Financial Markets, Technological Innovation, Investments in R&D, and public policies

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Abstract

This papers takes into consideration the potential incentive mechanism associating firms' investment in R&D with financial markets. Given the role of financial markets as an institution where information spreading provides a valuation of firms' profitability and managers' efficiency, this paper introduces a theoretical model analyzing the interaction between firms' profits cost of finance, financial markets and optimal R&D investments. The model can be used to analyze the effects of public policies to promote innovation and R&D investments consisting of tax incentives for firms that have documented a certain level of expenditure in R&D, have reported patents, have issued shares on the stock market beyond a certain threshold of their own capital and have obtained positive profits for a certain period of time after issuing shares.

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1. Introduction

A first basic element characterizing the expenditure in R&D are, first of all, the fact that the link between expenditure in R&D and technological innovation is characterized by significant uncertainty and, secondly, that the nature of pubic goods characterizing technological knowledge determines positive externalities for those firms who have not beard the initial costs of R&D: given the typical existence of relevant spillovers and given the appropriability of knowledge, patents do not always constitute a totally satisfactory instrument on the point of view of the firm potentially undertaking R&D investments.

Another basic element is the fact that technical innovation can deeply modify many features of the market and the context where firms' competition takes place, by affecting both the technological features of the production process and the characteristics of consumers' demand. An analysis of the (non) success of the Schumpeterian approach in explaining the process of technical innovation is well beyond the scope of this paper, but it might be interesting to remark that Rosenberg (1982, 2000) provides a wide historical and empirical evidence for the U.S., suggesting that technological innovation, in many industries has been successfully introduced, by new entrants rather than incumbent dominant firms

The performances and capital gains of the hi-tech stocks in the 1990's are well known and not only show that that technical innovation may generate a strong impact on firms' profits, but also that the stock market constitutes the most powerful and appealing way to finance innovation: in spite of all speculative attitudes (pointed out by the famous Greenspan's statement on "irrational exuberance") the fact of associating the R&D expenditure to issuing shares in the market eliminates the problems of monitoring and discretionality that characterize government investments and expenditure in R&D.

To point out the relevance of the link between efficient financial markets and technological innovation, one might consider the fact that one of the former G8 countries that is suffering more from an unsatisfactory level of R&D expenditure and witnesses a lively debate on the causes of a possible industry decline, Italy, has always been characterized by a relatively imperfect system of juridical protection for small

shareholders, not very extended developed financial markets (at least compared to bank intermediation), a relatively small number of public companies, significant concentration and rigidities in the market for firms' control, not necessarily associated with the market for shares (since hostile takeovers have historically been extremely rare and therefore the controlling groups of shareholders hold a complete control of their companies). One of the well-known peculiarities of the Italian industry is the fact that many companies (small as well as large) are controlled by the same family of entrepreneurs for several generations: Buckhart, Panunzi and Shleifer (2002) point out that such an ownership feature, on the one hand, sees the coincidence between owners and managers, while, on the other hand, raises very relevant problems for what concerns the selection process of the managers and raising financial resources. Furthermore, Santarelli and Vivarelli (2002) and Lotti, *et al.* (2001) remark, that the birth of new firms is, statistically speaking, a very significant phenomenon in Italy, but the new born firms are in general very small, have a high probability of exit and have historically received very unselective and distortionary policy incentives. All that is associated to an industrial sector strongly oriented toward the production of traditional commodities and rather week in all hi-tech sectors where size and scale economies play a relevant and strategic role: according to many analysts this is one of the main causes of the possible decline of the Italian industry.

R&D expenditure in % of GDP – Year 2001

	All sectors	private firms
Belgium	2,2	1.6
Danmark	2,4	1,7
Germany	2,5	1,8
Spain	1,0	0,5
France	2,2	1,4
Italy	1,1	0,6
Netherlands (year 2000)	1,9	1,1
UK	3,0	1,3
Japan (year 2000)	3,0	2,1
U.S.	2,7	2,1

Source: Baussola, M., (2003)

The next section contains a model of investment in continuous time showing the causal link between technological innovation, firm profitability, cost of finance, financial markets and optimal investment. Section 3 discusses some unconventional properties of the equilibrium in the model. Section 4 discusses a few policy implications.

