Financial System and Financing Innovation: A Keynesian-Schumpeterian Approach*

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Resumo: Este artigo analisa alguns aspectos conceituais e questões envolvidas na relação entre financiamento e atividades de investimento em Pesquisa e Desenvolvimento (P&D). Em particular, busca-se uma interação entre a abordagem de Schumpeter e a de Keynes, por um lado, e entre a abordagem neoschumpeteriana e a perspectiva pós-keynesiana, de outro, sobre financiamento, investimento e inovação. Para tanto, avalia-se a importância de incerteza na tomada de decisões empresariais relacionadas a inovação e os constrangimentos financeiros existentes para realização dos investimentos em P&D e conclui-se que não há um tipo de estrutura financeira "ótima" para dar sustentação a tais investimentos.

Palavras-chave: financiamento; sistema financeiro; inovação

Abstract: This papers aims at analyzing some concepts and issues related to the linkage between financing and investments in Research and Development (R&D). In particular, the paper searches, on one hand, the interaction between Schumpeter's and Keynes' analysis, and, on the other hand, between the New-Schumpeterian approach and Post-Keynesian perspective on financing, investment and innovation. For this purpose, it assesses the importance of uncertainty in the entrepreneur's decision making related to innovation and the financial constraints related to the R&D investments, and concludes that there is no 'optimum' financial structure that gives support to such investments.

Key words: financing; financial system; innovation

JEL classification: B52; E44; G29

Área 5.1. Economia Monetária e Financeira

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1. Introduction

In a review of the literature on the relationship between finance and innovation, O'Sullivan (2006, p.241) noted that "contemporary economists of innovation have largely neglected the relationship between finance and innovation" and, therefore, "[i]ntellectual exchange between evolutionary economist and financial economists seems a better route to an improved understanding of the relationship between finance and innovation".

One interesting and promising avenue to closing this gap between analysis of innovation and analysis of the workings of the financial system may lie in looking for interaction between the approaches of Schumpeter and Keynes, on the one hand, and between Neo-Schumpeterian and Post-Keynesian perspectives, on the other[1]. This is because, while Schumpeter's and the Neo-Schumpeterian approach stress the fundamental role of innovation in the dynamics of economic development, Keynes's and the Post-Keynesian approaches highlight the importance of the financial system in economic development. Also, in both perspectives, the free functioning of the market is not self-regulatory, decisions connected with long-term expectations, as in innovation and industrial investment, are subject to radical uncertainty, while the forces of innovation (on the Neo-Schumpeterian approach) and financial forces (on the Post-Keynesian approach) are by nature disruptive of the economy.

The purpose of this article is to examine how finance and the financial system interact with the dynamics of innovation, using an analysis that seeks to integrate some contributions from both Neo-Schumpeterian and Post-Keynesian perspectives. As a secondary addition to these, it also proposes to bring the institutionalist dimension to bear in analysing financing and financial structures, along lines already explored by Zysman (1983). It must be stressed that this article is eminently exploratory and that the intention here is not to develop any detailed theory integrating these approaches, but mainly to signal possible avenues for analysis of the relationship between finance and innovation.

[1] There is a ample literature related to these approaches. In the Neo-schumpeterian approach, see, among others, Dosi et al (1988), Fagerberger et al (2006) and Hanusch e Pyka (2007), and in the Post-Keynesian perspective, see Minsky (1986), Carvalho (1992) and Davidson (2002).

The paper is divided into four sections in addition to this introduction. Section 2 briefly describes Keynes'and Schumpeter's ideas on credit and investment, and suggests some possible interactions. Section 3 examines relationships among finance, investment and innovation from a joint Keynesian-Schumpeterian perspective. Section 4 discusses the concept of financial system functionality and typologies of financial systems, and their relationship with research and development (R&D) activities. Lastly, section 5 offers a summary, and concludes the article.

2. Schumpeter and Keynes on credit, innovationand investment: a brief analysis

In "The Theory of Economic Development" (TED), originally published in German in 1911, Schumpeter (1934/2010) defines innovation as an industrial or commercial application of something new, such as products and processes, new types of organisation or new markets, and highlights the importance of innovation as a fundamental primary stimulus to the process of economic development. A "circular flow" produces a stationary state – or one that is slowly changeable as a result of variations in "givens", such as population, level of consumption etc. – inwhich producers and consumers are in equilibrium, there are no innovations, and money and credit are not significantly important. This static state breaks down under the effect of innovations, which trigger the process of "economic development". The introduction of innovations– achieved by diverting the factors of production or creating new productive combinations –into the circular flow opens up new prospects of profit, which generate a series of alterations in how economic agents behave, leading in turn to a secondary wave of investment thrown up by the first one. In this way, changes that come about in production are a consequence of innovations made by innovative entrepreneurs, making innovations the "fundamental impulse that set and keeps capital engine in motion". (Schumpeter, 1942/2011, p.83).

