INNOVATION AND FINANCE: THE THEORETICAL LINKS

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1. Introduction
   The theoretical connections between innovation and finance can be analysed through different approaches, by emphasising distinct specific features of these two activities. On the one hand, innovative processes are characterized by extreme uncertainty, assets’ intangibility, relevant asymmetrical information and moral hazard problems (Hall, 2002; Akerlof, 1970); on the other hand, financial systems, composed by markets, institutions and instruments, have constant functions and changeable structures (Levine, 1997, 2004; Rybczynsky, 1974; Zysman, 1983). Then, do the characteristics of innovative activity shape financial systems and modify their performances? Furthermore, do financial systems influence innovative activity in the execution of their functions and through their different components?

   Schumpeter (1951) introduced the idea that, because of their characteristics, innovative activities can be difficult to finance in competitive market places. He suggested that efficient financial intermediaries can stimulate technological innovation by selecting and funding the most promising entrepreneurial initiatives. King and Levine (1993) developed this view, through a model which shows that efficient financial intermediaries and markets can facilitate the introduction of technological innovations in the economic system. Moreover, Block (2002) and Mayer (1996) demonstrated that different financial structures can determine divergences across countries with respect to their capacity of promoting innovation in specific industrial sectors. Dosi (1990) modelled the impacts of different financial structures on industrial innovation, confirming that specific financial setups exert different influences on the performances of innovative activity at the sectoral level.

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Venture capital, together with public support to R&D, often represents an ideal instrument for start-ups’ financing, since it adapts to the features of innovative activity. Kaplan and Stromberg (2000) showed that venture capital contracts can be considered as a hybrid between a debt contract and an equity contract, depending on the firm’s performances, while Rajan and Zingales (2001) stated that the venture capital industry combines the strengths of both market-based and credit-based financial systems. Besides, Hayami (2000), Governor of the Bank of Japan, and Levine (2004) asserted that innovation is one of the most important causes of financial systems’ modifications in developed countries: in particular, the evolution of the I.C.T. sector reduces information costs and permits new subjects to enter the industry of financial services.

This paper is a theoretical analysis of the links between innovation and finance. It has the purpose to show, through a systematic and analytical methodology, that the nature of this relation is bilateral: on the one hand, finance, by its functions and structures, can have a primal influence on innovation processes; on the other hand, the characteristics of innovative activities force financial systems to find new ways to efficiently organize themselves and accomplish their functions.

The paper is organized as follows. Section 2 defines the concept of technological innovation and describes the characteristics of innovative activity. It also presents an analysis of R&D investment decision. Section 3 defines the financial system, illustrates its functions and distinguishes between market-based and credit-based systems. Section 4 shows the interactions between innovation and finance, focusing on each side of the relation. It is divided in subsections, analysing the functions of the financial system in promoting innovation, the impact of different financial structures on specific innovative sectors, the emergence of venture capital as a response to innovative firms’ needs, the effects of I.C.T. development on financial systems. Section 5 concludes.

2. Innovation: definition and characteristics

Technological innovation is undoubtedly a crucial factor for economic growth. It is defined by Schumpeter (1951) as “the commercial or industrial application of something new, such as a new product or process, a new type of organization, a new source of supply or product market”. The aim of an entrepreneur who invests on innovation is to obtain temporary monopoly profits. Although the role of individuals and organized groups is fundamental in this kind of process, Schumpeter analyses with particular attention the fundamental relationship between innovation and resource allocation, especially the allocation of financial resources, as conditioned by the microeconomic characteristics of innovative activity. Innovation depends on
the investment resources, and is generally developed by new firms led by new entrepreneurs\(^1\). Given these features, this type of activity often experiences a resource allocation problem. Schumpeter claims that this is due to the dynamics of the capitalist economy in the absence of innovation, defined as the “circular flow of economic life”: the economy would be in motion, but would constantly tend towards a stationary state. In such a situation, existing resources are fully utilized in the flow, so that it is difficult to find new funds to be invested in innovative activities. The introduction of innovations, in fact, interrupts the circular flow, but the economic system tends to return to its equilibrium. As innovation evolves in clusters, the economic growth process consists in an alternation of expansion and recession (O’Sullivan, 2003).

Hall (2002) interprets the resource allocation problem associated with innovative activity as a “funding gap for research and development”. Research and Development (R&D) is the activity performed by firms with the aim of producing new technologies or modifying the existing ones, and Hall evidences that underinvestment in it has persistent financial market reasons, determining the increase of the cost of capital associated with innovative activities. In fact, there is often a differential between the rate of return required by an entrepreneur investing his own resources on new projects and the one required by external investors for the same purpose. Therefore, it is possible that some innovations are not introduced in the economic system because of the unbearable cost of the necessary funds.

The first characteristic which determines the distinctiveness of R&D activity is the intangible nature of its assets (i.e. the firm’s knowledge base), which will possibly be concretized in new products or production processes. The importance of human capital in these firms is maximal, since the employees incorporate the knowledge as long as it is not made tangible. To avoid the loss which would occur when a worker leaves or is fired, firms tend to smooth their R&D spending over time, as though it had high adjustment costs. Therefore, the required rate of return to R&D is high due to the necessity to cover these costs (Lach and Schankerman, 1988).

