FINNOV
Finance, Innovation & Growth

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Finance, Innovation & Growth (FINNOV)

State of the Art Report

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1 Introduction

The 2020 Strategy states that Europe's future prosperity is dependent on developing a knowledge-based economy driven by innovation. To stimulate the supply of innovation it calls for increased public and private investment in R&D to match the proportions of GDP being invested in R&D by Europe's major competitors. However the success of this strategy depends equally on the successful translation of innovation into economic growth. Business experimentation is central to these processes, and this ability is central to achieving the objectives of the 2020 Strategy and the new industrial policy in an enlarged European Union. FINNOV examines key factors that impact on those processes, in particular the interactions between innovation and financial markets.

In this state of the art report we review the key literature supporting FINNOV's work programme in order to understand the trajectory of research in the areas of finance innovation and growth. Much of the current debate on financing of innovative companies in Europe is based on models and data derived from experience in the USA, leading to recommendations intended to promote convergence on US structures and practice. We argue that there is now powerful evidence to suggest that the European situation is in fact different, and that Europe therefore needs to develop its own approach, adapted to its own circumstances. In this review we highlight empirical evidence and theoretical models to underpin the evolution of a distinctive and self-confident European approach to the financing of innovative businesses.

Key to the FINNOV approach is to develop research with a foundation in the sectoral and institutional dimension. A sectoral approach has become fundamental since the work on sectoral taxonomies of innovation (Pavitt, 1984) and on industry life-cycles (Gort and Klepper, 1982) match sectoral differences in the ways that innovation is introduced into differences in firm size dynamics and industry structure. Concerning the comparative institutional dimension, this review builds from a literature which has explored the properties of different finance-industry institutional links (Aoki and Dosi, 1992), the interaction of public and private sources of knowledge-led productivity growth (Hughes, 2008) and the political economy of diverse corporate governance structures (Carpenter, Lazonick and O'Sullivan, 2003; Lazonick, 2007a).

The structure of this review reflects the organisation of the FINNOV project which allows each team to develop its work within a collaborative framework, focused on the production of evidence and recommendations that will be of immediate value to both policy-makers and practitioners in shaping the way European financial markets respond to innovative businesses, as well as making a significant contribution to academic research. In this review we will reflect the key themes of the FINNOV research programme which are:

- *The interaction between financial institutions, modes of financing and modes of innovation and growth* (WP 3, 4, 5, 7, 8);
- *Finance and the Economics of Risk and Uncertainty* (WP 2, 3, 4, 6)
- *Links between economics of innovation and inequality* (WP 2, 5, 6)

First we discuss literature which contributes to the unique perspective applied to the project overall. Next we consider each of the key project themes at a project level. Finally we highlight specific areas of focus in the FINNOV work programme.

2 FINNOV perspectives

It was the renowned economist Joseph Schumpeter (1934) who first drew a strong connection between the innovation performance of an economy and the functioning of its credit and capital markets. Schumpeter's discussion of *creative destruction* is rightly regarded as one of the major contributions to how economists understand company formation and the effect on economic growth. Schumpeter's theme of finance and innovation translates into a series of important issues concerning the relative role of established and start-up companies in the innovation process, the complementarities between them, and the differential access they have to capital markets to fund business experimentation.

The innovation process in firms can be an expensive, time consuming and highly uncertain activity. As Lazonick (2010) argues, innovation is collective and cumulative, entailing high fixed costs that must be transformed into high quality products at low unit costs if the investment in innovation is to be transformed from a competitive disadvantage to a competitive advantage. Resources need to be applied to the innovation process in total, to benefit from any advances. Financial resources and the accessibility of these resources are critical to support such business experimentation. Financial resources are only one of a number of resources required to commercially exploit an innovation; human, technical, organisational and market resources are also required, but financial resources enable the acquisition of many of these other resources. Financial resources can be acquired internally; through invested profits of the firm, or externally through debt and equity financing mechanisms.

The ways in which innovative businesses are financed affect not only their own growth and economic performance, but the differential rates of return to owners, managers, workers, investors and financial institutions. They also impact on the evolution of the market as a whole; selection dynamics within the market; the rate of attrition of both new and existing enterprises; and the net contribution from innovative businesses to employment and economic development regionally, nationally and jointly across Europe. A better understanding of these processes is essential if Europe's slowly increasing rate of investment in R&D is to deliver the economic outcomes envisaged in the Lisbon agenda and in the most recent EC 2020 programme which explicitly considers how innovation led growth (*smart growth*) is tied to *inclusive growth*.

The long-term economic performance of Europe depends on its ability to first generate new knowledge and inventions, and, second, to translate invention into innovation and innovation into economic adaptation and growth. Business experimentation is central to these processes and this ability is central to achieving the objectives of both the 2020 Strategy, the Lisbon Agenda of 2000 and the new industrial policy in an enlarged European Union. However, innovation involves more than invention, more than the funding of science and technology, more than R&D. It is in relation to the exploration, manufacturing and commercialisation of novelty that the analysis of credit and financial markets is of the first importance. Their dependence on effective arrangements to supply finance and monitor and redistribute the returns to innovation is our central concern.

2.1 Evolutionary models: The interaction between financial institutions (and services), modes of financing and modes of innovation and growth

The recent extensive development of evolutionary models of firms, industries and economies has greatly sharpened our understanding of industrial dynamic processes and the links between innovation, competitive performance and economic adaptation more generally. However, the dynamics considered in much of this work have thus far been developed solely in the context of variation cum selection processes in product markets. A major gap in our

conceptual thinking therefore exists on the role of factor market processes in relation to the evolutionary dynamics of wealth creation.

However, rather than assuming that within Europe inter-agent differences are a transient state towards equilibrium with representative agents, instead it is necessary to study the source and evolution of persistent differences among economic agents (differences among firms' ability to innovate; differences among countries' growth paths, differences among claims to incomes). In fact, as in Schumpeter, these differences are viewed as lying at the centre of the competitive process itself, rather than requiring an analysis of 'imperfect' competition (Dosi et al., 2006; Delli Gatti et al., 2005a; Battiston et al., 2007; Mazzucato, 2000; Metcalfe, 1998). Thus heterogeneity among firms is explicitly considered as one of the foundations of industrial dynamics.