A second component of the economic development process is money creation by banks through credit. Schumpeter argues in TED that innovation is financed by credit creation, which does not need to be based on any existing money stock. In Schumpeter's word:

> The essential function of credit in our sense consists in enabling the entrepreneur to withdraw the producers' goods which he needs from their previous employments, by exercising a demand for them, and thereby to force the

> economic system into new channels. Our second thesis now runs: in so far as credit cannot be given out of the results of past enterprise or in general out of reservoirs of purchasing power created by past development, it can only consist of credit means of payment created ad hoc, which can be backed neither by money in the strict sense nor by products already in existence. (Schumpeter, 1934/201, p.106).

Schumpeter regarded credit creation as one of the basic elements of the economic development process and as the "monetary complement of innovation". In particular, credit becomes necessary as a development factor when innovations are made by new entrepreneurs who do not have their own means of production. Here, by creating ad hoc means of payment (bank money), the banks afford innovative entrepreneurs the purchasing power necessary to channel funds away from their traditional uses, thus permitting innovations to occur.

Note that Schumpeter did not regard the supply of bank credit as depending on prior savings. In this regard, "saving, properly so called, turns out to be of less importance than the received doctrine implies" (Schumpeter, 1928, p.381) and, therefore:

> As, however, innovation, being discontinuous and involving considerable change and being, in competitive capitalism, typically embodied in new firms, requires large expenditure previous to the emergence of any revenue, credit becomes an essential element of the process. And we cannot turn to savings in order to account for the existence of a fund from which these credits are to flow. For this would imply the existence of previous profits, without which there would not be anything like the required amount (…) Credit-creation, therefore, becomes an essential part both of the mechanism of the process and of the theory explaining it. (Schumpeter, 1928, p.381)

The role of credit begins to decline in trustified capitalism; although credit creation still has a role to play, both the power to accumulate reserves and direct access to the financial market tend to make it less important to the operations of oligopolistic corporations. Thus, in "Capitalism, Socialism and Democracy" (CSD), originally published in 1942, innovation activity ceases to be dominated by new firms and comes to be steered by the activities of large industrial corporations, thus making technological progress more and more the outcome of "teams of trained specialists". Schumpeter considered that competition led by innovative firms occurred by the introduction of new goods, new technologies, new sources of supply, new types of organisation (the "large-scale establishment or unit of control"). He called that process of competition the "process of creative destruction". In this way, Schumpeter moved on from the

competitive capitalism more characteristic of the 19th century, and still present in his TED of 1911, to 20th-century trustified capitalism, as in his 1942 book, CSD.

Keynes, meanwhile, developed a monetary theory that draws an important distinction between the cooperative or barter economy and the monetary or entrepreneurial economy. In the former, production and distribution decisions are made jointly by all producers, and payment is made with goods or some means of payment, in such a way that monetary income will all be spent and is equal to current product (i.e., Say's Law holds). A monetary economy, meanwhile, is a decentralised economy in which agents are organised for production, and goods are distributed by way of the market among independent units. In a monetary economy, instead of money being merely a temporary convenience, it plays a role of its own and affects agent's motivations and decisions; nor is it neutral in either the short term (when capital stock is given) or long term. That is, money affects not only decisions on production or labour supply, but also the form and pace of accumulation, which is the prime determinant of long-period equilibrium. Money is thus a necessary element that accounts for the existence of equilibrium with involuntary unemployment in the economy.

In a monetary economy, the modern banking sector plays a fundamental role as provider of the liquidity necessary for agents to make their expenditures. In his *Treatise on Money* (1930), Keynes showed that banks are able to create money both passively and actively; in the latter case, bank money (deposits) is created by granting loans and not (as in the former case) on the basis of previously collected deposits. In his discussions with Ohlin and Robertson after publication of the *General Theory*, Keynes drew an important distinction between finance and savings, and pointed out that investment will not be constrained for lack of savings, but rather for lack of finance:

> The banks hold the key position in the transition from a lower to a higher scale of activity. If they refuse to relax, the growing congestion of the short-term loan market or of the new issue market, as the case may be, will inhibit the improvement, no matter how thrifty the public purpose to be out of their future incomes. On the other hand, there will always be exactly enough ex-post saving to take up the ex-post investment and so release the finance which the latter had been previously employing. The investment market can become congested through shortage of cash. It can never become congested through shortage of saving. (Keynes, 1937a, p.668-669).