2. The model

Given that information asymmetries seem to be so important in the determination of the cost of capital, the security market can be regarded as a vehicle of information not only by the financial investors, but also by policy makers, since it may potentially reduce the problem of monitoring public investments in R&D and reduce the degree of discretionality. While Shiller [1984] and [1989], analyzes in detail the process of information spreading, this interpretation is consistent with the theoretical contribution by Anderson [1994] and the empirical study by Pagano, Panetta and Zingales [1994]. Anderson [1994] suggests that securities could be complementary rather than alternative to bank credit. The argument goes as follows: since the transactions on the stock market spread information on the profitability of a firm and on the quality of its investments, they can also potentially reduce the monitoring costs for a bank or a generic lender. For these reasons, the firms issuing shares in the stock market could also borrow at better conditions from the banks. This is also broadly consistent with the empirical evidence provided by Pagano, Panetta and Zingales [1994].

Let us assume that the transactions concerning the liabilities of the firm (i.e. equities and debt) are a major vehicle of information for the quality of firms' investments. This is equivalent to the rather orthodox assumption that prices are the main vehicle of information spreading. This assumption can be formalized following the "general epidemic model" (Bailey [1957], quoted in Shiller [1984] and [1989]).

It is assumed, first, that new carriers of news (as of a disease) are created at a rate equal to an 'infection rate' β times the number of carriers times the number of susceptibles and, second, that carriers cease being carriers at a 'removal rate' τ.

(Shiller [1989], p.15)

This model is quoted by Shiller as a possible tool for interpreting phenomena of information spreading in financial markets. It could be extended to the interpretation of the diffusion of information concerning the profitability of the firm. In particular, let us assume that the "infection rate" β is constant, the removal rate τ depends on the maturity of the financial assets (and, for simplicity, could be assumed to be constant, as a first approximation), the "number of carriers" of information correspond to the individuals who have been involved in the negotiations of assets issued by the firm, and that the "number of susceptibles" correspond to all of the potential buyers of the firm's assets (i.e., at least potentially, the entire population). We might now discuss what kind of transactions might be considered information carriers: only the transactions concerning the financial assets of the firms (whose price should be associated to the net present value of the future yields) or *just any transaction* (since we can assume that details such as the amount of sales and the time required to pay the creditors could carry relevant information on the profitability of the firm). The first thing to point out in this regard is that issuing liabilities in financial markets exposes the firm to a much larger information coverage, since data on stock and bond prices are much more easy to collect and process (even in continuous time) than any other price. We assume therefore that issuing securities and financial liabilities in the spot financial markets generates a process of costless information spreading, while, collecting information on other prices (such as commodity prices and banks' interest rates) entails considerably high costs.

The model we introduce intends to explicitly formalize how the increase in profits determined by technological innovation affects the cost of finance through the process of information spreading in the financial markets and, as a consequence, the optimal level of investment. The firm operate under a regime of imperfect competition, although perfect competition may be a limit subcase.

As a starting point, let us describe the situation of a firm whose activity may randomly generated (by a process of learning) a technological innovation consisting in

process innovation. Once technological innovation has been (randomly) generated within the activity of the firm it generates a positive shock on the variable profits.

We define the investment problem at time $t=0$ in continuous time as follows, where all the variables are defined as expected future variables and all assumptions on certainty equivalence are assumed to apply:

$$Max\ V(0) = \int_0^\infty exp[-\int_0^t \Phi(\tau)d\tau\ ]\{u(k(t),w^*\mid v_i) - A[I(t)]\}\ dt \qquad (1$$

subject to the following two constraints (apart, obviously, from the balance sheet constraint:

$$dk/dt = I - gk,\ k(0)>0 \qquad\qquad (2$$

$$\lim_{t\to\infty} k(t) \geq 0 \qquad\qquad (3$$

where $u(k(t),w^*\mid v_x)$ are the variable profits, which depend on the (exogenous) labor costs w^*, the stock of capital k and are conditional on an exogenous parameter v_x, determined by the (exogenous and constant) demand elasticity and the (exogenous and constant) degree of competition/collusion among the various firms. v_x can be though of as the result of a game among the firms competing on the market: the case where the effect of v_x is irrelevant would correspond to the limit and extreme situation of perfect competition; $\Phi(t)$ is the (instantaneous) optimized cost of firm's financial funds, and $A[I(t)]$ represents the adjustment costs function of investment, twice continuously differentiable, i.e. $A(0)=0$; $A'>0$; $A''>0$.

