reply was to reject the claim that its agents misguiused themselves as market analysts and declared that it had not indulged in any illegal activities. Yet, even though Procter & Gamble stated that these activities were against its strict business policies and guidelines, many industry insiders have expressed scepticism about this explanation. As Skapinker and Edgecliffe-Johnson (2001) maintain, it is quite common practice for companies that want to engage in dubious practices
to contract professional spies to 'do the dirty work' and provide 'plausible deniability' in case the operation goes wrong.

The two companies started negotiations to settle the issue amicably. Unilever stated that if a settlement agreement was not signed by the end of August 2001, it would start legal proceedings against Procter & Gamble. The case was finally resolved when Procter & Gamble surprisingly admitted corporate espionage against Unilever and made an out-of-court settlement of about $10m.

Another case of alleged espionage between bitter rivals was that involving the two huge media corporations, News Corporation and Vivendi Universal. This incident ended with a massive lawsuit (around $1bn) and represents a stark example of how competitive intelligence of rivals’ product and process technologies has become crucial for global competition. It started in March 2002 when a Vivendi subsidiary, the French pay-TV company Canal Plus Technologies, accused NDS, a UK based technology firm owned by News Corporation, of being responsible for providing the encryption services used by satellite television companies to prevent people viewing programmes they have not paid for (see Snoddy 2002; Cassey 2002).

Canal Plus used a rival security technology, which, it claimed, NDS employees deliberately cracked, and then sent to hackers on the west coast of the US to be published on a website used by software pirates. Following the publication of the smart card codes on the web, pirates were able to watch pay channels for free, depriving the Canal Plus of millions revenue and driving ITV Digital, another UK-based company controlled by Vivendi Universal, out of business. Although reverse engineering of competitors’ products is common practice in the world of anti-piracy, NDS vehemently refuted the allegation that it was involved in any way in such an incident. In a surprise twist, however, Canal Plus suspended and then completely dropped the ‘piracy’ lawsuit. The move came as part of a deal between the two parent companies Vivendi and News Corporation that was set to see the latter take over an Italian pay television company from Canal Plus (Godson 2002).

Finally, we provide another anecdotal evidence of information gathering becoming a major diplomatic incident between countries. The actors in this spying incident are the Swedish telecommunications company Ericsson, three former employees of the company, and two Russian diplomats.

Ericsson is best known for its mobile phones and communication equipment. But it is also one of the leading suppliers of mobile phones. In 2002, Ericsson was involved in developing highly sophisticated military technologies. The events of this industrial espionage case centred on the alleged leaking of information from Ericsson to a foreign intelligence service about the missile guidance systems for Sweden’s Gripen fighter plane, the country’s main strike aircraft. The implications certainly became more serious when
Sweden expelled two Russian diplomats who were said to be ‘directly linked’ to the industrial espionage case at Ericsson.

Although the Swedish authorities and Ericsson were reluctant to disclose too many details, such developments gave a clear indication that two Ericsson employees, and one former employee, had been passing sensitive information to a foreign country. In response, Russia subsequently announced tit-for-tat expulsions of two Swedish diplomats, drawing accusations from Stockholm that they were returning to ‘Soviet-era foreign policy’ (Osborn 2002). Whichever way one looks at it, the Ericsson incident is a clear-cut case of information gathering that not only threatened the company’s reputation for information security, but even had major implications for diplomatic relations.

3 The Model

The industrial framework consists of a continuum of industries indexed by \( \omega \in [0, 1] \). In each industry \( \omega \), firms are distinguished by the quality of the products they produce. Let \( j(\omega, t) \) be the quality vintage (or state-of-the-art) of industry \( \omega \) at instant \( t \), where higher values of \( j \) denote higher quality products. At time \( t = 0 \), the state-of-the-art quality product in each industry is \( j = 0 \), so that just one firm in each industry knows how to produce the \( j = 0 \) quality product and no firm knows how to produce any higher quality product.

To learn how to produce higher-quality products, firms participate in innovative R&D races. In contrast to the basic Schumpeterian growth model à la Grossman and Helpman (1991) though, we assume that each R&D race is a two-stage activity. In the first stage, firms invest resources to discover the way to produce the next quality rung \( j + 1 \) and, if successful, apply for trade secret in order to keep information secret. To simplify the analysis, we assume that keeping information secret is costless and that the duration of the trade secret is infinite. In the second stage, firms try to render the discovery useful for business purposes through a refinement of the previous discovery. However, this refinement can be independently carried out either by the innovating firm (henceforth the author) or some other rivals, whose main objective is to collect sensitive information about the radically new ideas, write down a marketable minor variation in competition with the author, and then try to beat the author in the "race to the Patent Office".

We assume that the probability that an author will win the "race to the Patent Office" is exogenously given, while the probability that a rival will win the race is endogenously given and depends on her intelligence effort. The winner of the "race to the Patent Office" becomes the only producer of the \( j + 1 \) quality product, regardless of who the author of the discovery is. The firm that produces a state-of-the-art quality
product is called the quality leader and the firm that produces a product one step below the state-of-the-art quality product is called the quality follower.