The second specific feature of innovative activity is the high degree of uncertainty of its output, especially at the beginning of a new project, when hurdles have to be constantly overcome along a way which is initially unknown. Uncertainty resides both in the level and timing of future returns and in the amount of resources needed to complete the project. The success

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\(^1\) Economic theory and empirical research do not clearly identify an ideal dimension for innovative enterprises. Schumpeter himself, developing the concept of “creative destruction”, modified his opinion and stated that great firms, menaced by the potential competition of new products and processes, have the greatest chances of successfully introducing innovations through the investment of their internal financial resources (Schumpeter, 1960).
of the project itself depends on the combination of these two factors, thus the risk of failure is difficult to estimate. Since new firms are the principal source of this kind of initiatives, an efficient risk-adjusting method becomes essential.

According to a widely accepted group of economic theories (starting from the “lemons market” modelled by Akerlof, 1970), there are also some specific reasons why there is often a gap between the external and the internal cost of capital, independently from the investment’s typology: asymmetric information between the investor and the financier; moral hazard on the part of the investor (which may also be due to the separation between ownership and management); taxation and its implications on the different financing methods. These factors are often particularly significant in the context of innovative activity.

With respect to R&D, the asymmetric information hypothesis refers to the fact that an entrepreneur who tries to introduce a new product or process in the market is likely to have a better understanding of the probabilities of success of his initiative than a potential external financier. Since the uncertainty regarding the goodness of a long term oriented, R&D based project is necessarily higher than that of an ordinary investment, the additional premium required by an investor as a consequence of the asymmetric information problem will be correspondingly higher (Leland and Pyle, 1977). In addition, firms are reluctant to reveal the details of their innovative projects, for the reason that their knowledge could be revealed to their competitors, with potentially costly consequences. Some projects risk not to be realized because of these problems, therefore new funding solutions may be needed to reduce information asymmetry and its costs.

In the context of innovative projects, like in the other cases, moral hazard consists in the consequences of the conflict between ownership and management when they are separated and have different goals: in this situation, the investment strategies may not maximize the share value. One of the possible manifestations of moral hazard is the hesitation of risk adverse managers to invest in R&D based projects, to maintain the variance of their earnings as small as possible. One possible solution is to increase the long-term incentives of the managers. Another, more extreme and less frequently adopted possibility is to yield the control of the firm to institutions such as

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2 Arrow (1962) develops this argument and considers it as the origin of the resource allocation problem for innovative activity. He defines R&D as "non-rival": its primary output is the knowledge of how to make new goods and services, and its use by one firm does not preclude its use by another. To the extent that knowledge cannot be kept secret, the returns to the investment in it cannot be appropriated by the firm undertaking the investment, and therefore firms will be reluctant to invest, leading to the scarcity of R&D investment in the economy.
banks and insurance companies, which can monitor managers’ behaviour more effectively than individual shareholders.

Finally, taxation can determine the convenience of internal rather than external financing (Auerbach, 1984), but in the case of R&D, tax treatment can be slightly different in comparison with the one applied to ordinary investments. In fact, some countries offer a subsidy to R&D spending, and moreover, the after tax cost of capital can lower because of the spread between the economic depreciation of R&D assets and the depreciation allowed for tax purposes.

An analysis of the R&D investment decision, taking into account the specific features of this activity, can be realized through a modification of the standard neoclassical marginal profit condition (Hall, 2002). The user cost of R&D investment $\rho$ is defined as the required pre-tax real rate of return on a marginal investment that earns $r$ after corporate tax. The firms invest to the point where the marginal product of capital ($MPK$) equals $\rho$. If $\tau$ is the corporate tax rate, $\delta$ is the economic depreciation rate (i.e. the obsolescence), and $MAC$ is the marginal adjustment cost:

$$MPK = \rho = \frac{I - A^d - A^c}{1 - \tau}(r + \delta + MAC), \quad (2.1)$$

where $A^d$ and $A^c$ are the present discounted value of depreciation deductions and tax credits respectively. Often, $A^d$ is equal to $\tau$, because, in most financial accounting systems, R&D is expensed as it is incurred rather than capitalized and depreciated. Tax credit for R&D is frequent, therefore $A^c$ is usually positive, but if it is null, the corporate tax rate does not influence the investment decision.

This formulation confirms that some of the most important determinants of R&D investing are:

- tax treatment;
- the rate of return required by the investor, which, as explained before, is often higher than the one required for ordinary activities, and, furthermore, can differ markedly according to the origin of the financial resources;
- obsolescence, which is not constant and is determined by the rate of technological change in the industry;
- the marginal costs of adjusting the level of R&D investments.
3. The financial system: definition and functions

Levine (1997, 2004) asserts that the financial system is constituted by the markets, the institutions and the instruments which emerge to lessen the consequences of information and transaction costs. In addition, according to the economic literature, the financial system influences saving rates, investment decisions, technological innovation, and economic growth. Different types and combinations of information and transaction costs motivate the existence of distinct financial markets, institutions and instruments.