Let us further define:

$$\pi(t) = u(\cdot) - A(I(t)) \qquad\qquad (4$$

and let p_S be the share price. Any hypothesis on the relation between $\pi(\cdot)$ and p_S should (at least implicitly) rely on some assumptions concerning the diffusion of information about the profits and the profitability of the firm. In fact one could say that the effects of an increase in $\pi(\cdot)$ on the cost of financial capital might be ambiguous and depend on the assumptions on how p_S reflects a risk premium depending in its turn on the process of

information spreading concerning the firm's profits. In what follows we assume that the optimized cost of finance $\Phi(t)$ contains a "risk premium" negatively correlated with profits $\pi(\cdot)$. This may be very simply justified by imagining that the firms operate in a context of uncertainty, where unexpected stochastic shocks may take place any time ant therefore, the event of bankruptcy (i.e. negative variable profits) is more likely the lower are the profits. Given that we are describing a situation where the firm as well as the external suppliers of finance operate under uncertainty, we can assume that any source of finance (i.e. both risk capital and debt) has a cost that contains a risk premium, which, on the basis of our assumptions, will be higher the lower the flow of profits. Obviously, the way the risk premium reacts to changes in the flow of profits depends on the assumptions we are making about the process of information spreading. As explained below, we can assume, in this regard, that if the external providers finance of are risk averse, with no information at all on the firm's profits (or with temporarily negative profits) the firm has to bear by default the highest risk premium. On the other hand, if the firm has positive profits and has issued shares on the stock market, a process of information spreading, affecting the risk premium on the cost of finance takes place.

On the basis of the above assumptions we assume that the causality from $\pi(t)$ to Φ^*, can be described by the following generical function, linking the optimized cost of finance to the risk premium $\Omega(\cdot)$, which is, in its turn, a negative function of the process of information spreading a, which, in its turn, is a function of the profits. The causal link going from $\pi(t)$ to Φ^* is meant to explicitly reproduce the dynamics of the "epidemic" model of information spreading invoked by Shiller in his above-mentioned contribution. We define therefore:

$$\Phi^*(t) = r^o_S + a(t) \qquad (5$$

where r^o_S is the *ex ante* theoretical rate of return on shares with perfect information, and "a" is a risk parameter associated with the lack of information (available to outsiders) on the quality of management and on the quality of investments of the firm under consideration.

$$a = \begin{cases} \overline{a_1(\xi)}/t & \text{for } \pi > 0 \text{ and } t > 0 \text{ with } d(a_1)/d\xi < 0 \\[2em] \xi^* & \text{for } \pi \leq 0 \text{ and/or } t = 0 \end{cases} \qquad (7$$

The conditions on the variable "t" reflect the fact that the phenomena of information spreading and processing, that asymptotically reduce and remove the risk parameter "a", do not take place immediately (i.e. at the exact time $t=0$ where the firm materially issues shares on the stock market), but after a length of time required by the market to process the data on which they may base their valuations of riskiness. For these reasons, "a" depends on a parameter ξ reflecting the process of information spreading only when $t > 0$, while for $t=0$ the firm is still regarded as "risky" and charged with the constant parameter ξ^* for risky investments.

(7) says that the risk factor "a" (and the function $a_1(\xi)$) tends to disappear when "t" tends to infinity: the rationale for such an assumption is that when the available amount of information on the behaviour of a given firm becomes very high, outsiders increase their ability to make inferences on the quality and characteristics of the firm's behaviour (profitability of investments, dividend policies, skills of the decision makers, etc.). In a sense, one could say that asymptotically the degree of information asymmetry is reduced.

Having said that the effects of the risk parameter "a" and the risk premium on shares ξ" tend to disappear when "t" becomes infinite, it might be reasonable to ask ourselves what happen to "ξ" when "t" is not infinite. It seems natural to assume that in these circumstances "ξ" depend on the qualitative characteristics of the process of information spreading. It also seems natural to assume that the information spread by such a process must reflect the performances of the firm under consideration. Then we define a parameter β which reflects the diffusion in time of the information concerning the profits

π. For the sake of simplicity, we also assume that the risk premium charged to "risky" firms will be the same for the firms having non-positive profits and for those not issuing shares in the stock markets (since the available information concerning the latter is generally considered much lower than for the firms issuing shares in the stock markets). In other words, both the firms with non positive profits and those not issuing shares in the stock markets will be charged with the maximum (constant) risk premium ξ^*. All the others enjoy the advantages of the "process of information spreading", but this process of information spreading could be suddenly interrupted whenever the performance of a firm worsens, causing the profits π to be non positive.