We focus on the steady-state equilibrium in which all innovative activity takes place in the long run and in which innovation takes the form of improvements in the quality of products.

3.1 Preferences

The economy has a fixed number -normalized to one- of identical households that provide labor services in exchange for wages. Each household is modelled as a dynastic family whose size grows over time at exogenous rate $n$, which also equals the population growth rate. At each point in time $t$, the economy is thus inhabited by a measure $L(t) = e^{nt}$ (with $L(0) = 1$) of identical individuals.

The representative household chooses from a continuum $\omega \in [0, 1]$ of products available at different quality levels. Perfect foresight of the future value of wages $w(t)$ and the rate of interest $r(t)$ implies that, for a given sequence of pairs $(w(t), r(t))$, $t \in (0, \infty)$, the problem for the representative household is to choose a sequence of consumption which maximizes discounted utility

$$\max_c U = \int_0^\infty e^{-\rho nt} \log u(t) \, dt$$

subject to:

$$\log u(t) = \int_0^1 \log \left[ \sum_j \lambda^j d(j, \omega, t) \right] \, d\omega$$

$$c(t) = \int_0^1 \left[ \sum_j p(j, \omega, t) \cdot d(j, \omega, t) \right] \, d\omega$$

$$W(t) + A(t) = \int_t^\infty c(\tau) \cdot e^{n\tau} e^{-[R(\tau)-R(t)]} \, d\tau$$

$\rho > n$, $L(0) = 1$

Eq. [2] is the Cobb-Douglas specification of the consumption index, where $d(j, \omega, t)$ denotes the quantity consumed of a product of quality $j$ produced in industry $\omega$ at time $t$, and $\lambda > 1$ measures the size of quality improvements or quality jump.\footnote{Because $\lambda$ is increasing in $j$, [2] captures the idea that consumers like higher quality and also has the property that vertically differentiated products in a given industry substitute perfectly for one another once the appropriate adjustment is made for quality differences.} Eq. [3] is the static budget constraint which assumes that in each instant of time $t$ the per capita expenditure of the representative household, $c(t)$, must equate the value of all final goods consumed, where $p(j, \omega, t)$ denotes the price of a product of quality $j$ produced in industry $\omega$ at time $t$. Finally, Eq. [4] is the intertemporal budget constraint.
which assumes that the sum of the household’s discounted wage income, $W(t)$, and the present value of the representative household’s financial assets, $A(t)$, must be equal to the discounted value of consumption, where $R(t) \equiv \int_0^t r(\tau) d\tau$ is the cumulative interest rate and $\dot{R}(t) = r(t)$ denotes the instantaneous interest rate at time $t$.

At each instant $t$, the representative household allocates expenditure to maximize the utility per person $u(t)$, given the prevailing market prices of each brand $\omega$. Because of the separability of Eq. [1], the representative consumer’s maximization problem can be solved in three steps. The first step is to choose the allocation of expenditure for each product across available quality levels. To solve this problem, the representative consumer allocates expenditure for each product at each instant to the quality level $j(\omega, t)$ offering the lowest quality-adjusted price, $p(\omega, t) / \lambda^j$. We assume that when quality-adjusted prices are the same for two products of different quality, consumers only buy the higher quality product.

The second step consists in choosing the allocation of expenditure across existing brands $\omega \in [0, 1]$ by maximizing discounted utility [2] subject to [3]. Given the Cobb-Douglas specification of the consumption index [2], solving this optimal control problem leads to the demand function for the product with the lowest quality-adjusted price in industry $\omega$ given by

$$d(\omega, t) = \frac{c(t)}{p(\omega, t)}$$

Aggregating [5], the aggregate market demand for each leader is

$$D(\omega, t) = \frac{c(t) L(t)}{p(\omega, t)}$$

Since [6] presents unitary elasticity\(^2\), this model focuses on the case in which innovation is non-drastic and assumes that for each industry only one firm can use leading-edge technology $j(\omega, t)$.

Finally, the third step is to choose the allocation of lifetime wealth across time by maximizing discounted utility [1], given Eqs. [3] and [4], and subject to the intertemporal budget constraint [4]. The solution for this optimal control problem leads to the usual Euler equation

$$\frac{\dot{c}(t)}{c(t)} = r(t) - \rho$$

According to Eq. [7], higher market interest rates induce consumers to save more now and spend later, resulting in an increased growth rate of per capita consumption.

\(^2\)This is the result of the Cobb-Douglas specification adopted by the consumption index [2], which implies that the elasticity of substitution between every pair of product brands is equal to one. For an alternative approach with drastic innovation see, among others, Aghion and Howitt (1992, 1998) and Dinopoulos and Thompson (1998).
However, in a steady-state equilibrium where per capita consumption $c$ is constant over time, the market interest rate must reflect the subjective discount rate.