Although the mix of markets, institutions and instruments which provide financial services (the financial structure) can change in time and across countries, the basic functions of financial systems are substantially constant. These functions include allocating capital, mobilizing savings, easing the trading of goods, services, contracts and risks, and can be synthesized in a single, fundamental function: “facilitating the allocation of resources, across space and time, in a uncertain environment” (Merton and Bodie, 1995). Detailing this primary function, Levine (1997, 2004) lists the five basic purposes of financial systems:

- facilitating the trading, hedging, diversifying, and pooling of risk: financial markets and institutions can arise to improve the trading, hedging and pooling of two types of risks: liquidity risk and idiosyncratic risk. Liquidity is the ease with which assets can be converted into purchasing power or into a medium of exchange by agents, and liquidity risk is due to the uncertainties associated with this conversion. Information and transaction costs can intensify liquidity risk, and therefore lessen assets’ liquidity, whereas an efficient financial system can augment it. Idiosyncratic risk, instead, is referred to the uncertainty associated with individual projects, firms, industries, regions, countries, etc: banks, mutual funds and security markets provide several vehicles for trading, pooling and diversifying these risks, such as futures contracts, options contracts and swaps contracts;

- allocating resources: the main obstacle when allocating resources are information acquisition costs that are often unbearable for an individual saver. Evaluating a great number of firms, managers and economic conditions is difficult and costly, and savers can be forced not to invest resources in activities about which they don’t have enough reliable data. Financial systems can act to lessen these costs, acquiring information about a large numbers of investment opportunities and allocating resources more efficiently (Diamond, 1984);
monitoring managers and exerting corporate control: financial systems can exert these roles with more efficiency and fewer costs with respect to individual investors. In fact, financial arrangements can oblige managers to exert their powers in the interests of the owners and external financiers; financial intermediaries can economize on monitoring costs by mobilising the savings of many individuals; efficient stock markets can promote corporate control; mobilizing savings: financial systems are the principal channel through which capitals from different savers are pooled together. This is important because it makes possible to use efficient scales for production processes, to hold diversified portfolios, to increase assets’ liquidity. Financial systems are able to overcome transaction costs associated with collecting savings from many individuals, and to obtain savers’ trust despite the asymmetrical information problem, therefore they have a unique role in this context; facilitating the exchange of goods and services: financial systems lower transaction costs, therefore they can promote and facilitate exchanges. Since specialization, the principal factor underlying productivity improvements, requires lots of costly exchanges, financial development will facilitate greater specialization and therefore improve productive efficiency.

Financial systems’ structure, that is the combination of the markets, institutions and instruments which exert the financial functions, differs across countries and evolves in time. Thus, financial systems can be classified in two main groups on the basis of the characteristics of their structure (Rybczynsky, 1974; Zysman, 1983):

- systems based on capital markets: in this case stocks and bonds are important long-term financing sources for firms. In contrast, bank lending is primarily used for short-term purposes. Agents, i.e. borrowers and lenders, meet across competitive markets and are helped by intermediary institutions. Entrance to and exit from financial holdings are simple processes, therefore the identity of the lenders can change frequently. Lenders themselves exploit this situation to exert their influence on firms. This system is adopted in the U.S.A., U.K. and the Netherlands;

3 If stock markets efficiently reflect information about firms, linking stock prices to manager compensation helps aligning the interests of managers with those of owners (Jensen and Meckling, 1976).
• systems based on credit: in these systems, financial institutions are more important than capital markets in providing funds to firms in the long-term. The exit process for lenders is difficult, thus financial institutions tend to have long relations with borrowers, and exert their influence in that context. This system is adopted in Japan, Germany, France, Italy and Spain.

In any case, the two financing mechanisms co-exist in each nation and are often both part of a firm’s financing sources. In every country, the particular combination of markets and institutions is the result of the interaction of a great number of variables, including historical evolution of financial regulation, production structure and investors’ behaviour.

4. Connections between innovation and finance

4.1. The financial systems and its impact on innovation: functional approach

The resource allocation problem can be solved, according to Schumpeter (1951), by an efficient financial system, and in particular by commercial banks: they create credit and induce technological progress by analysing, identifying, selecting and funding those entrepreneurial initiatives which have the best chances of introducing new products and new production processes in the economy.

Encouraging innovation is not the only task of financial systems, but given the increasing importance of dynamic firms, and given the importance of innovation in growth and job creation, this aspect is undoubtedly fundamental. As a matter of fact, financial systems, apart from promoting economic growth through an efficient allocation of capital, can have an important role on the innovation process, conditioning different aspects of its dynamics through each of the functions listed by Levine (1997, 2004):

• facilitating the trading, hedging, diversifying, and pooling of risk: with respect to liquidity risk, although the primary effect of a high assets’ liquidity is to make capital accumulation possible, there is also a secondary, indirect effect, which is strongly related to innovation. In fact, capital accumulation can permit entrepreneurs to undertake innovative projects, which are often complex and long-term oriented. If, thanks to the performances of capital markets and secondary securities markets in facilitating trades, long-term investments have a high liquidity, investors will have the possibility to maintain a satisfying control on their savings. Therefore, they will be motivated to fund long-term initiatives, and thus innovative ones, because of their high expected returns (Bencivenga, Smith and Starr,
1995). If equity markets are not liquid enough, financial intermediaries can anyhow have an important role: they offer liquid deposits to savers and invest the resources in a mixture of short-term investments (to satisfy demands on deposits) and long-term investments, facilitating innovative firms. With respect to idiosyncratic risk, financial markets, institutions and instruments can provide a good opportunity for trading, pooling and diversifying risks, affecting in this way technological change. Investing in innovative projects is less risky if the financial system makes it possible for investors to hold a diversified portfolio. If this happens, uncertainty will not discourage agents as much as it does if no risk-management is possible (Saint-Paul, 1992);