A conceptualization centred on the diverse ``fates'' of heterogeneous producers is typical within evolutionary models (e.g. Winter, 1971; Nelson and Winter, 1982; Metcalfe, 1998; Dosi et al, 1995, Bottazzi et al., 2001), but has also increasingly gained momentum in neoclassical theories, especially in the now relatively common setting where the attention has switched from standard static accounts to more dynamic descriptions of convergence toward industry equilibrium (see, for instance Jovanovic, 1982; Hopenhayn, 1992; Ericson and Pakes, 1995, and the literature cited therein; see also Melitz, 2003 and Asplund and Nocke, 2006, for more recent extensions). In this respect, one major difference between evolutionary and neoclassical thinking is that, in the former approach, firms are always seeking to grow more, on the basis of complex balances among switching technological paradigms, competition, path dependencies, modification of the organizational structure and adaptation to changing market conditions. In the neoclassical tradition, conversely, such kind of dynamics are conceived as out of equilibrium phenomena which stop when firms reach an optimal size, proper prices are set and expectations, possibly shaped by previous learning, perfectly forecast future outcomes. Nevertheless, although starting from different conceptual premises about motivations and modes of firm evolution, all these models deliver a common message: *first,* efficiency, profitability and growth represent the three crucial economic dimensions of revealed firm performance and, *second*, they are highly correlated over the selection process.

Theoretical and empirical issues concerning the relationships between financial institutions and business (non-financial) corporations have implications for innovation, growth and other corporate behaviours. This is justified by at least three broad empirical historical phenomena. First, the forms of financing of production and innovation activities have changed impressively in most of the industrialised countries over their development process, and have changed rapidly in the last 30 years (Nightingale and Poll, 2000). Second, significant differences in financial institutions and in their relative importance among industrialised and developing countries have persisted, and greatly influence the channels by which policy may influence innovation. Third, a widespread claim, albeit not uncontroversial as an accepted stylised fact, is that different financial setups have historically been an important conducive factor or alternatively an important obstacle to industrialisation and growth (Gerschenkron, 1953).

As to innovation, it is common wisdom that it concerns the processes of learning and discovery about new products, new production processes and new forms of economic organisation. In addition to product market competition, innovative efforts and ensuing growth patterns are shaped and selected also by the rates and criteria by which financial markets and financial institutions, such as stock markets, banks, informal investors and specialised financial institutions, allocate resources to business enterprises. These allocative criteria and rates of allocation should affect the amount and directions of resources which industries devote to innovative search.

Financial institutions simultaneously play the roles of a provider of investment funds and a selection mechanism for would-be innovative endeavours. Hence, is the relationship between finance and industrial activity, a powerful influence on the performance and paths of the evolution of different economic systems? Different financial technologies allow firms to exploit various scale and scope economies, which creates an important economic influence on how financial innovations are developed. This occurs with process innovations within banks, and also with the financial products and services they can sell. Both types of innovation influence the what financing is available for innovation elsewhere in the economy, but their workings are not well understood.

2.2 The Economics of Risk and Uncertainty

Investment in innovation can be described as a bet on the future. Both Knight (1921) and Keynes (1921), who distinguished 'risk' from 'uncertainty', used technological innovation as an example of *true uncertainty* which cannot be calculated via probabilities, whether objective or subjective. Since technological change produces a great amount of uncertainty for both the firms undertaking it and all other agents experiencing its effects (competing firms, workers employed by innovating and non innovating firms), it is paradoxical that the field of economics, orthodox as well as non-orthodox approaches, has not yet produced a thorough understanding of the links among the invention, innovation and diffusion and the financial analysis of risk, uncertainty and the innovative enterprise. One aim of this review and subsequent FINNOV research is precisely to contribute to fill this gap and analyse in this perspective also risk management instruments and associated institutions (ranging from bank assessment of risk and the related allocation of funds all the way to derivatives and hedge funds), in contemporary economies.

True uncertainty is ineluctably tied to the incomplete and asymmetric nature of information that intrinsically characterises all financial markets, but especially those that are dedicated to financing innovation. Clearly, the uncertainty associated with innovative activities further exacerbates the role of those informational asymmetries in the relationship between providers of financial resources and business firms highlighted in the new Keynesian literature (cf. the classic Stiglitz and Weiss (1992), Greenwald and Stiglitz (1990), and Greenwald, Stiglitz and Weiss (1984)). As is well known such asymmetric information is likely to result in the ubiquitous possibility of financial rationing in general, and rationing of innovative activities in particular. In this respect the project will undertake a detailed comparative analysis of the microeconomic longitudinal evidence on different forms of liquidity constraints and their impact on corporate investment and growth (Delli Gatti et al., 2005a, b; 2007).

In recent years there has been increased attention paid, by both the economics profession and the popular press, to the topic of stock price volatility. Interest peaked after the 'New Economy' period when many high-tech stocks that were considered overvalued experienced a large drop in their share price. But the idea persists that the 'knowledge economy' (less unfashionable a term than the New Economy), has resulted in greater volatility, especially of small innovative firms which tend to go public earlier in their life-cycle than in previous times.

Yet, in reality, there has been no trend increase of aggregate stock price volatility in either the USA or Europe (Schwert, 1989; 2002). Particular periods have been characterised by high volatility, such as the 1970's and the 1990's, but the increase has not persisted. Firm specific volatility has, on the other hand, experienced a trend increase over the last 40 years (Campbell et al., 2001). Various works have highlighted technological change as one of the key factors responsible for this increase in firm specific risk, as well as the periodic increases of aggregate stock price volatility. For example, Shiller's work (2000) has shown that 'excess volatility', i.e. the degree to which stock prices are more volatile than underlying fundamentals, is highest in periods of technological revolutions when uncertainty is greatest. Further recent work by Taleb (2007) reinforces this point by suggesting that financial

markets poorly anticipate speculative bubbles, particularly at times of rapid technological change, despite sophisticated risk management systems. Campbell et al. (2001) find that firm level idiosyncratic risk, i.e. the degree to which firm specific returns are more volatile than market returns, has risen since the 1960's and claim that this might be due to the effect of new technologies, especially those related to the 'IT' revolution, as well as to the fact that small firms tend now to go public earlier in their life-cycle when their future prospects are more uncertain. And Pastor and Veronesi (2005) claim that the reason that high tech firms have prices that appear unjustifiably high (at the beginning of a 'bubble') is not due to irrationality, but due to the effect that new technology has on the uncertainty about a firm's average future profits. The basic idea behind all these works is that innovation, especially when 'radical', leads to high uncertainty hence more volatility. Yet none of these studies actually uses innovation data. Innovation is alluded to (e.g. the 'IT revolution', the New Economy, radical change) but not measured, especially not at the firm or industry level.