### 3.2 Manufacturing

As in Grossman and Helpman (1991), a patent is needed to enter industries and produce the next higher-quality product. Once successful, production technology is the same across industries and one unit of general labor is required to produce one unit of output. The labor market is perfectly competitive and the wage of workers is used as the numeraire -i.e. $w(t) = 1$-, meaning that firms have a common marginal cost of production equal to one.

We assume Bertrand price competition between leaders and followers. In order to determine the profit-maximizing optimal pricing, consider first the profits earned by a leader when competing against a follower. With the follower charging a price equal to marginal cost, the quality leader earns the profit flow $\pi(t) = (1 - 1/\bar{p}) c(t) L(t)$ from charging the price $\bar{p} \leq \lambda$ and zero profits otherwise. As a result, by setting price $\bar{p} \leq \lambda$, each quality leader captures the entire industry market and will perform the same flow of sales equal to $D(t) = c(t) L(t) / \lambda$. Accordingly, all leaders have the same profit flow given by

$$\pi(t) = \left(1 - \frac{1}{\lambda}\right) c(t) L(t)$$

whereas all followers decide to stay in the market without producing.

### 3.3 The research sector

#### 3.3.1 Research and development

To introduce radical new ideas, firms participate in stochastic R&D races aimed at discovering higher-quality final consumption goods. We assume free entry into each inventive R&D race and the existence of common constant returns to scale technology available to racers.

Any firm $i$ that hires $\ell_i(\omega, t)$ units of labor (henceforth R&D workers) in industry $\omega$ at time $t$ is able to introduce a useful idea to discover the next higher quality product $j+1$ with instantaneous probability (or Poisson arrival rate):

$$I_i(\omega, t) = \frac{\ell_i(\omega, t)}{b\chi(t)}$$

where $b > 0$ is a technology parameter and $\chi(t)$ is a R&D difficulty index which tells us how the state of technology evolves over time.

The $\chi(t)$ term in the denominator of [9] is adopted in order to rule out the scale effect property of the early vintage of R&D-based endogenous growth models -e.g., Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992)- that...
share the counterfactual prediction that a permanent increase in R&D resources should lead to a permanent increase in economic growth rates. The specification adopted in this paper is the so-called PEG (Permanent Economic Growth) specification, which is given by:

\[ \chi(t) = \kappa L(t) \] (10)

where \( \kappa > 0 \) is an exogenous parameter. According to [10], as the population grows, \( \chi(t) \) increases over time and innovating becomes more difficult. The specification adopted by [10] can be justified by saying that R&D difficulty is proportional to the size of the market because of organizational costs related to product distribution (Dinopoulos and Segerstrom (1999)).

3.3.2 Information gathering and corporate intelligence

Instead of setting up a research lab, firms can invest resources in information gathering and corporate intelligence. Corporate intelligence consists of all those activities aimed at gathering relevant and up-to-date information about rivals’ market activities, such as market research, product development plans, research and development, etc.

Any firm \( i \) that hires \( s_i(\omega, t) \) units of labor (henceforth market researchers) in industry \( \omega \) at time \( t \) is able to come up with a radical idea and modify it into the quality product \( j + 1 \) with instantaneous probability (or Poisson arrival rate):

\[ \sigma_i(\omega, t) = \frac{s_i(\omega, t)}{\mu \xi(t)} \] (11)

where \( \mu > 0 \) is an exogenous technology parameter reflecting the degree of IPR protection on the economy and \( \xi(t) \) is a difficulty index which tells us how difficult information gathering is as time goes by.

We interpret parameter \( \mu \) as a measure of the thin line separating what is acceptable and unacceptable practice in information gathering. Differences in \( \mu \) may be the result of variations in the degree of IPR protection, meaning that an increase in \( \mu \) can be taken as policy measure that raises the cost of collecting information. Observe that in contrast to Cozzi (2001), the presence of the \( \xi(t) \) term in the right-hand side of [11] plays a very similar role to the one played by \( \chi(t) \) in [9]. We assume that \( \xi(t) \equiv L(t) \), meaning that as the size of the population increases over time, gathering information becomes ever more difficult.

The presence of the \( L(t) \) term in the denominator of [11] can be justified in the following way. Any increase in the size of the population, \( L(t) \), could potentially translate

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3Jones (1995) has persuasively criticized the empirical validity of this prediction by pointing out that several measures of R&D resources (such as R&D expenditure or the number of scientists and engineers in R&D) exhibit exponential growth in sharp contrast to the stationary per capita output and total factor productivity growth rates.
into either greater pure R&D or greater corporate intelligence, or both. If the size of the
corporate intelligence increases because of the increase in the size of the workforce, it
will also reduces the chances of a worker finding an idea that has not yet been used for
business purposes: the more corporate intelligence there is around, the less one single
worker can profit from being ready to find ideas. This is a sort of competition effect
which reduces the instantaneous probability that one worker will come up with the
right idea because of the presence of a larger number of workers gathering information.