If at any time the profits of the firm fall below the level π=0, then the firm is charged with the maximum (constant) risk premium ξ^*. The virtuous circle of information spreading may begin again (by setting again *t=0*) if and only if the profits increase again to the point where *π>0*. Furthermore, for *π>0* and *t≥0*, we assume that the process of information spreading does not only detect when the profits are positive but will also show "how good the performance" of the firm is, i.e. "how high" the profits are. Therefore, for *π>0* and *t>0*, we have the following function:

$$\xi = \xi(\pi(t),t) \qquad (8$$

Hence, under some (above mentioned) circumstances, Φ^* is a function of the total profits *π(t)*. It analytical form is meant to capture the above-metioned "epidemic" mechanism of information spreading introduced by Shiller.

We define then the function $\xi(\pi(t),t)$ as follows:

$$\xi(\pi(t),t) = (\beta/t)log(1+\pi \cdot t) \qquad (9$$

In definition (9), with an appropriate value for the constant parameter β, a dynamic behaviour can be reproduced where the function $\xi(\cdot)$ is monotonically increasing in "π" and has a point of maximum in t^o for what concerns the variable "*t*". When "*t*" further increase after the point of maximum t^o (i.e. when the 'removal rate' prevails over the process of diffusion determined by the "information carriers"), the function is decreasing in "*t*" (while it is still increasing in π). The phenomenon described by equation (9) could

reproduce the effects of an exogenous negative shock in the profits π, which would increase the risk premium.

We can now define the Hamiltonian of the problem can be defined as follows:

$$H = exp \left[- \Phi^*(\pi(t))t \right] \ \left[u(\cdot) - A(I(t)) \right] + z(t) \cdot \left[I(t) - g(k(t)) \right] \qquad (9$$

Since the discount factor is a function of π, which is, in its turn, a function of both the state variable $k(t)$ and of the control variable $I(t)$, the system is time dependent. Again, it might not have a solution, and, in any case, the determination of a solution requires a particular "heuristic" procedures. The method of solution is similar to the one followed in Mazzoli (1998, ch. 7) although here the assumptions of the model and the context are completely different.

3. A special solution

The risk valuation of the external investor reacts to any new information about successful technical innovation affecting variable profits susceptible to increase the profitability and performance of the firm *as soon as such information is known and spreads into the market*. The transversality conditions are the following:

$$\lim_{t \to \infty} z(t) \geq 0, \quad [k^*(t) - k(t)] = 0 \qquad (10$$

where k^* is the optimal level of physical capital. Remembering that

$$\pi(t) = u(k(t)|v_i) - A[I(t)]$$

it is assumed, in what follows, that the transversality conditions are satisfied. For $\pi > 0$ and $t > 0$. Assuming that the second order conditions are satisfied, the first order conditions will be the following:

$$\partial H / \partial I = 0 = -e^{-\Phi(\pi(t))t} \cdot A' - e^{-\Phi(\pi(t))t} \cdot \left[t \ (d\Phi / d\pi) \cdot (-A') \right] \cdot \pi + z(t) \qquad (11$$

Hence

$$d\Phi / d\pi = (d\Phi / d\Omega) \cdot (d\Omega / di) \cdot (di / d\pi) = \beta / (t^2 \pi) \qquad (12$$

$\partial H/\partial I = 0 = -e^{-\Phi(\pi(t))t} \cdot A' - e^{-\Phi(\pi(t))t} \cdot (\beta/t) \cdot (-A') + z(t)$ (13

and solving for z

$\qquad z = A' \, [1 - (\beta/t)] \, e^{-\Phi(\pi(t))t}$ (14

The condition for the state variable is the following:

$dz/dt = -(\partial H/\partial k) = -(\partial u/\partial k) \, e^{-\Phi(\pi(t))} + t \, [(\, d\Phi/\, d\pi)(/\partial u \, \partial k)] \cdot e^{-\Phi(\pi(t))} \cdot \pi(t) + z(t) \cdot g$

(15)

Hence, substituting in it equation 13 we get:

$dz/dt = e^{-\Phi(\pi)t} \, (-\partial u/\partial k) \, [1 - (\beta/t)] + z \cdot g$ (16