2.3 Linking the economics of innovation to inequality

An analysis of the role of the stock market in the innovation process is important because (a) within a business enterprise, equity finance forms the foundation for debt finance; and (b) the prevailing ideology that argues that companies should maximise shareholder value has placed great emphasis on a company's stock price as a measure of its economic performance. For the publicly held business enterprise, the stock market can perform five distinct functions – labelled, alternatively, "creation", "control", "combination", "compensation", and "cash" (Lazonick, 2007a) – which can in turn influence the strategic, organisational, and financial behaviour of the innovative enterprise (Carpenter et al., 2003; Lazonick and Prencipe, 2005; Glimstedt et al., 2006; Lazonick et al., 2007). In addition, the impact on innovation of new financial actors, including private equity funds and hedge funds, is a critical area for study.

Two key testable hypotheses concerning unequal outcomes emerge from this line of research. The first is that different actors in the economic system – call them "insiders" and "outsiders" – have differential access to information about the behaviour of innovative enterprise, and hence differential ability to gain from financial speculation over the future of innovative enterprise. Under these conditions, the "exuberance" of the insiders may be quite rational. This assumption differs from Shiller's (2000) assumption that all actors in the system have access to the same information and are all afflicted by "irrational exuberance". The second hypothesis is that the financial instruments can result in significant redistribution from labour incomes to capital incomes. The growing practice whereby private equity funds use the change in control of a company that is taken private to restructure labour contracts before putting the company back on the stock market is one important example. Another important example is the use of stock options as a compensation currency since it is often accompanied by large-scale, stock repurchases designed to boost stock prices and thereby increasing the incomes of the firm's employees, and especially the top executives who make allocative decisions. There is a "skill" component that underlies the allocation of stock options, but, even in the same industry, there can be dramatic differences across nations, across regions in a nation, and even across firms in a region in the allocation of stock options as a mode of compensation. Hence this hypothesis differs from arguments concerning the extent to which income inequality is the result of changes in the value of certain skills that result from technical change (see the summary of the literature in Acemoglu, 2003). Instead, or in addition, in the presence of stock options as an important mode of compensation, financial institutions, corporate location, and firm-specific compensation systems may influence the distribution of income.

2.4 A comparative institutional analysis: why a European perspective is key

Countries differ greatly in their forms of institutional governance of the relation between financial institutions and the corporate sector – in their different reliance on retained profits, bank loans, equity and venture capital in the finance of investment and innovation. What is the impact of such variety of institutional arrangements (e.g. the "varieties of capitalism", discussed in e.g. Hall and Soskice (2001) and Aoki (1990)) on information and incentive properties and, through that, ultimately on rates of innovation and growth?

Here we progress the state of the art by adopting an explicit focus on the Europeanisation of parts (but only parts) of the financial sector and their local and regional impacts on patterns of innovation and society more generally. Typically, the treatment of these relationships has been very abstract and has not taken account of national differences. Where national characteristics have been taken into account, the dominance of American studies in this area has led to a focus on the US, with the rest of the world either ignored, or treated as an embryonic form of US patterns. For example, Gompers and Lerner's (2001) review of the venture capital literature highlights how most analysis is based purely on US experience.

One clear difference between Europe and the US is in the activity of venture capitalists. Early stage VC in Europe has never mirrored the level or intensity of activity displayed by the US. An explanation of this difference is found in the institutional foundations of the VC industries in the respective countries. The founding institutions and individuals of the VC industries cast a long shadow over the development of VC activities. Understanding these foundations provides important context through which to interpret current activities. The US has many unique features that such as a pro-active industrial policy, levels of public research funding larger than all other G7 countries combined, risk-receptive securities market regulations, large innovative IT firms in Silicon Valley and beyond, the world's best universities, sophisticated technology development policies that focus on supporting research in universities and technology development in firms, (rather than the confused focus on university technology development in Europe), a large number of entrepreneurial and well-informed early stage investors, well developed entrepreneurial training that make the US VC industry pre-eminent and highly distinctive, and a liquid exit markets for technology based firms.

The early stage industry has also, particularly in the UK, diminished further in activity in the past decade. This reduction in activity is in response to the dire financial performance of early stage VC funds. This poor European early stage VC performance is in turn is related and the "two tyrannies" of early stage VC (Murray and Marriott 1998). The two tyrannies are project risk and scale related costs. Project risk concerns adverse selection problems in assessing "a technology that is unproven incorporated into products not yet demonstrated, for markets not yet developed" (Murray and Marriott 1998 p.954). The scale related costs are the fact that successful fund managers are able to raise progressively larger funds from investors. The relatively fixed costs associated with due diligence and deal negotiation and the relatively modest capital demands at the early stage compared with later stages, inevitably lead to a concentration on larger and later stage deals. The performance issues are arguably the most critical for private sector investors involved in early stage VC. However, it is important to maintain a European focus when exploring these phenomena as early stage US funds in general do not move into later stage private equity investment as they get larger. The typical early stage VC fund in the US may have over $1bn of funds under management.

Poor investment returns of early stage investments in Europe over the past twenty years, relative to risk, have significantly reduced the appetite for early stage venture capital investing. These three factors: performance, project risk and scale related costs, have led to situation of perceived market failure. A perceived failure, because as we see later in this review, there is no consensus on the motivations for public policy activity; there are

arguments supporting market failure in the provision of a public good (the development of NTBFs, creation of entrepreneurs, new knowledge based employment etc). There are also arguments supporting public policy intervention to provide a 'demonstration effect'; early stage VC can be profitable for private sector investors if different models are used. Public subsidies are therefore used to demonstrate these models.

The activities of Corporate Venture Capitalist (CVC) highlight further differences in the strategy of European versus American investors. For instance Dushnitsky (2006) observes that around 71% of companies active in CVC are based in the US, but corporations based in the UK, Japan, South Korea and France also appear among the leading investors. Whilst in one of the very few studies that have surveyed directly the target population and reported a clear geographical breakdown, Birkinshaw and Hill (2005) found a strategic bias in the choice of location of the new venture. They reported that "…more European parent companies saw their venture units as global vehicles in the search for investment opportunities than did their North American counterparts, which seemed to take a more U.S.-centric approach to investment opportunities. However, with little research on the relative CVC performance of different innovations systems, this contributes to generating a rather incomplete understanding of the country specific determinants and performances of direct CVC programmes in Europe.