3.4 The investment choice

In this Section we outline the essential features of R&D investment. The problem for
each firm is to decide whether to invest resources in either R&D or information gathering.
Consider first the case in which firm $i$ decides to do R&D by setting up a research lab.
Once successful in introducing a radically new idea, the firm has to face the second
stage of the R&D process which consists in making the discovery useful for business
purposes. We assume that the author’s probability of successfully modifying the first-
stage innovation - i.e. the measure of the advantage that an innovating firm has in writing
down a minor variation of its radically, but yet unapplicable, new discovery before
its competitors- is the same across industries and given by the exogenous parameter
$\alpha \in (0, 1)$. Parameter $\alpha$ can be taken as a measure of the degree of protection of firm’s
confidential information. The higher $\alpha$ is, the higher the set of information considered
as confidential.\footnote{Note that the authors’s winning rate $\alpha$ does not vary between industries. In a more general setting, cross-industry differences in this parameter may be the result of different industry-specific institutional settings of trade secret protection. In this paper we restrict our attention to analyzing the extent to which $\alpha$ is the same for all industries, leaving the analysis of cross-industry differences in the author’s winning rate to future research.}

Let $v(\omega, t)$ denote the expected discounted profit for winning an R&D race in in-
dustry $\omega$ at time $t$, which in this model is also the reward for winning the race to the
Patent Office. Given $\alpha$ and $\sigma(\omega, t)$, the probability that firm $i$ could enjoy the fruits
of its own innovation once successful in R&D is $\alpha / [\alpha + \sigma (\omega, t)]$. Thus, the prize of
winning the race to the Patent Office can be written as:

$$\frac{\alpha}{\alpha + \sigma (\omega, t)} v (\omega, t)$$

Next, the firm chooses the optimal labor input that solves the following maximization
problem:

$$\max_{\ell_i} \left\{ \frac{\alpha}{\alpha + \sigma (\omega, t)} v (\omega, t) \ell_i (\omega, t) - b \chi (t) \ell_i (\omega, t) \right\}$$
Differentiation with respect to $\ell_i$ gives the following free-entry condition:

$$\frac{\alpha}{\alpha + \sigma(\omega, t)} v(\omega, t) \begin{cases} \leq b(\omega, t) & \text{if } I_i(\omega, t) = 0 \\ = b(\omega, t) & \text{if } I_i(\omega, t) > 0 \end{cases}$$

(12)

The right-hand side of [12] is related to the benefits of becoming an Author while the left-hand side is related to the cost of becoming an Author. Costs exceeding benefits would discourage any possible attempt to create breakthrough ideas, whereas benefits exceeding costs would lead to innovation at an infinite intensity. As a result, an equilibrium with a positive and finite rate of innovation requires [12] to hold with equality.

Observe that according to [12], each R&D firm allocates the same number of R&D workers to innovative tasks. So, in the rest of the analysis, we focus on a symmetric equilibrium where $\ell(\omega, t) = \sum_i \ell_i(\omega, t)$ is the industry-wide number of innovative R&D workers in industry $\omega$ at time $t$.

Consider now the case in which firm $i$ decides to gather information by setting up a corporate intelligence system. By taking $\alpha$ and $\sigma(\omega, t)$ as given, the probability that the newly produced idea is caught by one for its employees equals $1/ [\alpha + \sigma(\omega, t)]$\(^5\) while the expected flow return of winning the race to the Patent Office is given by:

$$\frac{1}{\alpha + \sigma(\omega, t)} \frac{\ell(\omega, t)}{b(\omega, t)}$$

As a result, firm $i$ chooses its labor input to maximize its expected profits:

$$\max_{s_i} \left\{ \frac{1}{\alpha + \sigma(\omega, t)} \frac{\ell(\omega, t)}{b(\omega, t)} v(\omega, t) \frac{s_i(\omega, t)}{\mu L(t)} - s_i(\omega, t) \right\}$$

Differentiation with respect to $s_i$ gives the following free-entry condition:

$$\frac{1}{\alpha + \sigma(\omega, t)} \frac{\ell(\omega, t)}{b(\omega, t)} v(\omega, t) \begin{cases} \leq \mu L(t) & \text{if } \sigma_i(\omega, t) = 0 \\ = \mu L(t) & \text{if } \sigma_i(\omega, t) > 0 \end{cases}$$

(13)

The right-hand side of [13] is related to the benefits of corporate intelligence while the left-hand side is related to the costs of corporate intelligence. Costs exceeding benefits would choke information gathering, whereas benefits exceeding costs would lead to information gathering at an infinite intensity. Hence, an equilibrium with a positive and finite rate of information gathering requires [13] to hold with equality. Note that according to [13], the representative R&D firm allocates the same number of R&D workers to information gathering. As a result, in the remainder of the analysis we focus on a symmetric equilibrium where $s(\omega, t) = \sum_i s_i(\omega, t)$ is the industry-wide number of market researchers in industry $\omega$ at time $t$.

\(^5\)As information gathering has the same chance of finding ideas, the individual probability of being successful in finding a still not patented innovation is positive and described by density: $[\sigma(\omega, t) / (a + \sigma(\omega, t))] / \sigma(\omega, t) = 1/ [a + \sigma(\omega, t)]$. 