By putting together equations 35, 36 and 11 we determine the following system:

$$\begin{cases} z = A'[1 - (\beta/t)] \, e^{-\Phi(\pi(t))t} & (14 \\[2mm] dz/dt = e^{-\Phi(\pi)t \cdot} \, (-\partial u/\partial k) \, [1 - (\beta/t)] + z \cdot g & (15 \\[2mm] dk/dt = I - gk & (2 \end{cases}$$

Time differentiating equation 14 we get the following:

$dz/dt = e^{-\Phi(\pi)t} \, A'' \, [1-(\beta/t)] \cdot (dI/dt) - \Phi \cdot e^{-\Phi(\pi)t} \, A' \, [1-(\beta/t)] + e^{-\Phi(\pi)t} A'[1-(\beta/t^2)] \; +$

$+ \, e^{-\Phi(\pi)t} \, (-t) \, \{(-\beta/t^3) \cdot \log(\pi \cdot t) + (\beta/\pi t^3)[\pi + t(-A')(dI/dt)]\}$ (17

where, for simplicity, the arguments of π have been omitted.

In equation (17), for $t \to \infty$, the last two addends, i.e.

$e^{-\Phi(\pi)t} A'[1-(\beta/t^2)]$

and

$e^{-\Phi(\pi)t}$ *(-t) {(-β/t³) · log(π·t) + (β/πt³)[π+t(-A')(dI/dt)]}*

tend to zero, and the term *[1-(β/t)]* tends to *1*.

Therefore, for $t \to \infty$, we would obtain a model analogous to the standard neoclassical investment model, i.e. the following:

$$dI/dt = (1/A'') \cdot [-\partial u /\partial k + (\Phi^o + g)A'] [1 - (\beta/t)] + z \cdot g \qquad (18$$

$$dk/dt = I - gk \qquad (2$$

which yields the conditions

$I^* = A'^{-1}[\partial u/\partial k)/(\Phi+g)]$ for the locus *(dI/dt)=0* and

$I = g \cdot k$ for the locus *(dk/dt)=0* .

Therefore, the system composed by equations 18 and 11 yields a result which looks at a first sight very similar to the one of the standard neoclassical investment model. However, some relevant qualitative difference can be found in the long-run dynamics in the presence of an exogenous shock in the profits.
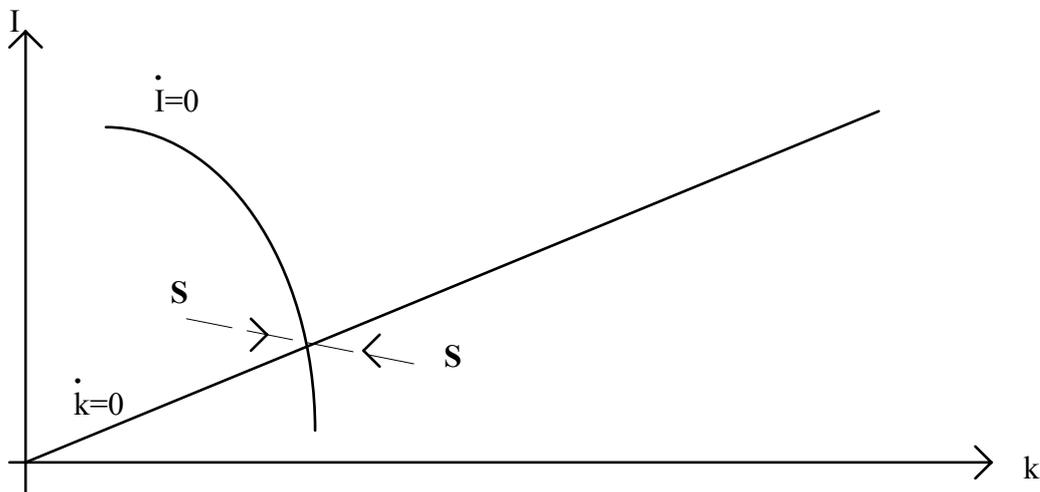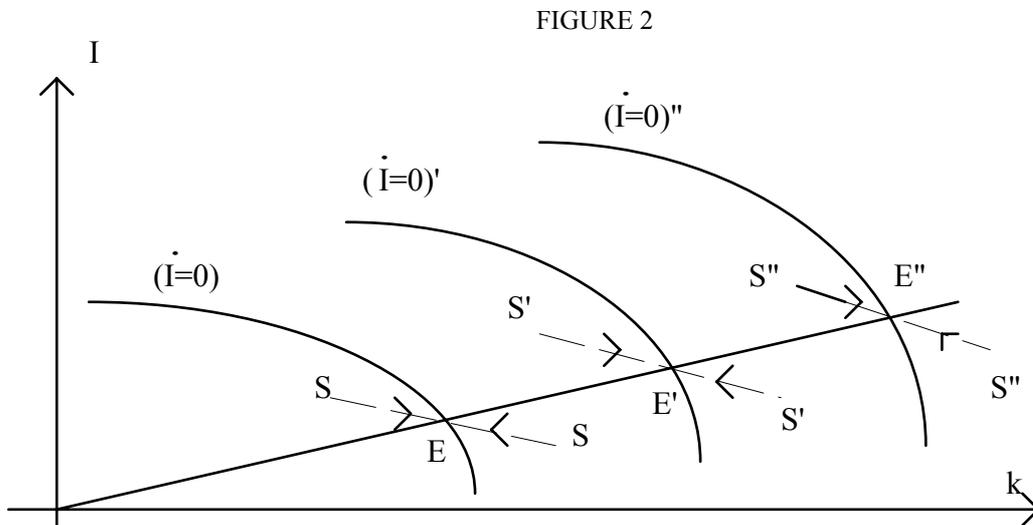