To Keynes (1936/2007, 1937a), saving is not a pre-condition for investment, and equality between saving and investment results from a change in income level, while the decision to invest comes logically before income creation. Investment is determined primarily by entrepreneurs' long-term expectations of future income from their capital assets. In an uncertain world, business success depends crucially on entrepreneurial expectations' being borne out, but this cannot be predicted in advance. Therefore, investments are only made if entrepreneurs' "animal spirits" are aroused, and also if the bank sector makes credit available. The aggregate supply of finance in a monetary economy is determined mainly by banks' willingness to create credit and corresponding deposits, and also by the existing stock of money.

Keynes(1937a)' analysis of how capital formation is financed describes a two stage-process: in the first, provision of money enables investment expenditure to be made (*finance*), i.e., the demand for money (liquidity) provided by the bank sector at the time the firm decides to invest; in the second, *ex post* saving is used to consolidate debt for investment expenditure (*funding*). Funding it thus the process in which short-termdebt is converted to long-term liabilities, so as to reconcile the maturities and amounts of the investing firm's liabilities with the returns it expects from the investments. Finance, meanwhile, is a revolving fund which requires no prior saving: if the flow of aggregate expenditures remains constant, given the constant velocity of money, the existing money stock can finance it simply by changing hands among agents as they conduct transactions, with no need for banks to create new loans. However, if aggregate spending is to be increased (investment expanded), then new money has to be created, which will be done by the bank sector and/or by agents' dishoarding.

Note lastly that, in his Treatise on Money (1930), Keynes agreed with Schumpeter on the role played by technological change in the economy, although he did argue that that role could only be played providing the "monetary machine" (a compliant bank sector) responds to that stimulus. Thus, according to Keynes (1930/2011, v.II, p.95-96):

> In the case of Fixed Capital it is easy to understand why fluctuations should occur in the rate of investment. Entrepreneurs are induced to embark on the production of Fixed Capital or deterred from doing so by their expectations of the profit to be made. Apart from many minor reasons why these should fluctuate in a changing world, Schumpeter's explanation of the major movements may be unreservedly accepted. (…) It is only necessary to add to

> this that the pace, at which the innovating entrepreneurs will be able to carry their projects into execution at a cost in interest which is not deterrent to them, will depend on the degree to complaisance of those responsible for the banking system. Thus whilst the stimulus to a Credit Inflation comes from outside the Banking System, it remains a monetary phenomenon in the sense that it only occurs if monetary machine is allowed to respond to the stimulus. (Keynes, 1930/2011,v.II, p. 95-96).

To Keynes, therefore, technological change should only be considered after the monetary factors are correctly understood. In the General Theory, however, he implicitly considered technology as a blueprint which would be available to any businessman whenever needed, i.e., it was incorporated into the capital goods acquired by the businessmen-investor. (Crocco, 2003, p.501)

To conclude this section, some of the more general similarities between Schumpeter's and Keynes' approaches to money and credit will be described in more detail, although there are also some important differences which, however, it is beyond the scope of this article to examine[2].

In the first place, it can be seen from the foregoing that there is some similarity between Schumpeter's distinguishing the (static) "circular flow of economic life" from the (dynamic) innovation-driven development process, and the distinction that Keynes draws between an economy with no increase in investment and an economy with increased investment. In both the "economic development" process and the "monetary economy" where investment is rising, bank credit plays a fundamental role. Nonetheless, the two authors view the role of money in the economy differently: "money", in Keynes'monetary economy, does not mean the same as Schumpeter's "credit", which corresponds rather to Keynes (1937a)' finance motive, a form of transactional demand for money to cover non-routine spending relating to investment decisions. Meanwhile, money in Keynes' monetary economy means something closer to a store of value, given the preference for liquidity under the conditions of radical uncertainty typical of that kind of economy. In any case, both authors reject the dichotomy between the real and monetary sides of the economy (the so-called "classic

[2] One of the important differences relates to determining the interest rate: Keynes regards it as determined on the money market (where the preference for liquidity plays a key role), while to Schumpeter the interest rate is a fraction of profits. Meanwhile, Schumpeter stresses the importance of money in its function as a means of payment, while Keynes highlights its function as a store of value. For further analysis, see Nassica (2002) and Bertocco (2007).

dichotomy") and, more importantly, they agree that credit or bank money plays a prominent role in financing economic activity, and especially productive investment or investment in innovation. In that regard, there is complementarity between Keynes and Schumpeter.

In the second place, as suggested by Bertocco (2007), one useful interaction between Keynes and Schumpeter would be to bring the Keynesian theory of income determination (and the principle of effective demand) to bear, thus emphasising that innovations are introduced by way of firms' investment decisions, which – as seen above – depend largely on liquidity provided by bank credit. Decisions to invest in innovation hinge on long-term entrepreneurial expectations, i.e., they are subject to the radical uncertainty that permeates such decisions. Evidently, there are specific features to the process of technological innovation which must be borne in mind (for instance, it does not involve tangible assets like productive investment conducted by acquiring capital goods), and which even have implications for innovation financing. That viewpoint makes for more organic integration between Post-Keynesian theory and Neo-Schumpeterian theory with a view to understanding the process of innovation finance. The next section will address that subject.

