FINANCE, INNOVATION AND THE VALUE OF THE FIRM

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Abstract

The traditional business corporation, emerged in the early 20th century, is facing dramatic changes, concerning the internal organisation, the crucial assets and the productive structure. In this paper, we will consider the firm as a "system", where knowledge becomes the crucial factor for a more realistic description of the internal workings of the black box, including the complexity of technology and the productive structure. From this framework, that permits to better assess the productive and organizational capabilities of the firm, with internal and external indicators, we try to make suggestions for a new financial approach, integrating some relevant variables in a model of incomplete contracts. We will present a path-dependent model applying this framework to debt financing, with the target of a more efficient project selection by a financial intermediary and the value creation for the economic system in which the firm is embedded.

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Introduction

During the last fifteen years, the traditional business corporation, emerged in the early 20th century, is facing dramatic changes, concerning the internal organisation, the crucial assets and the productive structure[1]. These changes have been accompanied by an increase in real interest rates and a strong demand for capital with effects of credit rationing and with a growing divide between the labor markets for skilled labor-force and the supply of low qualified, de-skilled workers. The opening up of world trade, that has increased the demand for process innovation and quality improvement, rising a global competition at the intermediate goods level with a consequent breakdown of the vertically integrated firm, has made evident that "*the firm is not anymore a well-bounded organisation that a theory of finance can take for granted while studying the impact of financing and governance choices*" (Zingales, 2000).

In this context, the traditional approaches on finance based on market imperfections, namely the asymmetry of information and the problems coming from the principal-agent bargaining, are not adding anything new on the analysis of corporate finance.

The literature on corporate finance relies mainly on *black-box* view of the firm and on the assumption of the public good character of knowledge, attempting to design models for firms with an optimal debt/equity ratio, feasible for a relatively stable long-term growth towards an equilibrium. In this approach, all techniques along a production function are equally and costlessly accessible, regardless of whether or when they have been practiced, without a proper consideration of the costs of learning routines, together with the consequence that these costs rise as firms need to leave recent practice, supporting in this way the tendency to adhere to prevailing routines[2].

In fact, the process of creative destruction is not automatic and costless. Instead, the potential complementarities between technologies are important, because often new technologies don't substitute completely the old ones, but co-exist with them, in the sense that efforts to advance technology today build from what the firm achieved yesterday. The central role of learning as

[1] See OECD (2000; 2003) and, among others, Harris and Raviv, 1991; Zingales, 2000; Golinelli, 2002.

[2] Because the departures from established routines can create occasions of conflict within an organization (between managers and shareholders, or managers and workers, or managers and managers) which tend to be costly to all participants, there is reason to avoid it by sticking with established routines.

main dynamic factor in the accumulation of tacit knowledge, can eventually activate a process of incremental technological changes (Rosenberg, 1976 and 1982) and for this reason the organization of firms appears now to be influenced also by the need to implement and valorise the complementarity of the bits of knowledge possessed and accumulated in the diverse units.
In addition, traditional investment literature still relies on the assumptions of quadratic adjustment costs and of capital homogeneity, in this way implying linearity in the dynamic adjustment of the firm's capital inputs. Recent investment researches (i.e. Caballero and Engel, 1999) have stressed, on the contrary, that the adjustment of the quasi-fixed inputs may or may not occur, depending on whether the marginal net benefit from investing exceeds (falls short of) a certain threshold value. Hence, the adjustment may be episodic and lumpy, rather than smooth for all the values of the marginal net benefits as implied by the traditional convex adjustment costs explanations of investment behaviour. This opens a new vision about the utilization by the firm of its resources, and about the relationship with the maximisation of the financial value.

The important suggestion for a new financial approach is the necessity of a more realistic description of the internal workings of the black box, where the complexity of technology and the productive structure of the firm are central points of the analysis.
Knowledge has become the crucial factor (Maturana and Varela, 1992). The significant progresses in the comprehension and the assessment of the role and the level of appropriability of knowledge in innovation processes, decomposing the knowledge itself and analysing systematically all the complementary factors that, within a dynamic model, influence rate and direction of the accumulation process, can be summarised in ***three new insights*** about the theory of the firm.
First, the firm is not only as a nexus of contracts, but rather a selective and selected combination of complementary activities based upon the capability to accumulate competence and knowledge. The creation of new knowledge and the introduction of new technologies are induced by a dynamic feedback where path-dependence, articulated in externalities and irreversibilities[3], plays a major role: innovation can be defined as a reaction to the continual mismatch between expectations and the actual conditions of factors and products markets.

[3] Irreversibility exposes agents to substantial losses and rigidities when their plans are not fulfilled and their expectations are not realized, and if the creative reaction is not appropriate and consistent, the system is kept within the standard conditions of the static equilibrium.

Second, the concept of knowledge as a public good has been eventually substituted by the new argument about the quasi-private nature of technological knowledge.
Third, the firm is a "system", which survives in a competitive environment only with an efficient combination of the resources and energies that are taken from the environment itself, and given back to it with a higher quality: this is the process of value creation (Miglietta, 2001).
All these points contribute to define a more accurate and complete description of the various economic subjects involved in the innovation process (and of the environment in which they are embedded), description that for the traditional theories is still a "black box".
In this work, the object of analysis will be not just R&D, but an entire complex innovative process, composed by many different factors. This opens a completely new perspective for the financial issue[4].