FIGURE 1

In the figure, SS is the stable saddlepath. In this case $\partial u/\partial k$ is the "marginal profitability" of capital (and not the marginal productivity of capital), which depends on

the profit rate. A few significant qualitative differences from the standard neoclassical model appear if we look at the effects of a perturbation in $u(t)$, given the interaction existing between this variable, the rate of discount, and the leverage ratio.

Let us assume that $A'>0$, that $A''>0$, and that the profit function $u(t)$ is homogeneous in k, so that an increasing monotone and differentiable function $f(\cdot)$ exists such that $\partial u/\partial k = f(u/k)$. This means that a disturbance in $u(t)$ would also imply a disturbance in $\partial u/\partial k$. Let us consider a medium firm which does not issue securities in the stock market. The cost of financial capital for this firm will be Φ^*, which includes a risk premium.

If this firm does not issue any shares in the stock market, or if we ignore the process of information spreading taking place in the financial markets our investment model would be exactly identical to a standard neoclassical investment model. The same would happen for $\pi<0$.

On the other hand, if the firm obtaining technical innovation decides to issue shares in the stock market, it will take advantage of the process of information spreading (described in this and in the previous section) that reduces asymptotically the risk premium. According to our assumptions, however, this process of information spreading generates a link between profits and the cost of financial capital. If, for example, an exogenous shock in the profits $u(k,w|v_i)$ takes place, two effects on the long-run equilibrium can be detected. First, by affecting $\partial u/\partial k$, the shock moves the locus $dI/dt=0$ to a new position $(dI/dt)'$. Second, when t is not infinite, a causal (time dependent) link between π and Φ exists, so that the initial exogenous shock in $u(k,w|v_i)$ would generate effects in the cost of financial capital and in the "financial side" of the firm decision. The asymptotic equilibrium E" is determined by the "real shock" (from E to E') and by the "financially induced shock" (from E' to E") determined by the process of information spreading (described in the present and in the previous sections) which allows the (profitable) firm to consolidate its reputation and reduce the risk premium and the cost of financial capital until the (asymptotic) level of the perfect information cost of capital r_s^o.

FIGURE 2

An initial unexpected disturbance in $\partial u/\partial k$ would shift the locus $dz/dt=0$ away from the initial equilibrium E to E'. However, to the extent that $\Phi^*(\pi)$ is affected by $u(t)$ (since $\Phi^*(\pi)$ is a function of $\pi=[u(t)-A(I(t))]$), the initial disturbance may also affect the financial variables of the problem (altering the "slope" of dz/dt) and determining (asymptotically) the new equilibrium E".

Furthermore, an exogenous negative shock in $u(\cdot)$ would affect I^* through two channels: the "real one", which is captured by the link between $u(\cdot)$ and $\partial u(\cdot)/\partial k$, and the "financial one", which is captured by the functional link $\Phi(\pi)$.