3. Finance, uncertainty and innovation from a Keynesian-Schumpeterian perspective

Technological innovation is an expensive process that not only calls for significant volumes of funds in order to take place, but occurs over indeterminate calendar time and the returns resulting from it are uncertain. The related selection process depends on a series of factors, including: (i) the nature of "key institutions" and their interest in pure research and economic applications; (ii) institutional factors, such as public agencies (armed forces, space agencies, health system, research funding institutions etc.); (iii) trial and error processes in exploring new technologies created by the "Schumpeterian entrepreneur"; and (iv) the possibilities determined in part by the prevailing technological paradigm that formats the patterns of opportunity for technical progress in

terms both of the scope of the innovations and how easily (or otherwise) they can be accomplished[3]. (Dosi, 1988)

Rosenberg (1982) sees the Schumpeterian businessman as a heroic figure ready to venture into the unknown and, accordingly, his decisions are not the outcome of precise, careful calculation. Therefore, entrepreneurial decisions on introducing technological innovations are strongly determined by long-term entrepreneurial expectations regarding future incomes expected from a successful innovative business venture, i.e., there is a strong exogenous, subjective component in terms of expectations, somewhat akin to the "animal spirits" suggested by Keynes, and particularly so with regard to more radical innovations[4]. After all, only the prospect of profits will justify investing in a long shot, as can be the case with investment in R&D. In Schumpeter's terms, "development" is a basic factor in the formation of monopolies and market imperfections, and the profit generated by successful innovation is associated with "monopoly profits". As a commercial venture, successful innovation inevitably comprises some degree of monopoly, because the innovation is the monopoly of the innovating firm (at least until it spreads to other firms,), and the profit obtained from it is due precisely to that monopoly. (Napoleoni, 1973) The monopoly is not absolute, but temporary, and tends to disappear during the dynamic process of competition, which generalises the innovation that enabled the monopoly to emerge in the first place, and then subjects the innovation to other innovations that emerge in the economic system. However, the innovative firm comes up against the problem of imperfect appropriation of the knowledge embedded in the innovations: it cannot appropriate the complete benefits of its investments in R&D, although it does have to defray all their costs, which can result in underinvestment in R&D. (Arrow, 1962) This often leads to a gap between private and social returns from R&D activities – the magnitude of the "spill-overs" varies by firm and by type of R&D activity.

Entrepreneurial decisions relating to investment in R&D, just like investments in fixed capital, are taken under the conditions of non-probabilistic uncertainty surrounding phenomena for which "there is no scientific basis on which to form probability

[3] For example, the clusters of new technological opportunities associated with electricity, synthetic oil-based chemistry and, more recently, microelectronics.
[4] We will return to this issue later.

calculations whatever" (Keynes, 1937b, p.214). Accordingly, it is impossible to determine *a priori* the set of significant influences that will act between when the decision to implement a given plan is taken and when results are actually achieved, hindering any reliable forecast that might serve as a basis for rational decision making, given the extremely precarious nature of the knowledge base. (Carvalho, 1992) The dynamics of the economy moves in historic time and is thus not stationary. Agents do not necessarily learn from past occurrences, and the outcomes of past events may not contribute completely to constituting the probability distribution necessary to underpin any formulation of rational expectations about future events. Davidson (2000) argues that Schumpeterian businessmen are constitutive elements of a nonergodic system ("systems of transmutable reality"):

> If entrepreneurs have any important function in the real world, it is to make crucial decisions. Entrepreneurship…by its very nature, involves cruciality. To restrict entrepreneurship to robot decision-making through ergodic calculations in a stochastic world…ignores the role of the Schumpeterian entrepreneur – the creator of technological revolutions bringing about future changes that are often inconceivable to the innovative entrepreneur. Entrepreneurs do not merely discover the future, they create it…Probability models are a rebuilding representation of decision-making only in a world where only routine decisions are made…these models cannot explain the essential creative function of entrepreneurial behavior in a Keynes-Schumpeter world where the reality is transmutable. (Davidson, 2000, p. 113)

In the same direction, Dosi (1988) defines *innovation* as discovery, imitation and the adoption of new products, new production processes and new organisational forms, and sustains that the results of introducing an innovation cannot be known in advance with any precision:

> what is searched for cannot be known with any precision before the activity itself of search and experimentation, so that the technical (and, even more so, commercial) outcomes of innovative efforts can hardly be known ex ante...innovation involves a fundamental element of uncertainty, which is not simply lack of all the relevant information about the occurrence of known events but, more fundamentally, entails also (a) the existence of techno-economic problems whose solution procedures are unknown…, and (b) the impossibility of precisely tracing consequences to actions. (Dosi, 1988, p.222)