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Combining [12] and [13], we find that firm $i$ will decide to become an R&D firm if and only if the following arbitrage condition holds:

$$\frac{\ell (\omega, t)}{L(t)} \leq \alpha \mu$$

(14)

Eq. [14] can be thought of as a cut-off. After the number of inventors in the total labor force has reached the threshold $\alpha \mu$, the marginal R&D firm will find information gathering more profitable than innovation and the number of market researchers will increase as the size of the workforce not in manufacturing grows. Note that according to [14], each industry $\omega$ devotes the same number of R&D workers to innovative tasks, implying that at each instant the economy-wide share of inventors out of the total employment, $\int_0^1 \ell (\omega, t) d\omega / L(t)$, is constant and equal to $\alpha \mu$, and that any increase in R&D employment results in corporate intelligence.

### 3.5 The labor Market

In each industry $\omega$, consumers only buy from the current quality leader and pay a price equal to $\lambda$. Since market demand [6] presents unitary elasticity, at each instant of time $t$ a mass of $c(t) L(t) / \lambda$ workers is employed by current quality leaders. In addition, a mass of workers (both authors and market researchers) equal to $L_R(t)$ is doing research at time $t$. Since the R&D races are structurally identical in all industries and the measure of all these identical industries equals one, the labor market-clearing condition requires:

$$1 = \frac{L_R(t)}{L(t)} + \frac{c(t)}{\lambda}$$

(15)

Observe that $L_R(t)$ can consist of either/both R&D workers or/and market researchers according to whether [14] is binding or not. In particular, when $\mu$ is high -i.e. proprietary information is well protected-, information gathering is not as profitable as innovating and [14] is not binding. In this case, there is no incentive for firms to invest in information gathering, with the result that all the employment in R&D is devoted to innovation. On the contrary, when $\mu$ is low -i.e. proprietary information is imperfectly protected-, information gathering is profitable for R&D firms and [14] is binding. As a result, if IPR protection is low enough to guarantee that both R&D and information gathering are profitable in the equilibrium, these two research activities can coexist in the equilibrium and the share of workers in research, $L_R(t) / L(t)$, will consist of both authors and market researchers. In the next section, we will assume that $\mu$ is low and carry out the equilibrium analysis by focusing on the case in which information gathering is profitable for firms.
3.6 The Stock market

To finance their research projects, firms sell equity shares to consumers. The stock market channels consumer savings towards firms engaged in both R&D and market research and helps households to diversify the risk of holding stocks issued by these firms. Over a time interval of length \( dt \), the shareholder receives a dividend \( \pi(t) \, dt \), and the value of the monopolist appreciates by \( \dot{v}(t) \, dt \) in each industry. Because each quality leader is targeted by R&D firms\(^6\), each shareholder will suffer a loss of \( v(t) \) if further innovation occurs. This event occurs with probability \( I(t) \, dt \), whereas no innovation occurs with probability \( 1 - I(t) \, dt \). Efficiency in financial markets requires that the expected rate of return from holding a stock of quality leader is equal to the risk-less rate of return \( r(t) \, dt \) that can be obtained through complete diversification.

A no-arbitrage condition in the capital market thus requires:

\[
\frac{\dot{v}(t)}{v(t)} + \frac{\pi(t)}{v(t)} = r(t) + I(t) \tag{16}
\]

Eq. [16] states that the profit rate from the stock of a quality leader \( \pi(t)/v(t) \) plus the capital gains rate \( \dot{v}(t)/v(t) \) equals the market interest rate \( r(t) \) plus the instantaneous probabilities of being driven out of business by another firm \( I(t) \).

Plugging [8] into [16] yields:

\[
v(t) = \frac{(1-1/\lambda) \, c(t) \, L(t)}{r(t) + I(t) - \dot{v}(t)/v(t)} \tag{17}
\]

Finally, by combining the free-entry condition [12] with [17], one obtains the following no-arbitrage/research equation:\(^7\)

\[
\frac{b\kappa}{(1-1/\lambda) \, c(t)} = \frac{\alpha}{r(t) + I(t) - n \alpha + \sigma(t)} \tag{18}
\]

Then, no-arbitrage/research equation [18] provides another equilibrium condition for solving the model. The left-hand side is associated with the cost and the right-hand side with the returns of innovating. Observe that in line with Cozzi (2001), the returns of innovating equal the expected flow of profits earned by each leader [8] (appropriately discounted by using the interest rate and the instantaneous probability of being driven out of business by further innovations) times the author’s probability of winning the rate to Patent office, \( \alpha / [\alpha + \sigma(t)] \).

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\(^6\)This is so because only innovative R&D can threaten a monopoly position by introducing a radically new idea to produce the \( j + 1 \) quality rung. Since we are dealing with a situation in which the race to Patent Office occurs instantaneously, once the method for producing the \( j + 1 \) quality level has been discovered, at least one R&D firm (either the original author or a spy) will get the patent and leapfrog the current incumbent’s monopoly position instantaneously.