I The traditional models of the firm and their financial implications

The traditional approach to corporate finance has usually designed static models to diminish the inefficiencies caused by market imperfections. In the last decades some scholars started instead to merge the neoclassical equilibrium analysis with the schumpeterian tradition about innovation. This group comprehends the so-called "***endogenous growth***" theories (Aghion and Howitt, 1992 and 1998; Romer, 1986 and 1990). These theories are essentially macro-oriented, but for the scope of our analysis we will look at their micro-foundations and at their financial implications.

Writers like Schumpeter, Kuznets, Abramovitz and many others had long pointed out the importance of endogenous technological progress for growth, in contrast to the traditional general equilibrium theory, for which the product space is given, technology is given and firms are mere placeholders for technological possibilities available to everyone. The

[4] The relevance of these hypotheses is confirmed by the evidence provided by advanced economies at the end of the century, characterized by fast structural changes with the two parallel dynamic processes of diffusion of new information and communication technologies, and of production of knowledge as an economic good, with a crucial role of the irreversibilities in an innovation process characterized by network externalities and path dependent technical change. The focus of the new growth theories on the R&D investment, characterized only by the production of scientific knowledge which is generally a non excludable, non rivalrous, public good that can be made partially excludable when patented, and with returns that usually manifest with considerably longer lags than physical investment returns, it appears inadequate to represent this complex systemic process of technological change, and to constitute the basis for an original analysis to the problem of finance for modern firms.

neoclassical theory needed to be integrated paying more attention on technological innovation: maintaining at the same time several assumptions of the traditional microeconomic approach, the models of endogenous growth include the various forms of the technological innovation, like the introduction of new final products, new intermediate products, new technologies, new organisational forms and new markets, so necessarily taking to the specification of different sectors or different goods. The financial side of these models is based on the common problems of the studies on corporate finance, namely the "*costly external finance*", that assumes a hierarchy of finance's sources (so-called "pecking order" hypothesis), and the "*agency conflict*", which analyses the relationship between managers and shareholders with different objectives and valuations[5].

In the models of endogenous growth the specific feature of innovation is assumed to be the production of scientific knowledge, which is considered as a non excludable, non rivalrous public good, that can be made partially excludable when patented. The lack of tangible assets as collaterals is considered really problematic for finance, because returns of research and development activities (R&D) manifest considerably later than physical investment returns, and because during the intermediate stages of the investment process, usually the immaterial research output can be hardly marketed, but can be appropriated by competitors if some forms of disclosure occur, because of the assumption of the public good character of knowledge and the consequent low appropriability.

This vision has many consequences on the traditional signalling financing strategies, when for R&D investment the signalling benefit may be outweighted by costs of disclosing knowledge to competitors[6]. Another feature is the more relevant information asymmetry, because of the more complex technicalities of an R&D investment that are very difficult to be fully understood by a financier. The financing of investment for R&D-intensive firms is so more prone to moral hazard and adverse selection problems than is the case for other firms, given

[5] While the literature on "costly external finance" analyses the problems of corporate finance from the point of view of the firm, the "agency" approach looks at the problems of control by the external financiers on the firm's activities. The two approaches present two different points of view, and this difference is reflected by the role of the managers: while the former assumes that the managers behave in the interest of the firm, and so of the shareholders, trying to maximize the value of the firm, the latter, on the contrary, is based on the concept of the discrepancy between the objectives of shareholders and managers, assuming that managers are oriented to obtain personal advantages.

[6] The problems about market structure are also evident: while in traditional sectors with horizontal product differentiation new entries only reduce market share, in high-tech sectors with "vertical product differentiation", new entries may eliminate some of the incumbents from the market when certain conditions on the quality of products and on the distribution of income are met. This higher risk of exit has obvious consequences on the financial side, in terms of a more prudent leverage structure.

the absence of collateral value. These factors should greatly enhance the role of internal finance for such firms, with the same process as the one presented by Myers and Majluf (1984) and Myers (1984) in their "pecking order" theory. The existence of informational asymmetries in these firms is then considered to discourage outsiders from making accurate appraisals of firm market value and to augment the strategic importance of internally generated funds. In the light of this, the only solution suggested by the scholars it has been that financial intermediaries developed a more effective financial and technological monitoring capacity, with ***huge costs and hardly quantifiable results.*** Maintaining the traditional arrovian vision of knowledge, the scholars of the new growth theory stressed the advantages of each system (debt or equity) arising from the relative effectiveness in spreading information about firm prospects and research activity in order to create technological spillovers.

But is this an original solution? Looking at the debt contracts, it has been stressed by the financial literature that the defining feature of debt is the ability of creditors to exercise control. Jensen and Meckling (1976), Ross (1977) and Harris and Raviv (1991) already argued that leverage-increasing issues are generally viewed as positive signals because debtholders seem to monitor investors more closely than shareholders and also because limited free cash flow reduces the possibility that managers pursue non profit rent- seeking activities.

If, instead, firms are required to finance new projects by issuing equity, and investors are less well-informed than firm insiders about the value of the firm's asset, then equity may be mispriced by the market (Myers and Majluf, 1984). Underpricing may be so severe that new investors capture more than the net present value of the new project, resulting in a net loss to existing shareholders, taking to a rejection of a project even if it has a positive value.

It is now evident that the efforts of the new growth theory of designing a new endogenous innovation process without undermining the traditional view of the firm, do not add ***anything new*** to the theory of finance, that already assumes a crucial role of financial intermediaries in providing external finance since financial markets cannot do all the job, in particular to innovating firms.