- allocating resources: financial institutions can use their ability to acquire and evaluate information to exert the function which Schumpeter (1951) attributes to commercial banks: selecting efficiently the most promising entrepreneurial initiatives (i.e. the ones which have the greatest chances of successfully introducing new products or production processes in the economy) and funding them, stimulating by this way innovation. Stock markets may have a similar role too: if they are large and liquid, this probably means that their agents will want to acquire the greatest possible amounts of information about firms, making it easier to allocate resources efficiently. The effects on innovation would obviously be positive because of the same mechanism which acts in the intermediaries’ case (Merton, 1987);

- monitoring managers and exerting corporate control: financial arrangements are the instrument which permits the capitals to flow to the best projects. With instruments like contracts, investors can exert their control compatibly with their limited resources and managers can increase firms’ leverage without determining additional monitoring costs for outsiders. This is particularly important in the case of young, innovative firms which have to rely on external funds. Financial instruments, institutions and markets, by improving corporate control, tend to ease capital accumulation and, consequently, promote technological change: new, innovative firms are among the ones which absolutely need to be easily controllable;

- mobilizing savings: financial systems can pool the savings of individuals in an efficient way, with important effects on development. A better savings’ mobilization will improve resource allocation, and therefore support innovative firms in their efforts finalized to the introduction of new technologies;

- facilitating the exchange of goods and services: there are important links between exchange, specialization and innovation. Efficient
financial markets will lower transaction costs, facilitating exchanges and, therefore, easing specialization. Consequently, productivity gains will become more frequent and complex, innovative projects based on specialization will be facilitated. According to Levine (1997), the role of financial institutions and financial instruments seems less important in this case: market’s efficiency is the primary precondition to higher specialization.

4.2. King and Levine’s model

King and Levine (1993) develop an endogenous growth model focusing on the links between finance, entrepreneurship and growth. Their objective is to describe innovation promotion as the primal channel, complementary to the one of capital allocation, through which every financial system influences economic growth. In the first part of their work they develop Schumpeter’s idea about the role of financial systems in stimulating innovation through a selection of the most promising entrepreneurial initiatives. This function is accomplished through two mechanisms: first, financial systems evaluate the potentially innovative projects, then they fund the ones which have the greatest probabilities of being successful. The immediate effect of these processes is a lowering of the costs associated with technological changes, which thus become more frequent.

The approach consists in identifying four functions of financial systems, for which the model generates a demand: evaluating entrepreneurial initiatives; pooling resources from different savers to allow the realization of great-scale projects; diversifying risk to reduce innovative activities uncertainty; evaluating expected returns for innovative projects to provide concrete incentives for pursuing them. According to King and Levine, financial institutions provide the first two services, while financial markets exert the third and the fourth function.

The model is based on a hypothetical economy in which there are many individuals, each with an endowment of $N$ units of time and a constant financial wealth, represented by a claim on a diversified portfolio of firms’ dividends. Some of them are able to manage innovative activity, therefore they are potential entrepreneurs, but this capacity doesn’t modify their level of wealth.

4.2.1. Selection of entrepreneurial initiatives

Each potential entrepreneur has the additional endowment of a project, which can be realized successfully with a probability $\alpha$, depending on the skills of the individual. These capabilities are unknown to both the potential entrepreneur and the financial intermediary, but can be investigated at the
cost of \( f \) units of labour input. The market value of an entrepreneur whose skills are known is \( q \), and the wage rate is equal to \( w \). The market creates a demand for this financial systems’ service, therefore, if the rating industry has to generate positive output and there are not shifts in the productivity of labour, competition among these organizations is based on the following condition:

\[
\alpha q = wf \tag{4.1}
\]

This means that the expected income generated by financial organizations through the evaluation of potential entrepreneurs (\( \alpha q \)) has to be equal to the cost of that activity (\( w f \)).

4.2.2. Financing of potential innovators

To begin exerting his activity, an evaluated entrepreneur needs to use \( x \) units of labour, including his own, without knowing the final result of his initiative. The wage rate is still \( w \). After that the required investment, equal to \( wx \), has been done, the probability of success is equal to \( \pi \).

As Schumpeter (1951) suggests, a success in innovative activity permits the entrepreneur to obtain temporary monopoly profits, thanks to the possibility of producing a particular good or service with low costs in comparison with the competitors. King and Levine define the present value of these profits as the stock market value of the incumbent firm. If \( \rho_{t+\Delta t} \) indicated as \( \rho \) is the discount factor for cash flows from \( t \) to \( t+1 \), and \( \nu_{t+\Delta t} \) indicated as \( \nu' \) is the expected stock market value of being an incumbent firm, the future gross profit of an innovator is \( \pi \rho \nu' \).

To obtain the expected innovation rent, it is necessary to deduct the labour cost \( wx \), and to consider the tax rate \( \tau \) which will be applied on the income generated by a successful activity, representing the cost of the financial resources provided by the intermediary (that is intermediary’s remuneration). In fact, the external funds are fundamental in this framework, because it is supposed that the \( x \) units of labour required for being an innovative firm cannot be limited to the entrepreneur’s own time (otherwise it would be \( x=1 \)). Therefore, in all likelihood, the entrepreneur will have insufficient resources to cover labour costs (since \( x>>1 \)) and will need financial intermediaries to provide external funds. The innovation rent corresponds then to the market value of a rated entrepreneur, previously indicated as \( q \), and can be expressed as:

\[
q = (1 - \tau) \pi \rho \nu' - wx \tag{4.2}
\]
If the discount factor, $\rho$, is constant in the long term, the entrepreneurial selection condition (4.1) and the innovation rents condition (4.2) imply that the growth rates of $q$, $w$, and $v$ must be equal in the long term.