3 The role of finance for supporting innovation

As noted above there is a perception that venture capital in Europe should attempt to emulate the US model, but instead develop appropriate models which take account of country specific determinants. Here we take the opportunity to review this literature from a European perspective and briefly review some of the policy motivations. We also consider a related equity class – Corporate Venture Capital (CVC), which has received less attention in the literature, but has important implications for both the financial support and direction of firm level innovation in Europe. Finally we consider the role and implications of the much larger investment class referred to here as institutional investment. In contrast to venture capital which focuses on early stage firms, institutional investors share holdings have important implications for strategic decision making in public firms. Thus institutional investor activity and corporate governance have significant scope to influence public firm investment in research and development.

3.1 Venture capital

In the literature, discussion of the roles of different types of investor and the implications for innovation are frequently concerned with the role of venture capital. Venture capital has traditionally been associated with financing innovation, supported by seminal studies such as Kortum and Lerner (2000). Venture capital, defined as independently managed, dedicated pools of capital that focus on equity, or equity-linked investments in privately held, high-growth companies (Lerner 2009), plays a role in translating R&D activities into commercial outcomes and is therefore credited with a catalytic role in innovation (Christofidis and Debande 2001).

The analysis of venture capital in the literature proceeds from two directions – venture capital as a financial asset class; and venture capital as a means of supporting new technology-based firms (NTBFs), who in turn act as vehicles for the commercialisation of innovative activity. The link between new business formation and economic development is well established (Hughes and Storey 1994; Denis 2004). Small and new firms are recognised as important drivers of innovations (Acs and Audretsch 1990) and employment (Lerner 1994). The creation of new and high technology firms plays a further role. These firms are associated with higher levels of innovative activity, radical innovation, and higher usages of research and development. They form the core of the knowledge based economy and the products and services that emanate from these firms create the markets and industries of the future (Sainsbury 2007). Venture capital is linked to debates on economic

development at the national, international and regional level. The linkage of VC activity and maturation of technology and economic development is long held and is increasingly given as the reason for public policy activity in supporting and encouraging the supply of venture capital.

The equity environment is broadly segmented into three categories; start-up or early stage finance, expansion finance and buy-out finance. The early stage or start-up finance is equated with venture capital. At the early stage there are a range of individuals and organisations that play a role in financing new technology based start-ups including business angels, venture capital funds and corporate venture funds and activities.

Public policy activity in the venture capital industry is often motivated by the expectation that by satisfying NTBF's demand for equity based financing, this supports technology and SME firm development. Here the link between NTBFs and economic development (nationally, internationally and regionally) through the translation of R&D into technology and the maturation of technology into new products, processes and businesses which in turn create profits and employment is frequently reported. However, whilst the link between NTBFs and increased economic activity is well established, the link between venture capital and NTBFs is more complex. More venture capital does not necessarily mean more NTBFs, as the maturation of technology requires many other factors to be in place in addition to finance. Yet venture capital remains an important source of finance to support NTBFs.

Public policy has also played a major role in creating new pools of capital through regulations relating employee funded pensions, and then regulations and guidelines which have allowed these pools of capital to invest in venture capital funds. However, in the past ten to fifteen years public policy support has switched from the direct provision of capital support to NTBFs, to public sector investment in private sector managed funds (Lerner 2002; Leleux and Surlemont 2003; Da Rin, Nicodano et al. 2006; Jaaskelainen, Maula et al. 2007). These funds are various, known as government-backed funds or hybrid funds, and involve public sector agencies investing capital as limited partners (in addition to other private sector investors) into privately administered venture funds. The reasoning for this policy movement and the identified shortcomings of hybrid funds serves to highlight the extremely difficult and complex environment that supports NTBF development. It also highlights the confusion in motivations for public policy actions, as to whether they address a market failure or an opportunity to provide a demonstration effect. The lack of clarity about government motivations for their support of hybrid models (i.e. demonstration or market failure) make it difficult for hybrid funds to be structured in a way that can deliver outcomes for private and public investors (Jaaskelainen, Maula et al. 2007; Sharpe, Cosh et al. 2009). There are several problems with hybrid funds worth highlighting at this point. Typically hybrid funds are far too small to be economically viable (i.e., approximately Euro 25m when they should be at least Euro 50m) presenting additional constraints for making follow on investments, with the result that their returns get diluted by deeper pocketed investors in subsequent funding rounds. Other concerns with hybrid funds include their tendency to focus on particular geographical areas and regions (which severely limits the 'deal flow' of high quality firms, and their ability to specialise by technology), a lack of commercial focus (i.e. have to address other areas of government policy), and lack of human capital, and poorly served by advisors and exit markets (Nightingale et al. 2009). Perhaps the main problem, resides on the demand side (at least in the UK) as there are not enough high potential firms being generated to justify an industry. When Nightingale et al. (2009) evaluated the UK hybrid funds they found very little difference between the performance of funded firms, in fact using a matched sample analysis suggested the supply side problem of lack of funding is over-stated in the UK.

Sources of finance for innovative enterprises encompass a variety of mechanisms of equity provision as well as a broad range of public and private investors. In recent years the lion's

share of studies and policy reports on the supply of risk capital has focussed on venture capital (VC). This has broadly been portrayed as an increasingly necessary, albeit not sufficient, condition for the formation of new businesses especially in high tech sectors. Among alternative sources of finance, corporate venture capital (CVC) has arguably received less attention than necessary and studies of its determinants and characteristics have been relatively rare.

3.2 Corporate Venture Capital

By and large, corporate venturing is not a new phenomenon. Large corporations have invested in new businesses through venture-type mechanisms since the mid-1960s (E.g. Xerox, Motorola and Johnson & Johnson) but the specificities of CVC have been less neatly identified, often for lack of systematic data, than the related VC market. Moreover, if estimates are correct, in recent years the volume of VC activity seems to have been significantly superior to that of CVC. Both types of venturing activity are most prominent in the US and for both of them the United States has become the main benchmark for international comparisons and policy design. Also, CVC and VC investments appear to follow the same economic cycles (with peaks in the late 1960s, mid 1980s and late 1990s) and share some of the financial and strategic trade-offs on which capital investment decisions are based.