\(^7\)Indeed, by using [12] and accounting for the symmetrical industrial setup, it is easy to verify that \( \frac{\dot{v}(t)}{v(t)} = \frac{\dot{\alpha}(t)}{\dot{\lambda}(t)} = n \). This result holds because we choose the instantaneous wage rate as numeraire.
4 The Steady-state equilibrium

4.1 Characterization of the steady-state equilibrium

In this Section we focus on the steady-state equilibrium of the model. In doing so, we suppose that condition [14] is binding and define the steady-state equilibrium as follows:

**Definition 1** The steady-state equilibrium for a dynamic economy with endogenous R&D investment and information gathering is the situation in which: (i) all endogenous variables grow at constant rates, (ii) all markets clear, (iii) the long-run rate of innovation is non-negative (e.g. \( I(t) > 0 \) for all \( t \)), and (iv) the long-run rate of information gathering is non-negative - e.g., \( \sigma(t) \geq 0 \) for all \( t \).

The equilibrium system consists of Eqs. [7], [14], [15] and [18] that has to be solved for the four endogenous variables: the long-run innovation rate \( I \), the long-run rate of information gathering \( \sigma \), the value of innovation \( v \) and per capita consumption \( c \).

Let "*" denote steady-state values. Because [14] is binding, the innovation rate of the economy is pinned down in any equilibrium and equals:

\[
I^* = \frac{\mu \alpha}{b \kappa}.
\] (19)

According to [19], the steady-state innovation rate will be higher, (i) the higher the author’s probability of winning the race to the Patent Office, \( \alpha \), (ii) the stronger IPR protection in the economy, \( \mu \), (iii) the lower the parameter measuring to what extent population growth affects R&D difficulty, \( \kappa \), (iv) the lower the technology parameter, \( b \).

This result contrasts with that found by Parello (2005) and is mainly due to the different technique used to remove the scale effect. In the presence of the PEG specification for the R&D difficulty index, stronger IPR protection has a positive impact on the long-run innovation rate via a permanent increase in the share of innovative R&D employment in the economy.

**Proposition 1** Regardless of the equilibrium properties of the model, at each instant \( t \) the innovation rate of the economy is always constant and equal to [19].

With the innovation rate pinned down by [19], in order to solve the model we need two equations giving us the steady-state solution for the two remaining endogenous variables \( c^* \) and \( \sigma^* \). From [7], a constant per capita consumption expenditure \( c^* \) requires \( r(t) = \rho \). Using this result to substitute for the interest rate and [19] to substitute for the innovation rate in [18], the steady-state no-arbitrage/research equation is given by

\[
b \kappa = \frac{(1 - 1/\lambda) c^*}{\rho + \mu \alpha / b \kappa - \nu \alpha + \sigma^*} \frac{\alpha}{\alpha + \sigma^*}.
\] (20)
Intuitively, the left-hand side of [20] is related to the cost of introducing a new radical idea while the right-hand side is related to its benefit. The benefit of introducing a new radical idea consists in the profits earned by each industry leader \((1 - 1/\lambda) c^*\) appropriately discounted by using the population growth-adjusted interest rate \(\rho - n\) plus the instantaneous probability \(\mu \alpha / \lambda c\) of being driven out of business by a further innovation, multiplied by the probability that the author can enjoy the fruits of its own innovation \(\alpha / (\alpha + \sigma^*)\).

To close the model, we need a side condition describing the resource constraint of the economy. This condition is the labor-market full-employment condition \(L_R(t) + c^* L(t) / \lambda = L(t)\). As IPR are not perfectly enforced, the share of non-manufacturing workers in the total workforce, \(L_R(t) / L(t)\), consists of both R&D workers -given by [14]- and market researchers, \(\mu \sigma^*\). As a result, the labor market full-employment condition [15] is:

\[
1 = \mu \alpha + \mu \sigma^* + \frac{c^*}{\lambda}
\]  

(21)

Eq. [21] has a natural economic interpretation. The first term on the right-hand-side is the share of labor in manufacturing, whereas the last two terms are the share of labor in R&D and information gathering respectively. Eqs. [20] and [21] complete the description of the steady-state equilibrium of the model. In the next Section we carefully discuss under what conditions a steady-state equilibrium, such as that described by Definition 1, exists and provide a closed form solution for the two main endogenous variables \(c^*\) and \(\sigma^*\).