### 4.2.3. Equilibrium in the intermediaries sector

The equilibrium for the financial intermediation sector can be obtained through combining the two conditions which describe the functions of the sector itself: the entrepreneurial selection condition (4.1) and the innovation rents condition (4.2). Starting from the expected gross profit of an innovator, $\pi_\rho v'$, we have:

$$\pi_\rho v' = (q + wx)/(1 - \tau)$$  

The expression $(f/\alpha + x)/(1 - \tau)w$ synthesises the combination of the different factors which represent the requirements of innovative activity: the full labour necessity, including both evaluation resources per funded project $(f/\alpha)$ and direct labour in the firm $(x)$, and explicit and implicit financial sector taxes $\tau$.

### 4.2.4. Stock markets’ role

Stock markets have two specific roles in King and Levine’s framework: they determine the value of firms on the basis of rational investors’ analysis and represent the primal way to diversify the risks associated to the claims on different firms.

The firms are evaluated on the basis of the fact that when an innovator becomes successful, correspondingly to the access of that firm to monopoly profits, the previously dominant firm experiences great losses, which have immediate negative consequences on the stockholders’ financial gains. In fact, dividends $\delta$ are regularly distributed. The market value of a representative incumbent firm is indicated by $v_t$, and the risk of capital losses due to the success of a new innovative firm is diversifiable (individuals are neutral to risk). This is a further reason why innovative firms are likely to use external funds to achieve their objectives. This risk must be taken into account as the probability that some of the firms of a specific industry succeed in introducing a new product or production process. Therefore, it must be proportional to the number of entrepreneurs which exert their innovative
activity in the sector: if this number is defined as $e$, the probability that some firms of the industry will effectively innovate is $\Pi = \pi e$.

At this point, the equilibrium condition for the financial market sector, i.e. the expected profit for holding a share of stock from $t$ to $t + \Delta t$ is:

$$\left(1 - \Pi\right)\rho_{t, t+\Delta t}V_{t, t+\Delta t} = V_t - \delta_t$$

This condition (4.4) implies that the expected discounted value of the future stock value, taking into account the probability of capital losses, is equal to the net firm value after dividends distribution.

4.2.5. Summary

After evidencing the connections between finance and innovative activity, King and Levine develop their framework by describing the links between innovation and economic growth, through the endogenous technological change theory, and finally they present an empirical analysis and conclude that financial systems have a primal role as an accelerator of economic growth. However, the first part of their contribution is obviously the most important one if we concentrate on the nexus between finance and innovation. Confirming the validity of both Schumpeter’s early theories and the functional approach, the analysis shows that financial institutions (or alternative instruments) can be fundamental in selecting the most valid innovative projects and for providing external resources to finance them. Financial stock markets, instead, allow agents to diversify the risks associated with innovative activities and evaluate the potential earnings of an entrepreneurial initiative. All these elements indicate that an efficient financial system can improve the frequency with which innovations are successfully introduced in the economy.

4.3. The financial system and its impact on innovation: financial structures

Although the basic functions of financial systems remain substantially constant in time and space, the financial structures are often completely different from one nation to another. As financial systems (including ownership structures and corporate governance systems) differ markedly across countries, they may have different impacts on national performances in the innovative activity. It may actually happen that a particular financial

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4 Allen and Gale (2000) argue that market-based financial systems are superior to credit based ones in promoting innovative industries which are characterized by sparse information and high levels of uncertainty. Under these conditions, rational disagreement about what the best
structure results to be efficient in promoting innovation in some specific sectors of the economy rather than in others.

Therefore, as Block (2002) shows, differences in national capacities of improving the innovative activity’s performances can be explained through an analysis of the differences in the correspondent financial markets, institutions, and instruments. The success of the U.S.A. in some innovation fields and the contemporary crisis of Europe, which lead to opposite consequences in terms of economic growth, can be considered, from this perspective, as the result of the differences in their financial structures.

In this kind of analysis, the focus is on the fact that the impact of a country’s financial system on its innovative capacity cannot be properly analysed at the national level, i.e. from a general and global perspective, but must be considered separately for each sector-specific type of innovative activity. In fact, although financial institutions evolve at the national level of the economy, innovation processes are strongly connected to the sector in which they are developed. Therefore, a certain organization of financial institutions and markets can respond to the requirements of some, but not all the industries.

A predominance of a large and liquid stock market, associated with a competitive banking sector and good accounting standards, can lead to the inconstancy of the flows of financial resources towards industries. However, the flexibility in the allocation of firms’ ownership and control which is inducted by this situation can permit agents to pursue those activities which are characterised by rapid changes in technologies and management practices (i.e. product innovations), and require frequent reorganizations. In addition, large stock markets can provide important incentives for traditional investors, venture capital firms, or employees in new companies to supply resources for innovative firms (e.g. through stock options).