Corporate venturing can take different forms. The literature distinguishes between internal and external corporate venturing (Sharma and Chrisman, 1999; Maula, 2006). The former includes venturing activities contained within the firm while the second includes a range of strategic decisions aimed to develop new organisations outside given firm boundaries. Keil (2000) abstracts a classification of corporate venturing from a study of the IT sector in the US and Europe. This includes in the group of external activities; corporate venture capital (CVC); venturing alliances (VA); and transformational arrangements (TA). CVC encompasses third party funds, dedicated funds and self managed – and often called 'directly invested' – funds. VAs include non equity alliances, direct minority investments and joint ventures. TAs include acquisitions and spin-offs. The recent review by Narayanan et al. (2009) follows similar lines. The authors define the general activity of corporate venturing as "the set of organisational systems, process and practices that focus on creating business in existing or new fields, markets or industries, using external and internal means" (p. 59). Innovation and new business incubation are classed as 'internal means'; licensing, joint venturing, acquisitions whilst corporate venture capital is classed as 'external means'. The literature does not always define the relevant unit of analysis clearly and this often makes comparisons across studies very difficult. However, a narrow, and therefore operationally reliable, definition of CVC is restricted to direct investments by corporations in new ventures (self-managed funds) outside it s organisational boundaries. Following Maula (2001), Narayanan et al. (2009) refer to CVC as "any equity investment made by non-financial corporations in start-up companies, for strategic and financial purposes" (p. 64).

3.2.1 Why do corporations engage in CVC activities?

There is no shortage of hypotheses about the motives for corporate venturing (among the most recent contributions on this are Kann, 2000; Keil, 2000; Chesbrough, 2002; Gawer and Cusumano,2002; Maula et al. 2005; Dushnitsky and Lenox, 2006). Maula (2006) rightly observes that no consistent answer emerges from research on the goals of CVC. Goals identified in existing surveys include:

- return on investment,
- identification of new technological opportunities,
- creation of new business relationships,
- identification of acquisition targets,
- exposure to new markets,

- diversification of product pipelines,
- R&D outsourcing,
- managers' training,
- acceleration of market entry,
- leveraging technological platforms, standards and underutilised complementary assets.

Overall, financial and strategic goals do not appear to be mutually exclusive (Chesbrough, 2002). On the contrary, the sustainability of a corporate venture capital programme may well depend on the right mix of short- and long-term objectives. However, and in spite of the fact that this is one of the areas most intensively researched, "…While many goals have been recognized, there is quite limited understanding of the circumstances under which different goals can create value for the corporation as well as proper design of effective venture capital programs […]" (Maula, 2006: p. 382).

Interesting insights regarding the role of innovation motivations in CVC can nevertheless be found in the literature. The following are relatively recent, have systematic empirical backing, are not based on single case studies and therefore stand out for comparative purposes. In a survey of 150 European corporations (Bannock Consulting, 1999, cited in Maula 2006), 62 per cent indicated strategic objectives as the main drivers of CVC investment. In a survey of 152 CVC programmes, Kann (2000) found that 45 per cent aimed to perform extra-mural R&D, 30 per cent aimed to accelerate market entry and 24 per cent to expand demand for their products. The same study reported that most of the initiatives focused on R&D purposes reflected investments in the same sector in which the corporation was active or in related sectors.

3.2.2 CVC opportunity cost and implications for firm innovation and performance

With respect to the opportunity costs, hence the choice of CVC vs. alternative forms of venturing, it is hard to find specific empirical evidence. The little evidence available (for example, Maula and Murray, 2002) points to the fact that only a minority of CVC-backed companies are later acquired by the corporation and that (on line with Winter and Murfin's earlier study from 1988) CVC is not an effective instrument to screen potential future acquisitions because of conflicts of interests among investors. With respect to the compatibility and/or relative advantage of CVC with alliances, although it is well known that both strategies are used, for example, to enter new markets and access new technology platforms (Ahuia, 2000), very scarce systematic evidence can be found in the form of comparative analysis.

At the firm level Dushnitsky and Lenox (2005a) finds positive correlations between the intensity of corporate venturing, firm size, firms' cash flow and absorptive capacity. Absorptive capacity is typically quantified by means of in-house R&D investment. This result, in line with Chesbrough and Tucci (2004), is interesting not least because it suggests that CVC is not a substitute for intramural R&D but instead a complement. Maula et al. (2006) add to the set of determinants exerting a positive impact on the likelihood of CVC the systemic nature of innovation. Interestingly, Dushnistky (2006) also finds from a panel (1990-2003) of established firms' portfolios that CVC were more likely to invest in mature stages of ventures than independent VCs[1] although recent EVCA figures seem to indicate that a more balanced proportion of investments is increasingly shared between expansion and start-up phases (EVCA Corporate Venturing 2005 Press release).

[1] Also, the average syndicate size is significantly larger when a CVC investor is part of the deal irrespectively of the round and hence independently of the maturity of the venture.

One area of research that has received increased attention in recent years concerns the performance of CVC. For example Gompers and Lerner (1998) showed that in the US CVC investments were more likely to lead to initial public offerings and that these tended to be higher for CVC than for VC. Also CVC have been associated with a positive impact on the future innovative performance of the new firm. Birkinshaw et al. (2002) found CVC programmes to be effective for (in order of importance): gaining a window on new technology developments, making better use of the corporation technology assets, increased visibility/awareness of the corporation, financial returns. Whilst Keil et al. (2003) study of ICT firms in the US concluded that CVC was associated with superior patenting activity of the investing company, an effect especially strong in cases of high technological relatedness between the competence bases of firms. Keil et al. (2008) finds CVC, joint ventures, and alliances for firms in related industries are positively correlated with increments in innovation performance, but no such correlation is found for acquisitions. Positive effects of patenting from CVC were also found on the likelihood of explorative learning in a similar panel of US ICT firms by Schildt et al. (2005). Finally, Dushnitsky and Lenox (2005a and 2006) worked on a larger sample of US firms covering a period of 20 years and reached similar conclusion on the positive relations 1) between involvements in CVC and patenting and 2) between CVC and firm value.

With regard to the determinants of firm performance as a consequence of corporate venturing, the literature highlights again many factors but in this case it is possible to establish a clearer profile. The latest studies (Dushnitsky and Lenox, 2005b; Birkinshaw and Hill, 2005; Wadka and Kotha, 2006) show a positive correlation between technological relatedness and both patenting and returns on investment. This is often mediated by levels of absorptive capacity and characterised by U-shaped patterns indicating diminishing returns. Returns are higher when the degree of autonomy of the new venture is more pronounced; when the venture is well connected with a broader network of VC investors; when incentive structures within the CVC operational unit are stronger and when short-term financial objectives are not predominant over strategic long-term goals.