In this way, the decision by an innovating firm to introduce a radical innovation is at least as subject to fundamental uncertainty as traditional investment decision-making. Note that the lack of significant information is not simply a problem of incomplete knowledge; it results from the fact that the future is unknown and unknowable.When

innovations are introduced, certain fundamental information does not exist at the beginning of the decision-making process, including how long it will take to complete the innovation, the final cost of the innovation, and how it will be received by the market. It is thus impossible *a priori* to determine the significant set of information relating to innovation: it is just as impossible as knowing *a priori* "the price of copper and the rate of interest twenty years hence" (Keynes, 1937b, p.214).

Crocco (2003a, 2003b) argues that different kinds of innovation can be associated with different degrees of uncertainty, according to the role played by prior knowledge, and that it is possible to identify the "emergence of a new technological paradigm with a radical innovation, and the development of one of the possible technological trajectories as a sequence of incremental innovations" (Crocco, 2003a, p.511). The knowledge underpinning decisions about introducing *radical innovations* (based on completely new knowledge) is extremely limited and weak, given the very strong uncertainty as to how they will be received by the market. *Incremental innovations*, meanwhile, are based on existing knowledge defined by an existing technological paradigm in which successive incremental innovations developed in the context of a given technological trajectory are accompanied by a process of knowledge accumulation that refines any assumptions associated with future decisions.This is because, as the innovating firm moves along the technological trajectory, its knowledge increases as its understanding of the technology it is using and of the market's behaviour improves. As a result, its state of confidence in the success of introducing further innovations improves: there is a "connection between the outcome of introducing a previous innovation and the expectations for the future yield of the next innovation". (Crocco, 2003a, p.511-512)

Uncertainty tends to be greater at the start of research programmes and innovation projects, which means that these cannot be analysed within a simple, static structure. Moreover, what is involved are intangible assets that cannot be used as collateral for credit and are difficult for lenders to monitor, which poses problems for innovation finance. Therefore, the specific features of the innovation process (its nature, the formation of expectations, financing etc.) must be taken into account when analysing an innovation, because from the investment theory standpoint research and development (R&D) has a series of characteristics that make it different from common industrial investment. Let us look at some of these issues.

Another important specific feature of R&D is that the knowledge asset created by the investment is intangible, partially embedded in human capital[5], and normally quite specialised in the innovating firm, with the result that the capital structure of innovating firms involves considerably less leverage than that of other firms. Thus, banks and other lenders, who prefer physical assets as guarantees, are reluctant to lend when the project involves investing significant amounts in R&D. The fact that the asset created by investment in innovation is intangible may make it more expensive to raise external funding for innovation than for other types of investment. Consequently, positive cash flows may be more important for R&D than for fixed capital investments. However, debt servicing usually requires a stable cash flow source, which may not be the case with investments in R&D: given the nature of innovation projects, many offer no assurance of immediate success, and it is accordingly more difficult and expensive to obtain financing for them.

As described by Minsky (1986) it is difficult for both lender and borrower to assess the project safety margin[6], because it is impossible to make any projection of expected returns. To the extent that the percentage of the investment financed by third-party funding increases, so lenders become reluctant to finance new projects by the same firm, because they may be committing too large a volume of funding to a single borrower. Risk is high for both lender and borrower, because of the possibility that the investment in innovation will generate less profit than the firm's debt commitments[7].

Thus, given the high risks facing borrowers and lenders, the latter are reluctant to lend and the firms are unable or reluctant to take out loans to invest in R&D, which cansubstantiallyincrease their cost of capital. (Hall, 2002, p.8) Therefore, the lenders themselves (banks or institutional funds) tend to ration credit, both because of the difficulty of making any reasonable evaluation of returns from the investment project –

[5]According to Hall (2002), the salaries of well-educated, specialist scientists and engineers account for about 50% or more of R&D expenditures.

[6]Cash-flow safety marginis the difference between expected profits and financial commitments in each time period. It relates to net cash flows which provide protection against unexpected events in each period of the project.

[7]Both lender's and borrower's risk involved a subject element, because both depend on the lender's and borrower's "state of confidence" in the firm's expected cash flow.

because they are often unable to assess the market potential of investments in innovation – and because of the lack of any tangible asset to back the credit operation.