By contrast, a bank oriented, credit based financial system which determines strong and concentrated ownership structures can have the best results in promoting those innovative activities which are characterized by an extreme organizational complexity and therefore require the stakeholders to commit themselves to the firm’s project in the long term (i.e. process innovations). Bank systems encourage and reward this kind of stakeholders’ behavior, motivating investors to supply funds, because financial projects are is likely to be present. Market-based systems populated by a multitude of investors are good at handling the resulting diversity of opinion, and consequently, these sectors can grow faster by raising the number of innovative projects financed. On the contrary, Petersen and Rajan (1994) evidence the effects of banking sector concentration on innovative, entrepreneurial firms, showing that it allows for the inter-temporal sharing of surplus between firm and creditor. Hence, concentrated banking sectors should enhance the growth of new sectors because they guarantee low-cost funding in the early stages of a firm’s development.
intermediaries tend to induce firms to complete their projects in order to avoid conflicts over information sharing.

In conclusion, as Mayer (1996) suggests, the most important aspect of financial structures for promoting innovative activity is perhaps the exit possibility for early stage investors. If the financial system is based on credit rather than on capital markets, lenders don’t have the opportunity of pulling out easily of their investments, with two possible effects: funds that could have been moved into other innovative projects are immobilised, and the agents’ willingness to engage in early stage investments can lessen. On the other hand, stable relations between borrowers and lenders can provide an incentive to banks to engage in long-term credit provisions for uncertain projects. Therefore, there is not such a thing as an ideal typology of financial structure for the promotion of innovative activity: the two systems provide different frameworks, which favour different kinds of innovative projects.

4.4. Dosi’s model

Dosi (1990) defines innovation as a process of learning and discovery about new products and production processes, in which uncertainty dominates in the early stages. Innovative projects are selected and shaped by financial markets and institutions, through the application of the criteria which regulate the allocation of resources to business enterprises. These criteria thus affect the amount of resources which the industries devote to the innovative process, and the direction of such activity.

Dosi’s analysis is focused on the environments which are explicitly assumed to be non-stationary, implying that technologies and organizations change over time. Consequently, agents continuously try to exploit the opportunities of creating a better product or production process, provided that they expect that the cost of the initiative will be lower than (or equal to) the expected economic benefit from its successful exploitation.

Although it is possible to separate the opportunities available at each time and the equilibriums that rational agents correspondently achieve, there is not separation between opportunity drifts and economic adjustments. This means that opportunities (what the agents consider possible to achieve), incentives (what is effectively achieved), and capabilities (the required skills) evolve constantly and endogenously and are dynamically linked. Therefore, innovative initiatives are oriented both to pose and to solve problems, and uncertainty is related to both the aspects of the process. Hence, innovative activity has a problem-solving nature and is path-dependent and institution-dependent: agents’ efforts depend on previous researches and on the incentives to research in some directions and not in others.
4.4.1. Evolutionary systems

Dosi defines non-stationary environments with technological and organizational change as “evolutionary systems”. They are characterized by two fundamental properties: learning and selection. Therefore, differences in their structure (e.g. firms’ size, etc) and performances (e.g. rates of innovation, etc) are due to different underlying modes of learning and selection.

Financial structures are linked to innovation through the influence which they exert both on the rates at which firms learn and on the criteria by which environments select among firms and technologies. In addition to the uncertainty problem, an analysis of evolutionary environments must comprehend the effects that current patterns of finance allocations are likely to have on the future capabilities of a given economic system to innovate.

4.4.2. Learning and selection: finance, diversity and evolution

In evolutionary systems, diversity among agents in terms of competences, behaviour and expectations is positively correlated with the long-term performances of the economy. This Dosi’s hypothesis has relevant implications in financial systems’ allocative criteria.

If efficiency was the primary aim of resource allocation, financial system’s criteria would be based exclusively on the past and expected results of a given type of project, and the worse ones would be discarded. The financial system would thus operate as a selection device. However, it is not certain whether more efficiency also implies better performances in innovative sectors or not. In fact, under non-stationarity, and because of innovative activity’s uncertainty, long-term aggregate performance might not be always positively related to the efficiency of the selection rules by which financial investors discriminate among alternative utilizations of their funds.

Therefore, financial markets and institutions may have to face a trade-off between static efficiency, defined as the opportunity cost of given resources at any time, and dynamic (or Schumpeterian) efficiency, defined as the capacity of economic systems to generate innovation and adapt to unforeseen changes. A high static efficiency can be reached through a tight discipline imposed to firms by financial institutions’ behaviour. This would increase the mean and decrease the variance in the performances of the single enterprise. However, the mean performance of the system in a future time $t+1$ may be positively related not to its mean performance at time $t$, but to its variance at time $t$. Dosi synthesises this trade-off by hypothesising that the competition process in product markets leads to variations of firms’ market shares (see
also Silverberg, 1987). If $f_i$ is the rate of change of the market share of the $i$-firm, then:

$$f_i = A[E_i - \bar{E}]f_i$$  \hspace{1cm} (4.5)

where $E_i$ is the competitiveness of the $i$-firm, and $\bar{E}$ is the average competitiveness of the industry ($\bar{E} = \sum E_i$). The competitiveness of each firm can be considered as a vector $\mu$ representing its production technology, product characteristics, organization, etc. While static efficiency is measured by $E_i$, dynamic efficiency depends on the variations of the components of $\mu$. Only if there is complete cumulativeness of technological changes, static and dynamic efficiencies are always positively correlated, which implies that the best firms at time $t$ continue to excel at any time $t + \Delta$. Conversely, if the best firms in the present are going to be the worst ones in the future, the financial system has to constantly choose between exploiting what is revealed by experience and trusting new initiatives with uncertain results. Empirical environments fall somewhere in between these two extremes, thus the trade-off between static efficiency and dynamic efficiency is always present, in various degrees. Therefore, diversity in agents’ competences, behaviour and expectations can have positive effects on the innovative performance of an economic system, and in some cases financial markets and institutions should pursue numerous alternative, uncertain projects.