A combination of financial and strategic objectives underpins the decision of large companies to engage in direct corporate venturing activities. While the sustainability of CVC programmes is highly likely to be related to satisfactory financial returns on investments (and it is plausible that expectations of returns vary across firms), survey evidence shows that these tend to come second to strategic objectives in various rankings of determinants of CVC. Strategic goals include, among others, access to new technologies, new markets, training, R&D outsourcing and the development of new business relations. At the industry level, decisions to engage in CVC appear to depend on the relative strength of IPR regimes, the presence of technological opportunities and the availability of complementary assets. At the firm level, firm size, firm cash flows and absorptive capacity (proxied by R&D) have been shown to be positively correlated to the choice of CVC investments. However, no systematic analyses have been found in the literature on the opportunity costs of conducting CVC activities vis-à-vis other forms of inter-organisation arrangements such as joint-ventures and R&D.

Whilst in this section we have considered the implications of equity investment in private firms, a missing element from our review concerns the influence of the characteristics of institutional investment holdings on the innovation strategy of public firms. For instance, given that institutional investors account for around 60% of the capital of the largest 1,000 U.S. companies (Hawley and Williams, 2000), the potential for influence is clear. Thus our discussion of finance and innovation would be incomplete without considering the relationship between corporate governance, institutional investment and innovation.

3.3 Corporate governance: institutional investors and innovation

Within Europe, different national systems of corporate governance and different models of capitalism prevail even if European integration is creating pressure toward convergence to a single model, largely inspired by the Anglo-Saxon system. Here we focus on two major issues: i) What types of reform of national systems of corporate governance would have to be made to establish a model of corporate governance that promotes innovation? ii) What are the effects of institutional ownership on corporate innovation strategies? More precisely, does ownership concentration or institutional activism have an effect on R&D investments?

Many theoretical and empirical works have been realized on these two issues and have led to contradictory results (see Kochhar and David, 1996, for a survey). Some research has demonstrated that institutional investors look for long-term gains and invest in firms that are more innovative (Allen, 1993; Jarrell et al, 1985). However, a large majority of empirical works consider instead that institutional investors, because they hold large stakes in corporations, will monitor managers and encourage them to increase the level of innovation. According to this thesis, institutional investors do not select corporations with a higher degree of innovation but rather monitor managers to become involved in strategies for innovation.

On the other hand, a large majority of the studies consider the hypothesis that institutional investors are motivated by the quest for profitability in the short-term and do not encourage managers to become involved in strategies for innovation in the long-term, which are by nature risky and uncertain. Some consider that institutional investors look for short-term gains from their investments (Drucker, 1986; Mitroff, 1987, Graves, 1988; Jacobs, 1991; Porter 1992). These researchers (and in particular Porter, 1992) show that managers underinvested in long-term to meet short-term objectives of institutional investors, considered as myopic actors. According to this myopic view, institutional investors could prevent innovation.

3.3.1 Managerial myopia or myopic viewpoint

According to the myopic viewpoint, institutional holding and firm innovation will be negatively correlated. In recent years, a number of studies (Drucker, 1986; Mitroff, 1987; Graves, 1988; Franko, 1989; Jacobs 1991; Porter, 1992) have explained the declining position of the United States in international competitiveness by managerial myopia. For instance, US firms have reduced their long-term investment and have become less innovative than Germany or Japan that have instead opted for the long-term investment (Jacobs, 1991; Porter, 1992,). Porter (1992) explains that this managerial myopia is created by “transient” investors that hold small stakes in numerous corporations and trade frequently according to earning news. He stresses that “dedicated owners”, on the contrary, because they hold large stakes in corporations, monitor managers and promote long-term investments. As for “quasi-indexers“(characterised by low portfolio turnover, high diversification and passive buy-and-hold investing strategies), Porter (1992) considers that they have little or no influence on corporate strategies of innovation. Indeed, given the fragmented ownership and passive investment behaviour of quasi-indexers, they tend to promote a myopic behaviour of managers with respect to long-term innovation. The question of the long or short term focus of institutions such as the City of London has been the subject of intense debate for decades. However, it should also be noted that the City of London, which has arguably the shortest term focus of its financial system in Europe, has been able to fund a number of extremely long term projects and develop relative technological strengths in pharmaceuticals, oil and gas and aerospace, which are technologies with decade long payback times.

3.3.2 Which institutional investors take a long-term perspective?

Whilst some studies have validated a negative relationship between institutional ownership and innovation (see Graves, 1988, 1990; Majamda and Nagarajan, 1997; Dixon and Seddighi, 1996). Graves (1988), for instance, has validated the myopic hypothesis while finding a negative relationship between institutional holdings and R&D intensity (R&D intensity is defined as expenditures per employee or per unit of sales). Nevertheless, a large number of studies consider that far from being myopic, institutional investors are superior monitors and can actually influence firms to be more innovative (Jarell et al, 1985; Baysinger et al. 1991; Hansen and Hill, 1991; Francis and Smith, 1995; Eng and Shackell, 2001; Kochhar and David, 1996; Zahra, 1996; Aghion et al. 2009). Such studies demonstrate the monitoring role of institutional investors by focusing on the relationship between ownership concentration and investments in R&D whereby a higher institutional ownership is associated with greater innovation.

Kochhar and David (1996) study focus on an outcome of innovation: new products developed by the firm as a sign of innovative ability. Their study postulates that institutional investors are not homogeneous entities and have different goals (see Roe, 1990; Black, 1992) and refers to the typology of Brickley et al (1988). Kochhar and David (1996) demonstrate that institutions do not invest for the short-term. Instead, institutions that hold large stakes in corporations influence managers to increase firm value and engage corporations in long-term innovation strategies. Aghion et al. (2009) show that a higher institutional ownership is positively associated with greater innovation (the positive effect is stronger when market competition is high). More precisely, they demonstrate that institutions have a weak and positive impact on R&D but a larger effect on the productivity of R&D. On average, their study demonstrates that institutional ownership is beneficial for innovation and efficiency.

Other studies have not focused solely on the relationship between stock ownership and investment in R&D: they have adopted a different perspective while stressing in particular the relationship between corporate governance and innovation. For example, the studies of David et al. (1996, 2001) underline that stock ownership alone can be inadequate when institutional investors remain passive. They explain that institutional investors are required by law to hold diversified portfolios and that specific restriction exist to limit their ownership in corporations for some types of institutional investors (see Roe, 1991). If institutional investors have high aggregate ownership in firms, individual shares are fragmented making it difficult for investors to exercise significant influence alone. David et al. (1996, 2001) show that institutional investors are not passive owners but exercise influence through activism that pressure managers to become involved in strategies for innovation.