One conclusion that emerges from the foregoing analysis is that the difference between the costs of financing an R&D investment project from internal or from external sources is often greater than with other forms of investment, such as in fixed capital. Some innovations may fail to be successful simply because of the high cost of external funding, even though they would provide good returns if the funding were available at a "normal" rate of interest[8]. As the knowledge asset created by R&D investment is intangible, partly embedded in human capital, and very specialised in the innovating firm, the capital structure of R&D-intensive firms tends normally to involve less leverage than that of other firms. (Hall and Lerner, 2009, p.13)

O'Sullivan (2006) argues that the claim that there has been an overall historical shift from a process of innovation dominated by "new ventures", of the type analysed by Schumpeter in his TED, to a process directed by large industrial firms, such as examined in his CSD, should be rejected. The importance of bank credit to small firms can coexist with the fact that large corporations predominantly use self-financing (retained profit) to fund their R&D activities. In other words, from the point of view of the structure of financing, it is important to draw a distinction between small and new innovating firms and large corporations. The former face far greater financial constraints on innovation, meaning they have to cope with higher cost of capital than their larger competitors. Indeed, empirical studies have found abundant evidence that small firms are more likely to encounter financial constraints, because they are usually unable to provide amounts of collateral comparable to those available to larger and more capital-intensive firms. (Czarnitzki and Hottenrott, 2010, p.8)

In order to analyse the innovation finance process one has to consider the stages of the innovation process. That process can be distinguished into four stages: seeding

[8]Indeed, one empirical study (Planes et al, 2001), which evaluated financial constraints on innovation in a representative sample of 5,000 French industrial companies from 1994 to 1996, showed that the innovating firms absorbed a greater proportion of financing of their own (or their business group) than non-innovating firms, and consequently used a smaller proportion of bank loans and other financial debts. Ughetto (2008) obtained similar results on examining a sample of 1,100 Italian firms: 50% of fixed capital investments are financed out of internal funds, while the percentage rises to nearly 83% for investments in R&D.

(conception of the innovative idea), start-up (the innovation process as such begins), initial growth (early expansion), and sustained growth (consolidation). Although, in developed countries such as the United States, smaller and newer firms tend to innovate more radically and create new technologies, products and markets, enabling other firms also to innovate, banks are generally reluctant to finance innovation projects by young firms because there are at an early stage and offer a greater overall risk of default. Access to financing can be one of the most important factors constraining the innovation activities particularly of young innovating firms[9]. External financing tends to be concentrated in the more advanced stages of the innovation process, when uncertainty falls to more acceptable levels. Small firms with no funds of their own face the problem of how to finance innovation activities, particularly in countries with no developed capitals market.

4. Functionality of the financial system and typology of financial systems

Today, it is starting to be widely accepted in Economics that the financial system is of great importance to economic development (Levine, 2004), even though there is no consensus as to what is required for a financial system to operate functionally so as to give support to economic growth.

From Keynes' analysis of the financing-investment-saving-funding circuit mentioned in section 2, some Post-Keynesian economists have developed the concept of financial system functionality or efficiency. Studart (1995-96, p.284) defines financial system functionality in the following terms:

> [A]n financial system is efficient to development when it expands the use of existing resources of an economy at the minimum possible increase in financial fragility and other imbalances that may halt the process of growth for purely financial reasons.

A functional financial system is one that can provide *finance* to allow entrepreneurs to make investment expenditures, and that channels savings (*funding*) so as later, directly or indirectly, to fund their debts. In Carvalho's words:

[9] According to Parris et al (2010, p.21), "In early stages of the industry life cycle innovations are more radical, innovative activities are distributed across a wide population of firms, while in the later stages of the industry life cycle a new innovation regime dominates in which the rate and magnitude of innovation become more cumulative and the innovators are mostly large firms".

> The financial system...has to meet two criteria of efficiency: It has to provide an *elastic* supply of finance to accommodate growing investment expenditures, and it has to create the direct and indirect finance channels to allow their funding. (Carvalho, 1997, p. 472, italics in the original).

The concept of financial system functionality clearly involves one dimension from Keynes (solving the problem of investment financing) and one dimension from Minsky (reducing the financial fragility of the economy). Financial system efficiency is another concept involving two dimensions. In the macroeconomic dimension, a financial system's efficiency is evaluated in terms of how well it performs the functions of finance and funding, i.e., how it provides support for *financially* stable growth. In the microeconomic dimension, financial system efficiency is the ability to provide the above functions at least possible cost. Accordingly, a financial system may perform its finance functions reasonably well, while maintaining high intermediation or financing costs for projects whose future is doubtful; alternatively, it may be technologically sophisticated and operationally efficient, but highly inefficient in terms of its macroeconomic functionality.

The lack of a financial system that is functional in the terms defined above can jeopardise the development and maturation of a "national innovation system". These institutional arrangements, involving firms, networks of firms, government agencies, universities, research institutes, corporate laboratories, and the activities of scientists and engineers, interrelate with the educational system and with the industrial and business sectors, and also with financial institutions, thus completing the circuit of agents responsible for generating, implementing and spreading innovations. Also, according to Edquist (2006), the *innovation system approach* places innovation and learning processes at the centre, and does not consider them as factors exogenous to the functioning of the economy. A developed national innovation system is fundamental to the advancement of innovation activities and the spread of innovation, and thus contributes to a country's competing successfully in international trade.