The systemic view of the firm, assuming the variety of firms in terms of product and factor markets (Vicari and Cillo, 2006), explains the ***value creation*** as the result of the interaction and competition in the market place of agents, which are able to change their production

functions and can influence, to some extent, the utility functions of their consumers. In this context, the important factors involved in the systemic process are the accumulation of technological knowledge and the generation and adoption of new technologies, together with the institutional characteristics of the economics systems into which firms are operating. These arguments can pave the way to link firms and finance within an original approach, merging these conclusions about technological change, production and organisational structure of the firm with a different view on financial issues.

II The "systemic" nature of the firm and a new approach to finance

Firms can be defined as complex "organisms-systems" with the target of creating value, by sustaining a long term competitive advantage. The main point is that **firms do more than adjust prices to quantities and *vice versa***: they are also able, *via* various learning processes (learning by doing; learning by using; learning by consuming etc.), to manipulate interactively the basic structure of the system, so that technologies and tastes at time *t* are the outcome of the strategic interaction in the market place of agents at time *t-1*.

This view has posed its foundations at the micro level on the important contributions from the resource-based theory of the firm (i.e. Teece, 1998; Foss, 1998)[7]. Acknowledging the importance of Penrose's contribution, Richardson (1972) argued that successful firms tend to specialise in activities for which their capabilities provide a competitive advantage. The firm is treated as a dynamic collection of capabilities (i.e. the roles of organisation, knowledge, skills and experience) required to carry out particular functional activities, such as R&D, design, production, marketing, etc. Richardson helps to explain how firms grow along paths set by their prior possession of capabilities and how these capabilities themselves slowly expand and alter.

In this context, knowledge is assumed as intrinsically indivisible but, at the same time, dispersed in a variety of individuals, no one of which can claim to control it entirely: this is

[7] The resource-based theory of the firm has grown as a development and an application of the economics of learning, providing an alternative approach to analyzing the firm, where the emphasis is put on the process by means of which the firm is able to introduce technological and organizational innovations (Penrose, 1959). A distinction is made between resources and the services a firm provides. Resources are used by organisations with the specialised knowledge, experience and skills needed to provide a productive service. A firm is able to explore, experiment and innovate in the use of resources to provide new or an expanded set of services. Firms that have grown successfully in new areas of business have done so by establishing and maintaining "a basic position with respect to the use of certain types of resources and technology and the exploitation of certain types of markets", rather than by building a collection of unrelated resources (Penrose, 1959).

why the complementarity among individuals is central in the accumulation, generation and eventual valorization of knowledge. The firm is considered the institution that is better able to manage such complementarities in a market economy (Vicari and Cillo, 2006). So, the answer of the resource-based approach to the question raised by Coase (1937) about the necessity for the economy of the existence of an organization like the firm, is that **the firm can be defined primarily a governance mechanisms for the production of knowledge.**

Part of the economic literature directed the attention more towards the role of localized learning and technological cumulability, irreversibility and local externalities, arriving to define systematically the notions of "localized technological change", that had been introduced in 1969 by Atkinson and Stiglitz, and of "path-dependence", developed by David (1985 and 1997). The "technological path" substituted the trajectory as the new heuristic metaphor, explaining that technological change is introduced locally, by firms able to learn about the specific techniques in place and hence to improve them, into "technological paths" in which firms are able to innovate, and to increase the total factor productivity in a limited technical space, retaining the original production mix. This theory of induced innovation incorporates the intimate evolutionary connection between factor prices, the choice of technique and the rate and direction of technical change (David, 1975).

The importance and the role of non-convexities and irreversibilities in capital inputs has been now recognized also by several researches on investment (i.e. Dixit and Pindyck, 1994; Abel and Eberly, 1994, 1996; Caballero and Engel, 1999): these studies showed that the firm's capital adjustment is a non-linear function of the imbalances between desired and actual capital (the so-called "gap methodology"). In particular, the actual capital stock is referred to as mandated stock, while the desired stock is taken to be proportional to the frictionless stock. The frictionless capital stock, in turn, is the level of input that would hold in the absence of frictions at any time. Fixed costs, irreversibilities, and other forms of non-convexities may explain why traditional models of investment such as Tobin's Q and Euler equations, do not perform empirically well (Whited, 1994, 1998). Non-convexities alter investment dynamics both at firm and aggregate level, making optimal investment a non-linear function of its fundamentals. The firms do not consume production factors smoothly and entirely: the competitive advantage (and so the creation of value) lays in the ***optimisation*** of used resources, linking together financial and productive structure of the firm (Miglietta, 2001).

This is why the access to localized knowledge, the role of demand, the costs of production factors and the organisational structure selected after repeated interactions within the firms and in the market have to become the pillars on which a new model of finance can be built.
The process of value creation is in this way strongly linked with the dynamics of demand and factor prices, and it has important consequences also on the governance structure of the firm: competence constitutes a central production factor, which can be embodied both in the organization of the firm, in the stock of fixed capital, in the levels of human capital, in the relations with suppliers and customers and in the communication channels in place with the markets and within the company itself. Trough all these communication channels and learning processes firms create a network relation with their stakeholders in the economic environment, which conduces to the creation of value for the entire system (Rullani, 2004).
At any point in time in the market place, there is a competition among an heterogeneous population of firms of different size and age, with different factor costs, different techniques defined in terms of factor intensities, competencies, organisations and productivity levels. In this context selection, and growth, are the result of the failure-inducement mechanism, with a process of "adaptation" where least efficient firms will not be forced out of the market providing they are able to introduce new technologies.