4.4.3. Evolutionary properties of different financial systems

Market-based and credit-based financial systems differ markedly in the ways in which they deal with the trade-off between static efficiency and dynamic efficiency. In credit-based systems, as Dosi shows, learning is usually more important than selection, thus processing competences are high, but many opportunities are not exploited, because institutions consider few alternative projects before allocating their resources. Therefore, the more knowledge is asymmetric and scarce, the more credit-based systems will be dynamically-efficient. These conditions are frequent in industrialising countries, in which long-term commitments between lenders and borrowers are required to accumulate technological competences, despite unfavourable short-term profitability.

Conversely, marked-based systems are frequently more attentive to the analysis and selection of new innovative initiatives, provided that success probabilities are high and that innovative competences are diffused throughout the economy. In addition, a necessary condition for the dynamic
efficiency of a market-based system is that it must operate near the technological frontier.

The potential conflict between static efficiency and dynamic efficiency may also apply at the level of individual companies. In fact, other things being equal, in credit-based systems, industrial growth will occur principally by the way of diversification of existing companies, while in market-based systems it will be mainly due to specialization in high profitable activities. None of the two solutions can be considered as the best one from the point of view of long-term innovative performance.

4.4.4. Summary

Dosi describes the properties of financial systems’ structures in environments where innovations continuously occur through trial and error search processes, and opportunities for agents are exploited depending on their innovative capacities. Financial systems’ performance is determined by the patterns which regulate the financing of experimented activities and new initiatives: specific financial setups, with their mechanisms of allocation, control and ownership transfer, exert different influences on the rates and modes of industrial innovation. Since these effects are ambiguous at the aggregate level, they can be properly evaluated only through a sector-oriented approach. Block (2002) substantially confirms these results with an empirical analysis which shows that complementarities between financial infrastructures and complex organizational innovation processes can help to explain observable differences in national industrial structures. Specifically, market dominated systems are relatively better at promoting innovation activities characterized by high technological opportunity and a focus on product innovation. On the contrary, insider systems in which market allocation of funds and ownership is limited are compatible with innovation regimes characterized by higher levels of cumulativeness of knowledge, such as process innovations.

4.5. Innovation and its impact on the financial system: venture capital

According to Hall (2002), since the problems of asymmetric information and moral hazard are particularly relevant in the field of innovative activity, firms’ retained earnings often become the ideal source of funds for such enterprises. Still, when innovation is brought by new entrepreneurs external

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5 Aghion, Bond, Klemm and Marinescu (2004) show empirically that mature innovative firms tend to use less debt finance and are more likely to raise funds by issuing shares in comparison with less innovative enterprises.
finance is a fundamental resource. Therefore, more effective solutions for the problem of financing young firms are needed, and public support to R&D, together with alternative funding sources, can represent a good response.

Many governments, both in the United States and in Europe, provide some form of assistance to young, innovative firms, e.g. through direct funding, tax reliefs, appropriate fiscal treatments of investments, by developing mechanisms for innovation risk insurance and by encouraging banks to provide long-term loans. However, these policies’ effectiveness is difficult to estimate, because it’s not possible to know how beneficiary firms would have performed without them, and, in addition, there are many spillovers and trade-offs between the separate measures.

King and Levine (1993) suggest that the role of financial institutions in selecting and funding promising entrepreneurial activities can also be exerted by other financial subjects, such as venture capital firms. Venture capitalists are financial intermediaries who combine financial skills with technological expertise, and are organized in funds with a limited term of life or as companies. They form an industry which is focused on helping new and small firms by funding innovative projects in exchange for a part (the majority) of the firm’s shares. They operate by collecting funds from private and institutional investors and allocating them in young enterprises with high growth potential, bringing their professional advice together with financial resources. Doing so, they often increase the value of these firms and help them to grow faster.

Venture capitalists hold equity for an average of 5 to 7 years. When they are certain about the result of an innovative project, they sell off their shares, preferably on the stock market after the quotation procedure, in order to generate a capital gain. Thus, venture capitalists have a financial objective: they are not themselves entrepreneurs, and their contribution of advice and expertise is provided in order to create value in the firm they are funding. The equity is sold on the equity markets or through a buyout by a larger corporation (trade sale). If the funded firm goes out of business, the venture capitalist loses his initial investment (write-off). If the funded firm gets into difficulty, the venture capitalist can in many cases cut his losses, by selling his equity at a written–down value to other venture capitalists or to the managers of the company concerned. At macro-economic level, venture capital industry’s performances tend to be pro-cyclical, but it’s difficult to clarify the interactions between growth and the supply of funding (Gompers and Lerner, 1999).