Examining the relationship between corporate governance and innovation, Baysinger and Hoskisson (1990) conclude that boards dominated by outside directors may lead firms to reduce investment in the development of internal innovation and may focus more on product diversification and external innovation through acquisitions. They demonstrate that outside directors perceive less risk to be associated with external innovation than with internal innovation. The study of Ortega–Argiles et al. (2005), led on a sample of Spanish manufacturing industries, considers the effect of the inclusion of owners in the management of corporations. It demonstrates that an increase in the participation of owners in management positions lower the probability of adopting R&D projects and the probability of formalising the result of innovation in register of patents. They explain this result by the concentration of risks in the hand of few owners.

3.3.3 Toward a typology on institutional investors to better understand the relationship between institutional ownership and innovation

Porter (1992) has asserted that the transient ownership behaviour of U.S. institutional investors has contributed to the development of a myopic capital market in the U.S. However, it is crucial not to consider institutional investors as a homogeneous group. Instead, institutional investors have different investment behaviour in terms of portfolio turnover or in terms of activism in corporations. Some institutional investors are in particular more favourable than others in R&D investment and thus in long-term investments: public pension fund managers are for example more likely to focus on firms that have long term new product development strategies and will engage in investor activism more than professional investment funds (David et al. 2001).

Some studies present typologies of institutional investors that can be useful to study the relationship between institutional ownership and innovation. In particular, Brickley et al. (1988) have found that pressure resistant (i.e. public pension funds, mutual funds) investors are more positively associated with the rate of new product development. Whilst Bushee (1998) using the past trading behaviour of investors demonstrates that, as a whole, institutions reduce incentives for managers to act myopically. Cuts in R&D following poor earnings performance are less likely the greater is the degree of institutional ownership. Hoskisson et al (2002) also differentiates among types of investors to test the relationship between institutional holdings and investment in R&D. Hoskisson et al (2002) demonstrate that pension fund managers avoid investing in corporations that pursue external innovation through acquisition and prefer internal innovation, whilst mutual fund managers prefer external innovation that generate more immediate returns and consider that investments in R&D as an expense that reduces short-term returns.

More recent works have been realized to differentiate among types of institutional investors and their time horizons. In particular, the study of Dupuy et al. (2010) questions the thesis that large institutional investors require high returns on invested capital in a shorter time period and are said to be impatient contributing to the “financialization” of economies and corporate strategies (Williams, 2000; Froud et al., 2000). Their study clearly differentiates between strategic holders (State, family, corporations, banks) and institutional holders (pension funds, mutual funds, private equities, hedge funds). It demonstrates that U.S. investors trade securities most frequently relative to other international equity investors. The most volatile actors are hedge funds followed by investment advisors, endowment funds and brokers/dealers, the least volatile actors being State, individual and corporations, whereas banks, insurance companies and pension funds occupy a middle position in terms of portfolio turnover. Overall, the United States is the most active country in terms of portfolio management, confirming that this country is clearly the archetype of “finance-driven” capitalism. The study of Dupuy et al. (2010) reveals that Asian investors have on the contrary long-term horizons and that European investors are characterized by intermediate behaviours (and are finally relatively similar in how they manage their portfolios of financial assets). This work focuses on two factors that can be fundamental for understanding the time horizon of institutional investors and by extension their influence on innovation: the type of investor (pension fund, mutual funds...) and its nationality (U.S. investors versus Asian or European investors). These two variables deserve to be included in a work that seeks to analyze the relationship between institutional investors and investment in R & D.

In this section we have considered the implications of different types of investment, as well as different types of investors within investment classes, on innovation at the firm level. However, so far we have stopped short of analysing the performance implications of the relationship between finance and innovation. In the next section we examine the performance outcomes of innovation from an evolutionary perspective focusing on market selection.

4 Innovation and performance, financial markets

A large body of empirical research has grown over the last twenty years exploring the impact of firms' selection on the aggregate properties of industry evolution. Building upon the increasing availability of large longitudinal datasets, particular attention has been devoted to decompositions of aggregate productivity and growth aiming at the identification of the relative contribution of entrant, continuing and exiting firms or plants (see reviews in Caves, 1998; Ahn, 2000; Bartelsman and Doms, 2000; Foster et al., 2001). Considerable selection seems to operate especially among young and small firms, but market pressure does not seem to work particularly well on incumbents, at least on the rather short time horizon covered by firm level data (Dosi, 2007).

Possibly due to the theoretical presumption that efficiency, profitability and growth are highly correlated with each other, productivity is commonly considered as an exhaustive measure of fitness. Here we mean fitness to be the relative-rather than absolute- efficiency of firms upon which firm growth and survival is determined. Dosi and Nelson (1994) argue that fitness is determined by a combination of several different efficiency criteria at the firm level, the cash flow situations, accounting profits, investor expectations regarding profitability, relative quality of products, prices and after-sales servicing, delivery delays and marketing networks being some of these (p.156). In this picture, innovation stands as a crucial factor that can improve the fitness of a firm through boosting several of these dimensions of firm efficiency.

Despite very strong differences in their treatment of technological change in economic theory, both the neoclassical and the more Schumpetarian (and evolutionary) economic approaches often assume that market selection rewards the most innovative firms: more innovative (and hence, more efficient) firms should outperform the less innovative ones, with higher growth, profits, and stock prices. This is because product innovation can create new markets and/or increase the market shares of innovators. Similarly, process innovations improve the productivity of innovators by cutting production costs. However, despite such strong assumptions, empirical evidence on whether innovative firms perform better than non-innovative firms remains inconclusive.

While the positive effect of innovation on financial performance, such as market value and stock prices, has been found to be more or less robust (Blundell et al., 1999; Griliches 1984; Hall et al., 2005; Toivanen et al., 2002), the empirical evidence for the impact of innovation on firm growth is more mixed and does not firmly confirm the assumption that innovative differences among firms lead to growth differentials. Dosi (2005) formulates this problem in the following words: "...The impact of both innovativeness and production efficiency upon growth performances appears to be somewhat controversial...Contemporary markets do not appear to be too effective selectors delivering rewards and punishments according to differential efficiencies" (p.25 and p.29).

If innovators do not grow more, does this imply that market selection fails? And does the different impact of innovation on industrial performance (measured by firm growth and profitability) and financial performance signal differences in how industrial and financial markets react to firm level efforts around innovation?