The creation and implementation of organizational capabilities is crucial especially in a context of oligopolistic competition, providing dynamic for the continuing growth of firms involved in national and international markets. Such skills of the members of the organisation clearly depend on the organizational setting in which they have been developed and used, so that this type of knowledge is not, of course, patentable, but is instead company-specific and industry-specific.
The firm can be defined as a bundle of activities that are complementary with respect to the generation of knowledge and competence. So, new technologies are sorted out not only by their absolute levels of efficiency, but also with respect to their complementarity and compatibility with the installed stocks of fixed and irreversible production factors. Adoption of new technologies will be determined by the durability and irreversibility of internal factors such as the capital stock, but also the skills of human capital, the location in a given space, the relationships with customers and suppliers. The effects of technological "lock in" become, then, just a possible outcome of path dependent diffusion, as well as a "lock out" solution (Antonelli, 1999 and 2003).

III New insights on corporate finance

In a world of incomplete contracting the capital structure of the firm matters, because it induces a particular governance structure and not all governance structures are equally efficient with respect to project selection. Traditionally, the choice is between debt or equity financing, as seen in the above paragraphs. While the possible suggestions for equity finance coming from this new vision of the firm have been analysed in another work (Peirone, 2007), in this paper we will concentrate on debt finance.

A debt investor has a deeper relationship with the financed firm than an equity investor: in fact the investments by shareholders are largely sunk, and further investment in the firm is generally not needed from them. This is why shareholders have fewer protections from expropriation than the other stakeholders do. This is not the case of I_D, that instead has some guarantees for the non observable risks: these guarantees are the collaterals, which are, basically, the required residual rights on the capital goods used by the firm.
A financial intermediary is a firm that process information. As every firm, it works with a specific technology. In the financial literature this is called "lending technology". We can distinguish two different lending technologies, depending on the type of information used by the intermediary: transactions lending technology (or arm's length funding) and relationship lending technology.
Transactions lending technologies – such as financial statement lending, asset-based lending, and small business credit scoring – are primarily based on "hard" quantitative data. These transactions lending technologies are distinguished primarily by the source and type of information used: 1) financial ratios for financial statement lending; 2) the quantity and quality of the available collateral – usually accounts receivable and inventory – for asset-based lending; and 3) the financial condition and history of the principal owner of the firm for small business credit scoring. The information used in transactions lending is generally relatively transparent and is easily observable and verified at the time of the credit origination.
Relationship lending technology, in contrast, is based in large part on "soft" information, such as the character and reliability of the firm's owner, the history of the firm's relationships with its suppliers, and the business prospects in the local neighbourhood in which the firm operates. The loan officer generally gathers the information through contact over time with

the firm, its owner, its suppliers, its customers, and its local community on a variety of dimensions. The firms with relationship credit are generally informationally opaque, without sufficient high-quality quantitative and verifiable hard information on which to base the credit. This difference reflects also on the interest rate of the loan. Lower loan rates charged by financial institutions most likely reflect lower risks, because relatively transparent firms, with sufficient hard information to obtain bank credit, may generally be less risky than relatively opaque firms whose credit is primarily based on soft information. The lower rates may also reflect lower operating costs because the processing of hard information may be generally less costly than the processing of soft information. To some extent, lower rates may reflect lower marginal funding costs, because large organizations may generally be more diversified and have access to more funding sources. Finally, the lower rates may to some degree reflect less market power, because hard information may generally be less proprietary to the lender than soft information. Thus, transactions loans based primarily on hard information to relatively transparent firms may be generally less risky, less costly, and/or involve less market power than relationship loans based on soft information to relatively opaque firms.

Another important distinction in this context is the one between ***fixed and non-fixed capital***. Financial intermediaries usually found their plans distinguishing between these two different data. Instead, capital homogeneity is an assumption often made by static and dynamic studies on production and factor demands, even if the possibility of combining different capital inputs into a single aggregate relies on a very restrictive assumption on the firm's technology, namely that capital inputs must be perfect substitutes independently of the amount of labor in use: but the importance of human capital in the firm's innovation and growth has made difficult to maintain this assumption. In fact, various capital goods command different prices, display different depreciation patterns and receive different tax treatments. However, it is very difficult to catch these differences in a stylised model of finance. This is the reason why traditional financial models, and the firm-models based on human capital, even recognizing the differences in the various capital goods, continue to "collapse" them in a unique variable, in this way obtaining a growth process with the sole accumulation of human capital.
We will try to formalize a lending technology keeping in mind the distinction between fixed and non-fixed capital.

The finance from a debt investor ($\mathbf{I_D}$) can be assumed as specified in a financial contract based on the observable factors in the cost function of the firm. Capital will be indicated by the variable *K*, with value equal or greater than one in the case of fixed capital, and of zero otherwise. Following this description we design the collaterals as $c = F(K)$, namely the collaterals are function of the capital stock *K,* which results from:

$$\overline{K} = \varepsilon + st \quad (1)$$

This means that the capital stock is made by a non-fixed component ($\boldsymbol{\varepsilon}$) and a fixed component, called structure.

In consequence, the investment (purchases) of a firm are defined by:

$$P^{+} = P(K^{+}_{\varepsilon}); P(K^{+}_{st}) \quad (2)$$

while the disinvestments are:

$$P^{-} = P(K^{-}_{\varepsilon}); (P/K^{-}_{st}) \quad (3)$$

What characterizes the fixed capital from the non-fixed capital is the cost, and so the frequency, of substitution. To show that K_{st} has a high level of inactivity, as the fixed component of capital, the cost of changing K_{st} is assumed to be ≥ 1, while the cost of P/K^{+}_{ε} is assumed to be equal to 0, in a situation where the internal budget constraint of the firm is between {0, 1}.