The financial system is an integral part of the national innovation system, because finance arrangements are fundamental to the course of R&D activities. A functional financial structure is a precondition for a dynamics of innovation to develop in an economy. Indeveloping countries, however, particularly those with underdeveloped

financial systems, the solution to the problem of financing for innovation activities does not result spontaneously from the workings of the market. Thus, the high degree of uncertainty and risk involved in financing innovation may require some kind of public finance, mainly when the country has no developed capitals market. There is thus a structural constraint preventing market forces from solving the problem of innovation finance in developing countries that are seeking to develop rapidly.

Zysman (1983) suggests a taxonomy of financial systems that divides them roughly into two major types of financial structure: *capital market-based systems* and *credit-based financial systems*. Capital market-based systems involve substantial participation by direct financing instruments (shares and debt bonds) as sources of long-term financing, a diversity of financial instruments and markets, and a short-term bank credit market; these are characteristic of the Anglo-Saxon model (USA and United Kingdom). In credit-based financial systems, the capitals market is weak, normally there is little institutional specialisation, and financing is predominantly indirect, i.e., short- and long-term bank credit is the main form of financing in the economy. Credit-based financial systems can be further divided into two types: the German type, where financial systems are controlled by large autonomous financial groups, and the French type, where financial systems controlled by government agencies. Financial system structures (segmented financial systems or universal bank-based financial systems) have been modified substantially as a result of recent changes and developments in the world financial system, and the two structures have converged to some extent, but that typology is still quite valid and can be useful for analysing the relationship between financial system functionality and economic development, with particular emphasis on investment in R&D.

The underlying question in this respectis: what model of financial system is most functional for stimulating investments in R&D? Empirically, it is difficult to evaluate how functional one type of financial structure is for economic development, i.e., what financial structure is most functional for supporting development. Zysman (1983) points out that historically both capitals market-based and credit-based systems have been successful in underpinning economic development, as exemplified in the former case by the USA and the United Kingdom, and in the latter by Germany and Japan.His analysis also shows that not all countries have displayed a synchronised combination of financial

development with economic growth.The experience of developed countries shows that there is no single "ideal" model of financial system for giving support to economic development.In fact, how financial systems have developed in different countries is shaped largely by their specific historical and institutional characteristics.

Albuquerque (1996) shows that the literature is not conclusive as to what financial setup is most functional for stimulating investments in R&D. To some authors, capitals market-based financial systems enable new technologies to be selected better, while bank credit-based systems facilitate development based on technological learning. (Christensen, 1992) Other authors, meanwhile, sustain that credit-based financial structures (as in Germany and Japan) stimulate long-term investment, while those based on the capitals market tends to prioritise short-term investments. (Pavel and Pavitt, 1994) An empirical study by Mulkay et al. (2000) of a sample of large manufacturing firms in France and the USA found that cash flows had much greater impact in the USA than in France both on investment in R&D and on fixed capital investment, which seems to offer evidence that large firms in the United States depend more on internal funding than French firms do. In any case, countries whose innovation systems are more or less at the same level (USA, Japan and Germany) have differing financial structures, which seems to corroborate the difficulty of defining *a priori* what type of financial system is most functional for innovation activities to prosper.

As pointed out in the previous section, the high risks for both lender and borrower present in R&D investment finance mean that large firms particularly are more likely to use internal, rather than external, funding than would be the case with other types of investments. In any case, credit is important to financing for small innovating firms, which in developed countries can often rely on market mechanisms and, above all, on public or semi-public funds designed to support innovation[10].

The United States capitals market is sophisticated and well developed, and specific financial instruments – known as "venture capital" (VC) – have developed for the purpose of financing small, innovative firms. VC can be defined as "independently managed, dedicated capital focusing on equity or equity-linked investments in privately

[10] Hall (2002) reports various government financial initiatives to support small and medium-sized firms pursuing innovation projects.

held, high-growth companies" (Parris et al, 2010, p.9). These are a pool of specialised funds, normally from private investors (institutional investors or wealthy individual investors), which are managed by professionals who know the industry where the investment is being made, and who therefore invest in firms that offer greatest potential for profitability and growth. This instrument is often used as a means to support "new technology-based firms" that are R&D-intensive and show high potential for radical innovation, and they function as vehicles for commercialising innovation activities. In principle, using this financial instrument reduces problems of information asymmetry, because the investment managers are better informed about the enterprise, meaning that the innovating firms are better monitored than is normally the case with investment financing via the bank sector. This type of innovation financing is more important in the United States and to some extent in the United Kingdom, but is of lesser importance in other developed countries, although several specific programmes and funds to encourage its spread do exist.