### 4.2 The solution

According to point iv of Definition 1, a viable steady-state requires a positive rate of information gathering. This point can be represented diagrammatically in \((\sigma, c)\) space (see Figure 1). Eq. [20] -the R-curve in Figure 1- is globally increasing, whereas Eq. [21] -the L-curve in Figure 1- is globally decreasing in \((\sigma, c)\) space. The unique intersection between the two curves occurs in the positive orthant if and only if the vertical intercept of [20] is lower than that of [21]. It is easy to check that this result occurs if and only if the following restriction on the exogenous parameters of the model holds:

\[
\mu < \bar{\mu} \equiv \frac{(\lambda - 1) - b (\rho - n) \kappa}{\alpha \lambda}
\]  

(22)

Threshold [22] is strictly related to [14]. When \(\mu \in (0, \bar{\mu})\), [14] is binding and the mass of workers currently hired by the research sector, \(L_R(t)\), is larger than cut-off \(\mu \alpha L(t)\), with the result that the extra-supply of researchers is engaged in corporate intelligence. In contrast, when \(\mu \in (\bar{\mu}, \infty)\), [14] is not binding, the mass of workers currently hired by the research sector is lower than cut-off \(\mu \alpha L(t)\) and the economy has
Figure 1: The steady-state equilibrium with information gathering

no room for information gathering. In the last subcase, the model works like a standard Schumpeterian growth model with endogenous innovation.

Solving [20] and [21] for \( c \) and \( \sigma \) we obtain:

\[
c^* = \frac{\lambda [\alpha \mu + b \kappa (\rho - n)]}{\alpha \lambda \mu + b \kappa (\rho - n)}
\]

and

\[
\sigma^* = \frac{\lambda - 1}{\alpha \lambda \mu + b \kappa (\rho - n) - 1}
\]

According to [23], the higher the protection of the trade secret, \( \alpha \), the lower the steady-state per capita consumption expenditure, \( c^* \). This result can be explained via Eq. [19], by saying that the higher the protection of the trade secret, the higher the steady-state rate of innovation and the lower the mass of workers available for manufacturing.

In contrast to [23], Eq. [24] does not display a clear-cut relationship with \( \alpha \). This result is surprising because it tells us that helping authors to win their race to the Patent Office, although potentially beneficial for economic growth, does not help to secure firms’

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In our framework, the level of \( \alpha \) depends on the amount of information covered by the trade secret. The greater the set of information protected by every trade secret, the higher the probability for the author to patent its own discovery.

In fact, differentiation of [24] with respect to \( \alpha \) gives:

\[
\frac{d\sigma^*}{d\alpha} = \frac{b \kappa (\rho - n) (\lambda - 1)}{[\alpha \lambda \mu + b \kappa (\rho - n)]^2} - 1,
\]

whose sign is ambiguous and depends on both \( \alpha \) and \( \mu \).
confidential information. The economic explanation of this result is not difficult to grasp. The higher the steady-state rate of innovation, the larger the flow of radically new ideas available to corporate intelligence. Such an abundance of ideas can endanger the privacy of firms’ data and leads the economy towards greater information gathering. Notice also that, for the rate of information gathering to be positive, the degree of information protection must be not higher than [22]. Indeed, if condition [22] were binding, the steady-state rate of information gathering would be zero. As a result, if the final goal of the government is to wipe spying out of the economy through a restriction of the set of so-called legal practices of corporate intelligence, strengthening trade secret protection is not an efficient tool.

All these results can be collected in the following proposition.

**Proposition 2** When IPR protection is lower than [22], a steady-state equilibrium, such as that defined by Definition 1, exists and is unique. In the steady-state equilibrium, strengthening industrial secret protection is not an efficient tool to reduce information gathering.

Given the steady-state pair given by [23] and [24], the aim of the next Section is to study the steady-state impact of a stronger IPR regime that makes corporate intelligence more expensive. As mentioned above, in this paper stronger IPR protection corresponds to an increase in μ.

## 5 Strengthening IPR protection

According to Proposition 2, a steady-state equilibrium with a positive information gathering exists if and only if the current strength of IPR protection is lower than threshold [22]. Let’s now suppose that the government will decide on stronger IPR protection. Such an intervention can be studied through an increase in parameter μ.\(^{10}\)

Differentiation of [23] and [24] with respect to μ gives:

\[
 \frac{\partial c^*}{\partial \mu} = -\frac{ab\kappa(\lambda - 1)\lambda(\rho - n)}{[\alpha\lambda\mu + b\kappa(\rho - n)]^2} < 0
\] (25)

and

\[
 \frac{\partial \sigma^*}{\partial \mu} = -\frac{\alpha^2\lambda(\lambda - 1)}{[\alpha\lambda\mu + b\kappa(\rho - n)]^2} < 0
\] (26)

According to Eqs. [25] and [26], strengthening IPR protection has a detrimental effect on both \(c^*\) and \(\sigma^*\). Graphically, an increase in \(\mu\) makes the L-curve shift downward

\(^{10}\)In our model, the level of \(\mu\) depends on all those of intelligence practices that society considers as acceptable forms of information gathering. The higher \(\mu\) is, the smaller the set of acceptable practices and the higher the probability that corporate intelligence can be considered spying.
and the R-curve rotate counter-clockwise. The steady-state equilibrium moves from point A to point B, where both the steady-state per capita consumption and the steady-state rate of information gathering decrease.

**Proposition 3** For economies in their steady-state equilibrium, an increase in $\mu$ leads to (a) lower steady-state per capita consumption and (b) lower steady-state rate of information gathering.