It follows from this assumption that the entrepreneur can't change K_{st} without asking for an external financing.

We define the cost function of the firm as:

$$C = C(q, T(K, \chi)) \quad (4)$$

where **q** is the produced output and **T** is the technology parameter: as we stressed in the first chapter, technology is modelled as a function of both the capital stock **K** and the competence of the firm $\boldsymbol{\chi}$.

The internal budget constraint of the firm is given by:

$$B = w(L) + p(K_{\varepsilon}) + v(K_{st}) \quad (5)$$

with the usual indications of wage as the unit of measure for labor, and of *p* as the price of the equipment. Instead, $\boldsymbol{v}$ is a parameter that indicates not the price but the depreciation over time of the fixed capital stock of the firm. It is assumed to be $v' > 0$ and $v'' < 0$.

It is possible, then, to use these three variables (fixed and non fixed capital, and produced output) for a formalisation of the lending technology, looking at the cost of the contract for a debt investor:

$$I_D = \mu[p(K_\varepsilon), v(K_{st}), q] - g \qquad (6)$$

The first variable $\boldsymbol{\mu}$ indicates the cost for the investor of stipulating a contract (basically, of monitoring the financed firm), which is usually lowered by the geographical proximity $\boldsymbol{g}$ to the location of the borrowing entreprise. This parameter $\boldsymbol{g}$ captures one of the main characteristics of relationship lending, that is the narrow relationship between investor and firm.
The individual rationality constraint of the lender must be obviously $\mu \leq c$.

The role of the collaterals is to guarantee the control of a part of the firm to the investor, in case of a financial distress. It is clear, then, that the importance given by the I_D to each of the three variables will be proportional to the solidity of the guarantees with respect to the possibility of bankruptcy: more negative will be the expected performance of the financed firm, more important will be the collateral requirements. Among the three variables, it is also clear that the fixed capital $\boldsymbol{K_{st}}$ will be considered by the investor as the biggest collateral guarantee, because of its scarce sensitivity to the (good or bad) performance of the firm. We said before that the cost of changing the equipment K_ε is assumed to be 0, so it is possible to say that also the *value* as a collateral of this variable for the investor is around zero as well. It is then reasonable to assume that ***the real attitude towards risk*** of the debt investor is given by the ratio between the output **q** and the fixed capital $\boldsymbol{K_{st}}$.

For understanding better the mechanism of lending technology, let's start in a situation in which everyone in the economy is risk neutral, implying that a complete description of any feasible set of contracts is the sum of monitoring costs and expectation of the new cost function of the firm in period $t + 1$, that we assume as equivalent to the expectation of the possible bankruptcy penalties[8]. An intermediary (such as a bank) is delegated the task of costly monitoring of loan contracts written with firms who borrow from it. It has a gross cost advantage in collecting this information (Leland-Pyle, 1977) because the alternative is either

[8] Because the expectation of the cost function in the next period implies the possibility of a financial distress.

duplication of effort if each lender monitors directly, or a free-rider problem, in which case no lender monitors[9].

A financial intermediary must choose an incentive contract such that it has incentives to monitor the information, make proper use of it, and make sufficient payments to depositors to attract deposits. Providing these incentives is costly, but diversification serves to reduce these costs[10].

When the investor is risk neutral, the expected firm's cost function at $t+1$, $\mathbf{C'}$, is considered equal to **C**, the firm's cost function at time t. In a good economic situation, at time $t+1$ the expected cost function of the firm will be $\mathbf{C'} < \mathbf{C}$, then the cost of the contracts for the investor will be $\mu' + C' < \mu + C$, with an increase in the performance of the firm reflected by an expected increase in the produced output, $\mathbf{q'} > \mathbf{q}$.

In this case, because the value of **q** is greater than the value of $\mathbf{K_{st}}$, there will be *a change in the attitudes towards risk* of the debt investor. One consequence will be that, in the case of a very good economic period, the I_D that could even become risk favourable: risk favourable is intended here in the sense of a behaviour which gives more value to the expected profits, dependent on the expected output, than to the collateral requirements, linked to fixed capital. ***Then, in a good state of the world, it is possible that the I_D behaves more like an equity investor, so financing also risky investments (= with lack of collaterals).*** At the limit, in a good economic situation, the debt investments could follow exactly the same course as the equity investments[11].

If, instead, at time $t+1$ the economic environment becomes bad, the expected cost function of the firm will be $C' > C$, then for the investor the contractual provisions will be negative:
$\mu' > \mu$ and $q' < q$.

[9] Schumpeter assigned such a "delegated monitoring" role to banks: "...the banker must not only know what the transaction is which he is asked to finance and how it is likely to turn out but he must also know the customer, his business and even his private habits, and get, by frequently "talking things over with him", a clear picture of the situation" (Schumpeter (1939), p, 116).

[10] As the number of loans to entrepreneurs with projects whose returns are independent (or independent conditional on observable variables) grows without bound, the costs of delegation approach zero, and that for some finite number of loans financial intermediation becomes viable, considering all costs.
Instead of independence, it is possible to assume that entrepreneur's project returns depend on several common factors that are observable: these factors might include GNP, interest rates, level of inflation, etc. Since these are observable, they can be used as the basis for contingent contracts. This assumption weakens to some extent the result of Diamond, that however remains valid in principle. This assumption seems not so far from the reality, because, since these variables are observable, they can be used as the basis for contingent contracts, so describing a change in the attitude towards risk by the I_D according to the bad or good economic situation.