The venture capital industry represents, especially in the United States, but also in Europe, an effective solution to the problem of financing

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6 For a systematic analysis of public incentives to innovation, see OECD, 2005.
innovation (Bottazzi and Da Rin, 2002). In fact, it can be an alternative to financial institutions and ordinary stock markets, because, with respect to venture capital firms, the problems of asymmetric information and moral hazard are mitigated, and the additional premium required by the financer is reduced. In fact, the specific characteristic of innovative activity, such as assets’ intangibility and uncertainty, are faced with a more proper approach. If the venture capital contract is well designed and is suitable for the specific situation which it regulates, the investment managers are better informed, and the level of monitoring is higher than that used in ordinary investments. Because of the exigency of tempering the difficulties associated with the financing of innovative projects, venture capital contracts are often complex, and include clauses for the allocation of cash flow rights, voting rights and liquidation rights, which are usually dynamically linked with performance measures. Kaplan and Stromberg (2000) state that the complexity of the typical venture capital contract is inherent in its double nature: it can be considered as a hybrid between a debt contract and an equity contract, depending on the firm’s performances. If these are poor, the investors obtain almost full control on the firm, while if these are good, the control is in the hands of the entrepreneur (or the managers).

Anyhow, institutions and markets in which the venture capital industry is inserted have a great importance. As showed by Rajan and Zingales (2001), venture capital industry can represent, once more, a hybrid, because, like stock markets, it can provide strong incentives to the firms’ managers and in the same time, like banks, it can improve the monitoring activity. Nevertheless, the presence of an efficient stock market also consents venture capitalists to adopt better exit strategies, allowing financers to reinvest their resources, and entrepreneurs to regain control of their firms, thus facilitating even more the innovative activity. As a consequence, market-oriented countries often feature the highest levels of venture capital, thanks to the existence of an active IPO (Initial Public Offering) market.

4.6. Innovation and its impact on the financial system: I.C.T. and finance

The recent, rapid evolution of information and communication technology (I.C.T.) is being one of the most important causes of financial systems’ modifications in developed countries. Hayami (2000), Governor of the Bank of Japan, claims that the most relevant consequence of technological innovation in the context of the financial services industry is the reduction of information costs, due to the increase in the speed and reliability of activities like data processing and data networking. As Levine (2004) states, “technological innovation substantially affects the operation of financial systems by transforming the acquisition, processing, and dissemination of information”. Computers and communications networks have greatly
improved the efficiency and safety of business, and have created the conditions for the advancement of the securitization process and the spread of new instruments such as derivatives, options and swaps. In addition, the Internet represents a new channel for financial services supply, with the characteristic of being independent from the networks of financial institutions, similarly to A.T.M. systems. Consequently, the cost of financial transactions has being drastically reduced.

These changes have also permitted non-financial firms to enter the industry of financial services, whose composition is thus changing continuously, especially in the specific sectors, such as payments and settlement, which result to be profitable opportunities for firms which don’t have the necessary characteristics to accept deposits or according loans. Recently, licensed non-financial firms have begun to be active in the securities field and to organize themselves to provide banking services, while security houses and banks often enter in each other’s sectors. In addition, traditional financial institutions are experiencing important reorganizations. These processes tend to consolidate them in greater subjects through merging and acquiring operations, with the purpose of improving their competitiveness by increasing their capacity of undertaking fundamental IT-related investments in strategic areas. Without the fast evolution of I.C.T., and the resultant reduction of entry costs, these modifications in the financial structure wouldn’t have been possible.

In any case, according to Hayami (2000), this type of innovation can lead to the rise of new and complex risks, which can rapidly diffuse. The consequences of technological changes are, in fact, extremely uncertain, so that the systems’ stability may be altered. Thus, an effective risk management and an equilibrated market discipline become key factors to conciliate efficiency and stability in financial systems.

5. Conclusions

This paper has examined the reciprocal interactions between finance and innovation through an approach which was articulated as follows. Financial systems may influence innovative activity by exerting each of their functions, and, simultaneously, through the different components of their structure, i.e. markets, institutions and instruments. At the same time, technological innovation can condition financial systems both indirectly, as its specific characteristics require the emergence of alternative funding solutions, and directly, since technological evolution modifies financial systems’ performances and transforms their structure.

Several results emerged. Firstly, efficient financial systems can promote innovation, and thus economic growth, by facilitating risk management, allocating resources, monitoring managers, mobilizing savings and
facilitating the exchange of goods and services. In particular, financial institutions select and fund the most valid entrepreneurial innovative initiatives, while financial stock markets evaluate their potential earnings and allow agents to diversify the related risks.

Secondly, divergences in national innovative capacities can be explained through an analysis of the correspondent financial structures. In fact, market-based systems favour the activities which require a dynamic approach and frequent reorganizations, i.e. product innovations, whereas credit-based systems privilege the activities which require the stakeholders to commit themselves to the firm’s project in the long term, i.e. process innovations.

Thirdly, the venture capital industry represents an effective solution to the resource allocation problem for technological innovation, combining the strengths of both market-based and credit-based systems. In fact, venture capital contracts are designed to meet the specific requirements of innovative activity and reduce asymmetric information and moral hazard problems.

Lastly, innovation in the I.C.T. sector reduces information and transaction costs and transforms financial structures, by permitting non-financial firms to enter the industry of financial services and inducing traditional financial institutions to consolidate through merging and acquiring operations.

Further, more detailed research could usefully focus on two main aspects. The first one is the role of financial systems in accelerating growth by helping the economy to effectively exploit technological innovation. The second one is the integration between public policy, venture capital and other instruments, e.g. business angels finance, aimed to generate the ideal services and conditions for innovative firms in each stage of their development.
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