In order to find the economic intuition underlying this result, let’s start considering the result shown in [26]. An increase in $\mu$ has a twofold impact on R&D incentives. Firstly, an increase in $\mu$ makes the cost of corporate intelligence increase and the productivity of every corporate intelligence unit fall. This encourages firms to invest more in innovation and less in corporate intelligence, thereby making the steady-state rate of information gathering fall and eventually disappear once $\mu$ hits cut-off $\bar{\mu}$. Secondly, increased $\mu$ makes the fruits of their innovation effort more secure and increases the prize for winning the race to the Patent Office. This spurs R&D investment and makes the steady-state rate of innovation (19) increase.

To provide an economic explanation to Eq. [25], we focus on the steady-state condition [21]. Full-employment requires that the rise in the R&D firms’ demand for labor is matched by a rise in the supply; since the mass of workers freed by the firms engaged in information gathering is not enough to reach full-employment, manufacturing must free workers by reducing their sales. In the new steady-state equilibrium, the economy ends up with more R&D and less manufacturing.
6 Discussion

Thus far we have looked at corporate intelligence from an economic point of view. What has emerged from the previous Sections is that corporate intelligence exists only when \( \mu \) is sufficiently low and that reducing the productivity of corporate intelligence is more effective in protecting confidential information than increasing the authors’ probability of being the first to the Patent Office. This result has a remarkable impact in terms of policy because it directly impinges on the ways a government can tailor the institutional setting in order to protect confidential information. But is there a way of measuring and determining \( \tilde{\mu} \)?

As Edgecliffe-Johnson (2001) and Shing and Spence (2002) point out, not all means of gathering information are acceptable in a competitive context; there are limits to acceptable forms of intelligence gathering beyond which corporate intelligence might be considered illegal. In order to answer such questions, Crane (2005) has recently proposed a criterion for distinguishing information gathering from spying. This criterion is based on ethical concerns and relies on three major points:

1. The tactics used to secure information;
2. The nature of the information (whether private or confidential);
3. The public interest.

As far as the first point is concerned, the tactics used in gathering information have to be clearly legal and ethically acceptable. In other words, they can neither take illegal forms, such as breaking and entering a competitors’ offices to steal information or infiltrating competitor organizations with professional spies, nor infringe the so-called deontological code, i.e. the set of duties of being honest and truthful in business dealings. In this vein, either searching through a competitors’ rubbish or contacting a competitor in the fake guise of a potential customer or supplier, as Procter & Gamble did in the aforementioned espionage case, can be taken as a form of spying.

As regards the nature of the information, even though the IPR regime can assign rights to many intangible assets, firms often go to great lengths and invest substantial resources in trying to keep a great deal of information secret from their competitors. With the emergence of the information communication technology, the ease of replication of digital information, as well as the refinement of the so-called reverse engineering techniques, the unauthorized accessing and exploitation of firms’ internal information has increased dramatically over the last decade. The ‘theft’ or ‘hacking’ of sensitive digital information has thus become a major problem for many high tech industries and IPR infringements on digital information have been the subject of numerous recent cases,
including the record industry’s battle against Napster, the internet music-swapping service (see Grimes 2002), or the case of espionage allegations made by Canal Plus against NDS. This is a very difficult problem, whose solution requires policy-making institutions to correctly identify what the substance of IPR is and how IPR-legislation has to be adapted to changes in technology.

Finally, intelligence gathering can turn into spying when it can potentially endanger the public interest. Public interest issues can arise in at least two cases. First, when the information acquired generates anti-competitive behavior, including the deliberate removal of competitors or the entrenchment of a monopoly position. Second, public interest issues may arise when corporate intelligence is closely related to national or international security, or when the target firms are involved in designing, producing, and servicing military technologies or other security-related products and services. Obviously, it is not so simple decide whether an act of intelligence gathering is in the public interest or not, especially if, as in the recent Sweden-Russia diplomatic crisis after the Ericsson case, it risks having major implications for diplomatic relations.

7 Conclusion

In this paper we have studied the economic implications of corporate intelligence on long-run technological change and economic growth. To accomplish this objective, we have presented a dynamic, scale-invariant Schumpeterian model of growth with information gathering and analyzed the steady-state equilibrium effects of introducing stronger protection for firms' confidential information.

In modelling information gathering, we split R&D races into two stages. In the first stage, firms invest resources to discover the way to produce a new quality product. In the second, the firm has to make the discovery useful for business purposes by introducing minor variations to the basic idea. In the passage from the first stage to the second, the author of the basic idea applies for trade secret and tries to keep all the main information concerning the new radical idea secret from its competitors.

We found that the model generates a unique steady-state equilibrium with both innovation and information gatherings when the degree of IPR protection in the economy is low. We also find that every restriction of the IPR regime aimed at increasing the cost of corporate intelligence is more effective in protecting confidential data than helping authors to better protect their trade secrets. Based on Crane (2005), we have concluded the paper by proposing three possible guidelines to identify the boundaries of corporate governance and to distinguish the legitimate tactics of competitive intelligence gathering from the ‘illegitimate’ practice of industrial espionage.
References


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