[11] For an analysis of this phenomenon in the last years, see Rivaud-Danset, 2002.

So, the ratio q/K_{st} will be in favor of $\mathbf{K_{st}}$. This means that, if the firm will have to ask for money to financiers in bad periods, there will be a renegotiation of the financial contracts**,** and **the projects selected by a debt investor will be strongly biased towards the activities that use the same stock of fixed capital $\mathbf{K_{st}}$,** that is a factor monitored by I_D.

This conclusion has a relevant influence on the process of value creation. If, as we said before, the competitive advantage of a firm is a function of both its technology "competence", in the case of an unfavourable period more the firm will choose a new project that is not based on the same stock of fixed capital, but instead on the exploitation of competence, less money will arrive from debt investors, which instead will finance only projects concentrating the activities on the technology based on the existent stock of fixed capital, even if the other technology could be not only more profitable, but socially preferable.

This is a different explanation of the well-known effect of credit rationing[12].

This simple formalisation of lending technology has shown why ***debt financing does not allow in most of the cases for an efficient project selection, because the observable factors included in the financial contracts are not anymore the decisive variables for the decision of a firm to carry on investment projects***.

In fact, the traditional business firm, with stable technology and clear cut boundaries is facing dramatic changes. The governance structures of firms are in constant flux, and the most dynamic subjects in the market are moving from production towards the provision of services to their clients, including or excluding activities during their economic lives, with a lower importance of the fixed capital inside the firm. The decisions of inclusion and exclusion of each specific segment of the production process can be assessed only when coordination and transaction are viewed as the result of well specified forms of economic activity characterized by their own specific form of competence and organizational knowledge. However, the analysis of coordination and transaction specific activities cannot be conducted in isolation with respect to the choices and the characteristics of the production process and the markets for products and intermediary inputs (Antonelli, 2003).

In this context, there are many reasons why financiers may take advantages from different types of firm-loans to different customers using different lending technologies. But, until now, it prevails the traditional distinction between transactions and relationship funding. This is because large banking organizations have comparative advantages in transactions

[12] Usually this effect is described looking at the interest rate. We decided instead to look at consequences on the production plans.

technologies to relatively transparent enterprises because of the **economies of scale** in the processing of quantitative information. On the contrary, small banks are likely to have comparative advantages in relationship lending to informationally opaque firms (particularly small and medium sized firms) because the soft information on which the credits are based is difficult to quantify and transmit through the communication channels of large banking organizations. As well, because the loan officer that deals directly with an individual firm, its owner, and other local market participants is the primary repository of the soft information, agency problems may be created within the banking organization that may best be resolved by structuring the bank as a small, closely-held organization with few managerial layers (Berger and Udell, 2002). Such organizational arrangements are generally inconsistent with the structure needed by large banking organizations. It is also often argued that large banking organizations are disadvantaged at extending relationship loans to informationally opaque SMEs because of organizational diseconomies of providing relationship lending services along with providing transactions lending services and other wholesale services to their large corporate customers (Williamson, 1988).

Then, because of the specialisation of lenders, the traditional lending technologies are "locked-in", to use the terminology of path-dependence. This means that a technology becomes "dominant" over a long period of time, with strong economies of scale, where its dominance is continuously reinforced by the number of early adopters. So, when it occurs a change in the environment Ω at time t, the firm has to face an exogenous shock ξ_t, such that the cost function becomes:

$C' = C(q, \theta(K,\chi), \xi)$.

The crucial problem is that the traditional lending technology we have presented so far doesn't provide a support for such situations, constraining the firms into a technical space limited by the irreversibility of the existing stock of fixed capital, with no possibility for the firm of exploiting the accumulated competence in an innovative effort, because they will receive no funds upon the guarantee of their "competence". ***This is why it is necessary to include other variables in the financial contracts for breaking off the link between debt, irreversible capital stock and economic cycle.***

We can do this using the tools of path-dependence, applying them to lending technologies, in this way obtaining, rather that a 'lock-in' effect, a **"lock-out"** solution: in path dependence firms are induced to change their current state of affairs by some unexpected events they cannot cope with – by means of traditional adjustments - because of irreversibilities and

constraints, on the one hand, and the opportunities for the introduction of new technologies. Such dynamics is fuelled by irreversibility and shaped by the changing effects of local externalities and feedbacks, within a path.
In our case, the traditional lending technology is a financing method already "locked in": using the methodology of the path-dependence approach, we can starting to analyse if and when a different financial contract can take place and eventually substitute the old and less efficient one, designing a "lock-out" process with a "Polya-urns" model.

IV Path dependence and debt contracts: a model

In our exposition, we distinguish between short and long period expectations. Short period expectations are focused about the direction of movement of a single variable, which computationally involves solving a closed form model. Long period expectations are those that involve factoring into account changes in the very nature of the economic system.
In this way, it is possible to consider at two separate levels the expectations about the movement of variables such as prices, and expectations about possible changes in the set of connections within the system. For the aim of this work, we will concentrate our attention on the formers, so trying to show that a "shock" in the prices of inputs is a radical change of the economic system in which the firm is embedded, and so also the network of relationships between the firm and its stakeholders will be modified. For facing this situation maintaining a competitive advantage, it is needed ***a strategic behavior not only by the firm, but also by the financiers. The creation of value, in this case, can be obtained only if this strategic response will be connected to the same variables used by the firm to build its expectations***. Here there is a "***network of expectations***", based on the common knowledge of the same relevant factors in the production process.