If (for $t>0$) at some point we have $\pi>0$, the risk premium on the cost of finance reaches the constant value ξ^* attributed to risky firms. In this case, the functional link between the profits π and the rate of discount Φ would disappear, and we would have again the common (and less interesting for our purposes) standard neoclassical investment model.

Our model introduces therefore an additional channel of transmission of the shock on profits generated by technical innovation that can amplify the fluctuations in the optimal level of investments generated by the original exogenous shock. In might be

interesting to note, incidentally, that this last result is consistent with the implications of the "excess sensitivity" literature.

4. Interpretation of the results and policy considerations

The results of the model suggest a feedback mechanism among profits, the cost of capital, and firm's investments. The nature and characteristics of this feedback depend upon the assumption one makes about the relationship between future profits, the price of the firm's shares, the yield on shares, and, how the cost of debt is affected by the behaviour of stock prices (i.e. whether and how the risk premium on firm's debt reacts to the information revealed by the behaviour of stock prices).

By simplifying the feedback mechanism between profits and the cost of financial capital, it has been shown that the interaction between financial and investment decisions introduces an additional "financial" channel of causation between profits and real investments. This "financial" channel can potentially amplify the effects on the investments of an exogenous shock in the profits of the firm. This last result is broadly consistent with the implications of the literature on "excess sensitivity" of investments to firm's cash-flow.

In the interpretation suggested here, the "financial channel" would amplify the effects on the profits of the firm determined by technical innovation.

Furthermore, the existence of a causal nexus (determined by the process of information spreading associated to the negotiation of securities in the spot financial markets) between profits and cost of external capital also accounts for the different credit price conditions granted by the banks to heterogeneous firms. Such an heterogeneity among different firms in their ability to borrow is also a typical assumption of the macroeconomic "creditist" models.

The model can be used to analyze the effects of public policies to incentivate innovation and investments in R & D.

Public policies consisting of tax incentives for firms that have documented a certain level of expenditure in R & D (for instance beyond a certain threshold defined in percentage of the sales), have reported patents (therefore have provided evidence of product innovation), have issued shares on the stock market beyond a certain threshold of their own capital (and therefore have contributed to increase the size of the market for firms' control and, more in general, the size of the stock market) and have obtained positive profits for a certain period of time after issuing shares could, in term of our model, have a double impact on the level of investments in R&D.

First of all, there is an impact on the flow of profits: Technological innovation in itself would increase the profit flow of the firm who has successfully performed investments in R&D. Tax incentives would increase the firm's payoff in case of success; on the other hand, in case of unlucky and unsuccessful investment in R&D, in case the profits are still positive, some new patents are documented and the firm has issued shares on the stock market, tax incentive would still improve the result of the firm and, therefore, make less negative the situation of the firm in case of unlucky outcome.

Secondly, another impact could be given by a reduction in the cost of finance, carried over by the process of information spreading that would take place in financial markets and would convey the information of successful outcome of the investment in R&D: the consequent reduction in the risk premium (both on debt and stock issued by the firm) would reduce the discount factor of the future flow of profits: this would also increase the incentive for the investment in the piece of capital that has been the object of successful expenditure in R&D .

Policies consisting of tax incentives could be preferred to direct public investments, because they would reduce the problem of monitoring the quality of the investments and the management ability by forcing the firms willing to get fiscal advantages to face the "stock market valuation". By looking at the behaviour of the stock price it would be possible for the policy maker to assess and monitor the effectiveness of the innovation

policies and, in this way, tax advantages for the firms responding to the above mentioned requirements would reduce the degree of discretionarity of the public investments.

Such a policy choice would act on the randomness and intrinsic riskiness of the expenditure in R&D performed by the firms and would increase the firm's payoff in case of successful technological innovation, determined by the R&D expenditure.

Finally, in some "bank oriented" financial systems, where financial markets have not yet been widely extended (see Allen and Gale, 2000 in this regard) and the market for firms control is not always associated to the market for shares, policies consisting of tax incentives for the expenditures in R&D associates to issuing shares in the stock market could create the public good "competition in financial markets" and in the market for firms' control. If, as argued by Rosenberg (2000, 1982) a wide historical and empirical evidence for the U.S., has suggested that technological innovation, in many industries has been successfully introduced, by new entrants rather than incumbent dominant firms, the above mentioned mechanism of fiscal incentives would both create incentive for new firms to enter the market and for the incumbent dominant firms (usually already well present in the stock markets) to increase their expenditure in R&D in association with issuing new shares.

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