Hall (2002) shows, however, that the "VC solution" to the innovation finance problem has its limits. Indeed, one key factor in the United States' competitive advantage in venture capital is the existence of a robust market in initial public offerings (IPOs). Venture capitalists can only undertake to transfer control of the firm to the entrepreneur when a dense public market exists for new share issues. On the other hand, financial intermediaries, such as banks, are unable to replicate the work done by such investors or to develop proper monitoring of firms with innovation potential, given the difficulty of evaluating projects with few assets that can be used as collateral and the high degree of uncertainty involved in R&D projects. (Hall and Lerner, 2009, p.34) Lastly, one of the greatest problems for venture capital to develop lies on the demand side, in that there may not be enough high-potential firms to justify the existence of a VC industry (Parris et al, 2010)[11].

5. Conclusion

This paper examined the relationship between finance and investment in R&D activities, in terms of conceptual considerations and some of the issues involved, in the

[11]This problem of demand tends to be greater in developing countries, given the characteristically low rate of innovation by their firms.

light of theoretical developments emerging from Neo-Schumpeterian, Post-Keynesian and Institutionalist approaches.

To that end, it endeavoured first to highlight certain similarities and complementarities between the analyses of Schumpeter and Keynes, both of whom emphasised that bank-created credit (independent of saving) plays a fundamental role in financing investments (whether in fixed capital or in R&D) in the economy. One useful avenue for exploring the interaction between those approaches is to consider that innovations are introduced through firms' investment decisions, and that these depend on long-term entrepreneurial expectations as to future returns from a successful innovation venture, which is subject to the radical uncertainty that permeates such decisions. Investments in R&D are subject to radical uncertainty, because it is impossible to forecast the actions of innovation activities with any precision, as their trajectory is strongly "path-dependent".

Another important issue raised in the article are the problems of financial constraints on R&D investments: the assets involved are intangible and thus cannot be used as credit guarantees and are difficult for lenders to monitor. Moreover, there is the additional difficulty for both the lender and the borrower of arriving at a reasonable assessment of the safety margin involved in the project, given the impossibility of accurately projecting expected returns or of knowing in advance whether the innovation will be successful. Consequently, the difference between the cost of financing investment in an R&D project from internal and external sources is often greater than would be the case with other forms of investment. In particular, the financial constraints on innovation are far greater for small firms than for large ones, because the latter can apply internal funds to finance their R&D activities.

Lastly, the paper shows, from the existing literature, that there is no single "optimal" type of financial structure for providing support to investments in R&D, but rather that there are a number of pros and cons to both the credit-based and capitals market-based systems.There are specific features to each country's financial system that must also be borne in mind: what types of institutions and markets, financial instruments, regulations etc. are in place there. Countries with highly developed innovation systems, such as the USA, Germany and Japan, have differing financial structures, which seems to indicate

that ultimately the development of its financial system is shaped largely by each country's particular historical and institutional characteristics.

There is particularly an abundance of public or semi-public programmes and funds designed to grant credit to small and medium-sized firms at costs compatible with innovation activities. As mentioned above, small firms with no funds of their own for high-risk investments depend on financing at accessible cost, which normally entails setting up specific funds for the purpose. Many countries do in fact provide some form of assistance for such firms, given their potential for generating radical innovations. Venture capital – the market solution to the problems of financing innovation by small firms in capital's market-based systems – is of some importance in the USA, but has serious limitations. It tends to be concentrated in only a few sectors and the minimum investments tend to be too large for pioneering firms in some areas. Also, there also needs to be an exit strategy for investors, which calls for a highly-developed share market.

For developing countries, particularly those with poorly developed financial systems, the problem of financing innovation activities is not solved spontaneously as a natural outcome of the market, and may call for some public financing instrument to provide support for R&D activities.This is because such countries often have a lesser capability to mobilise capital, less widespread innovation culture in their firms, and a much less developed national innovation system – all leading to greater difficulties in promoting and fostering innovation. Such countries tend first to concentrate not on developing leading-edge technologies, but on acquiring knowledge of mature technologies. At a later stage, when they are more capable of pursuing a successful learning process, they embark on incremental innovation, following established technological trajectories (assimilating and refining technologies), until subsequently achieving the higher levels of the product technology cycle (with a technology generation capability of their own).

For developing countries to be able to catch up technologically, it is essential they constitute well developed national innovation systems, in which functional financial structures to encourage investments will play a fundamental role. Analysis of the functionality of financial structures and financing arrangements that provide support to

R&D investments is a field requiring more in-depth research, in both theoretical and empirical and institutional terms.

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