A new version of the "Polya-urn" model fits for the scope of our analysis, namely the "two urns" extension.
The standard Polya process, primarily described by Arthur et al. (1983), shall be briefly summarised. Suppose a new invention is made, together with two technological standards A and B to realise it, and that each product of technology A/B can be represented with balls of white/black colour in an urn. The process starts with a very small number of balls of either technology. A potential adopter wants to inform about which technology to buy and does so

by taking one ball out of the urn, blindly and randomly. The probability to choose a certain technology depends on the number of balls of each type in the urn. The new adopter decides to buy a product of the chosen technology. Together with the old ball, the ball with the choice's colour is put into the urn. By each step, one additional ball is added. The probability to choose a certain technology depends on the number of balls of each type in the urn.
The process converges with probability one and the final results are uniformly distributed between extinction and dominance of one technology. The interesting conclusions of this method are the impossibility of predicting a priori which market share a certain technology will attain, and the crucial role of the early fluctuations in determining the system's path and final outcome: after a short initial iteration time in the beginning, in fact, **escape from a chosen path is not probable, then a so-called "Lock-In" happens.**

This standard model gained a lot of attention and was extended in several ways. Especially convergence theorems and extensions taking product prices into account were intensively examined (e.g. Dosi et al., 1991). There are, however, many problems not considered in the standard model: because it is implicitly supposed that the customer's decisions only depend on the number of product users, it follows that only markets exhibiting very high increasing returns to adoption can be simulated. It is not possible to model different kinds of markets with varying importance of externality. In addition, the derived properties focus on the case of homogenous technologies: so, different product qualities or prices cannot be taken into respect, with the other consequence that the model is restricted to the case of a completely new innovation, with all realisation technologies starting at the same time, so leaving out he context of new and better or cheaper technologies which could replace a predecessor, as well as the case of new product versions. As the Polya framework itself seems to be an interesting approach, we used part of the Arthur's original framework (Arthur 1989, 1990) with specific modifications in order to the urn scheme to our analysis of financial contracts.

We think that a new type of financial contract can be qualified as an innovation in the lending technology, and that the two types of contract can be interpreted as two different urns. Then, we need a model able to simulate the substitution of an inefficient locked-in contract with a new better type, with some modifications: but this is in contrast with the assumption of homogeneous technologies present in the standard Polya framework, which seems to impede

the modelling of new and better or cheaper innovations replacing a predecessor already "locked-in".

We decided then to use the model with two urns, designed with the modifications needed to include an exogenous shock. The first urn will contain the old type of debt contracts, while another urn will contain the new ones: an unexpected change in the economic environment will activate a reaction allowing to pass from the first urn (where there is the locked-in contract) to a second urn, in this way obtaining a lock-out solution. Of course it is possible to use the Polya framework when debt financing is considered as a process given by repeated iterations: for example, borrowers have to come back at regular intervals for more funds, with a potentially infinite temporal horizon. This allows for the use of the path-dependent approach.

We identified the price of production factors and the level of demand as the two driving forces for a localised technological change. But the technology used by a firm is unknown to an external financier, because it is a parameter that is too costly to monitor for the investor and his lending technology. The level of demand is also difficult to monitor and forecast for the investors: this is a variable not in control of either the entrepreneur or the investor, so we can consider it as exogenous. **Then, the only variable that is observable and can be used in a financial contract is the price of production factors**. In fact, the changes in factors' costs oblige firms to alter their production techniques, and they are variables that a financier like a bank can easily know capitalising on **its knowledge of the productive environment**, based on the repeated interactions with the economic agents.

Considering all agents as risk neutral, we can modify equation **(6)** adding the cost of production factors, so obtaining:

$$I_D = \mu\left[p\left(K_\varepsilon\right), v\left(K_{st}\right), \left(q / p\left(inputs\right)\right)\right] - g \qquad (7)$$

where the price of production factors becomes a crucial unit of measure of the costs of the firm to produce the output **q**.

It is worth noting that input prices are part of the economic cycle, but their inclusion in the contract as a balance for the output can be useful to make less drastic financial renegotiations in the cases of unexpected changes of the economic environment.

Let's call $\mathbf{I_{DF}}$ the new type of contract that includes the price of production factors. As explained above, there is an external shock ξ in the economic environment that induces a strategic reaction of the firm to introduce innovations (so looking for an external finance). This shock is composed by two different factors: a change in factors' price and a change in demand, and the former is the only one observable and verifiable by the external financier. It is necessary, then, to establish a connection between the change in input prices and the adoption of the new contract as a possible cause for a lock-out solution.

We model the probability function of the adoption of the new financial contract I_{DF} with a temporal horizon $t\rightarrow\infty$, and with roots zero or 1: the former represents the absence of the external shock ($\xi = 0$) or the prevailing of the demand-side inside ξ; the root 1 will represent a "lock out" solution, so it will be more convenient for the debt investor to adopt the new contract.

The parameter δ indicates the dimension of that part of ξ which is given by the change in input prices. The global function of the investors adopting the contract I_{DF} ($\mathbf{\Sigma\mu(I_{DF})}$) is added to the strength of interaction between the change in factors' price and the investments ($\xi\delta I$), and everything is divided by the pecuniary costs of acquiring information about observable factors ($\mathbf{C(\mu_F)}$), and the non pecuniary costs ω for establishing this new contract; this function is compared with the function of the adopters of the traditional contract, divided for the pecuniary costs of this type of investment and the non pecuniary costs of maintaining this method of financing (for example in terms of missing opportunities).

$$F(I_{DF}) = \begin{cases} \textbf{1 if} & \dfrac{\Sigma\mu(I_{DF}) + \xi\delta I}{C(\mu_F) + \omega} - \dfrac{\Sigma\mu(I_D) + \xi\delta I}{C(\mu) + \omega} \geq 0 \\ \textbf{0 if} & \dfrac{\Sigma\mu(I_{DF}) + \xi\delta I}{C(\mu_F) + \omega} - \dfrac{\Sigma\mu(I_D) + \xi\delta I}{C(\mu) + \omega} \leq 0 \end{cases} \qquad (8)$$

Because of the necessity to separate the "demand pull" component of the shock ξ from the component due to changes in factors' prices, it is clear the importance of the parameter δ, that

we can reasonably assume as possible to measure: the higher will be δ, the higher will be the possibility of a lock-out.

This new type of financial contracts can be defined "path-dependent" because the specifications of the contracts change accordingly with a variation in some crucial variables influencing the innovation process, namely the prices of production factors. The result will be that, when a firm will have to carry on an investment for innovation, instead of a credit rationing effect, will ask for a renegotiation of the financial contract with the debt investor on the basis of the new level of input prices.

As explained by the corporate finance literature, with a debt function like the **(6)** mainly based on fixed capital, the cost of contracting will decrease as $M \to \infty$ (Diamond, 1984).

The value of diversification is slightly different in the model with risk neutral agents from the one with risk adverse agents.

In the risk neutral model, diversification is important because it increases the probability that the intermediary has sufficient loan proceeds to repay a fixed debt claim to depositors; in the limit, this probability is one, and the probability of incurring necessary bankruptcy costs goes to zero. This has been also our assumption.

In the model with risk aversion, but no binding constraints on non-negative consumption, ***diversification increases the intermediary's risk tolerance toward each loan, allowing the risk bearing necessary for incentive purposes to be less costly.*** This has been evident recently, in the misuse by financial intermediaries of the so called "financial derivatives", that is taking to a crisis both in the financial and the real markets.

Conclusions

With this model of financial contracts, we suggested a new comprehension of the **strategic relationship between finance and the systemic view of the firm towards the creation of value**.

During our analysis, we have stressed that modern firms rely on a crucial asset, that is knowledge. We have showed that this knowledge is localized, and so it doesn't present the typical characteristics of a perfect public good. Finally, we sustained that corporate finance theories have to be assessed in terms of the different efficacy of projects' selection.

This aspect is not sufficiently considered in the existing literature on finance, where knowledge is still assumed to be a perfect public good: the consequence is the concentration on the principal-agent models of finance, dominated by the contractual view of the firm and by the assumption of the asymmetry of information. The traditional theories sustain that it is possible to overcome the problem of credit rationing only by diminishing the asymmetry of information, with the development of a (difficult and costly) monitoring capacity of the investors, and with the design of strong monetary incentives inside the financial contracts. We showed, instead, that the real problem of these theories is about their model of the firm, where knowledge is assumed as floating in the air, and can be translated in innovations by R&D laboratories, that seem to be just waiting to be financed, for exploiting new technological opportunities.

We used instead another view of the firm, where the entreprise is considered something more than a nexus of contracts, and the "organism-system" is analysed in its entire complexity. In fact, the process of the generation and use of new knowledge in firms interacts in a reciprocal way. The introduction of a single technological innovation is conditioned by decisions regarding the adoption of complementary or related innovations by other firms, and the circulation of information increases the opportunities for external learning, that is learning from the specific knowledge generated by other firms, and the scope for capitalising on potential complementarities, between both the variety of firms and the different R&D activities performed by them.
We claimed as necessary the design of incomplete contracts that make the investors able to finance firms along this path, using their knowledge of the same productive environment in which these firms are embedded.

These considerations show that it is possible to design a model of finance for innovation adding something new with respect to the information asymmetry and the principal-agent problem. The assumptions of agents able to react to the changing conditions of their environment, not only by adjusting prices to quantities and viceversa, but also, by changing their technology, preferences and tastes, have been explained in a dynamic and systemic context. In our work, we looked for a new role for finance, where the access to credit and financial resources at large become most important in that it can give to firms new opportunities for developing and generating localized technological changes, allowing

enterprises to sustain their competitive advantage and to create value also for the entire system. We showed that the several factors involved in the complex process of technical change can be used as indicators and signals for financial markets and intermediaries, without that costly implementation of technical and scientific monitoring capacity with the perennial risk of imitation, implied by the endogenous growth models based only on R&D.

The exploitation, by the financial intermediaries, of their knowledge of the market, can be very important in this context, even becoming a crucial service provided by financiers together with the flow of funds. This opens new possibilities for the most dynamic financial intermediaries, for exploiting their ability in processing information.

In conclusion, in all this work we have faced the gap of financial issues for innovation, posing the basis to design a model of financial contracts using the tools provided by the economics of innovation literature. The access to localized knowledge, the role of demand, the costs of production factors and the organisational structure selected after repeated interactions within the firms and in the market can become the pillars on which a new model of finance should be built. We think to have provided some suggestions for future analyses, by means of our critical interpretation of the traditional tools of corporate finance theories, namely principal-agent, transaction costs and incomplete contracts, going beyond them and towards a more complete investigation of production, investment and value creation.

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