4.1 Innovation and Market Selection

Friedman (1953) argued that the survival of firms depends on their ability to maximise profits. He argued that firms that fail to maximise profits will eventually be driven out of the market. While it is not unreasonable to assume that more profitable firms will grow at the expense of the less profitable, the "profit maximisation" principle stands out as an unrealistic

means of describing what “fitness” entails (See Nelson and Winter, 2002 for a detailed critique of Friedman and followers).

The market selection processes that choose the winners and losers based on their relative efficiency, supposedly favour those who operate more efficient technologies. Firms operating less efficient technologies have lower profits and consequently, less money to fund their growth. As the industry evolves, the market shares of the inefficient firms converge to zero and they are driven out of the market (Beker, 2004). Freeman (1995) holds that the fastest growing firms have larger capacity for a flow of incremental innovations and occasional radical innovations. Bigsten and Gebreeyesus’ (2008) find empirical evidence showing that most productive and efficient firms are more likely to grow fast and through this process, resources are “reallocated from less to more productive firms”. Shiferaw (2007), using the same data set as Bigsten and Gebreeyesus (2008), adds that firm investments into technological capabilities enhance firm level efficiency, which in turn, allows the firm to perform better than other firms (with lower investments).

Kiyota and Takizawa (2006) find that market selection works gradually to eventually drive the inefficient firms out of the market. “Gradual declines in productivity ultimately cause the exit of firms from the market, which implies the existence of the ‘shadow of death’” (Kiyota and Takizawa, 2006; p.2). Griliches and Regev’s (1995) and Bellone et al.’s (2005) results also confirm that ‘continuously below the average’ efficiency results in firm exit.

Of course, the degree to which market selection is tolerant to temporary losses of efficiency determines the time horizon in which inefficient firms are driven out (Bellone et al., 2005). Innovation is a very uncertain, expensive and lengthy process, with R&D projects (if successful) taking up to 20 years to come to fruition. Thus too short a time horizon may lead to the failure of the most innovative firms that undertake the biggest risks with a view of long term gains. At the other extreme, very slow operating of the selection mechanism will lead to efficiency losses on the whole as the market takes too long to reallocate the resources to more productive firms. Geroski and Mazzucato (2002) show that the capital market eases the selection pressures on innovative firms by providing them with the means to survive until their innovative products make it to the market. If the capital market does its job well by financing the most innovative firms, myopic selection in product markets may allow innovative firms with long time horizons to be rewarded rather than punished.

Product innovations play a significant role in market selection as consumers base their purchase decisions on the merits and quality of the products in question (Geroski and Mazzucato, 2002). On the other hand, process innovations contribute to the efficiency of firms by reducing production costs. Bellone et al.’s (2005) results indicate that the product-innovation based efficiency counts more for the small firms while for the large firms, productivity (achieved via process innovations) is the key criterion based on which market selection rewards the winners. Yet, it is not always clear that market selection works as smoothly as anticipated. Indeed, there are growing concerns that selection does not quite do the job of correctly rewarding the most innovative and efficient firms in industrial markets. For instance, Tamagni (2007) shows that the firms that exit the Italian markets are not always the least efficient and the slowest growing firms (See also Nishimura et al. 2005 for a similar result for Japan). Bottazzi et al. (2002) find that market selection operates rather gently on the ‘near-average’ firm but "... its role, it seems, is mainly to cut out the very worst performers".

Similarly, the degree of persistent heterogeneity in relative productivity across firms is usually taken as an indicator of (lack of) competitive pressure. Accordingly, a great number of results have been gathered confirming the empirical relevance of the productivity-survival link, whereas much less work has been done on the existence and strength of the relation between productivity and profitability and between profitability and growth. In this respect a

first natural question is whether profitability, rather than productivity, represents the proper fitness measure. Indeed, theory as well as reality suggests that it is not merely the efficient use of inputs which determines survival on the market. Continuation of activity is warranted until the interactions occurring between efficiency and market characteristics are such that there is room for profitable operations.

If prices, as it might well be often the case, embody demand conditions or firm specific market power, then there is no need to expect that selection operates in the same way on technical efficiency and profitability (Foster et al, 2008). In order to recompose the overall picture, it is also necessary to analyze if, and to what extent, higher levels of profitability and productivity generate increased growth rates. Indeed, despite the crucial role which these dimensions are usually assumed to play in shaping the overall selection process, one is lacking any conclusive evidence on whether the most productive firms grow faster or on the tendency of firms to translate profits into an expansion of their market shares. It is only very recently that some -- still limited -- evidence on the sign of the correlation and the direction of causation between these variables has appeared (see Goddard et al., 2004; and Coad, 2007; Bottazzi et al., 2008; Coad et al., 2008). Next we look at the relationship between innovation and market selection further, taking industrial markets and financial markets separately.

4.1.1 Market Selection in Industrial Markets: Innovation, Profitability and Firm Growth

The empirical evidence on the impact of innovation on profits and firm growth (indicators of firm performance in industrial markets) is mostly mixed especially for the latter. Geroski et al. (1993) find a small positive impact of firm (successful) innovations on profit margins. Geroski and Machin (1992) point out the persistent and significant differences in profitability of innovators and non-innovators. Freel (2000) argues that such profitability differences among innovators and non-innovators are contingent on several factors such as firm size and industry characteristics. Leiponen (2000) also finds persistent differences in determinants of profitability for innovators and non-innovators: factors such as patenting and educational competencies positively affect the profitability of innovators while such factors have no significant (or even negative) effects on the profits of non-innovators. Stoneman and Kwon (1996) find in a sample of UK firms that those firms which fail to adopt new technologies experience reduced profits while the adopters of new technologies gain an annual gross profit of 11% above the mean profit of the sample firms. While there seems to be a relationship between innovation and profitability, these studies fail to consistently establish the exact nature of the relationship. Contradictory findings such as in Robson and Bennet (2000), for example, do not find any evidence of profitability growth for a sample of innovating small UK firms.

The empirical results regarding the effect of innovation on firm growth is even more mixed than that on profits. While some studies confirm that more innovative firms grow more, others fail to see such a clear relationship. Adamou and Sasidharan (2007) find that firms which have higher R&D intensity ratios (i.e. R&D/sales) grow faster. Also, Yasuda (2005) shows that R&D expenditures per employee have a positive impact on firm growth. Yang and Huang's (2005) work on Taiwan's electronics industry confirms that R&D is an important determinant of firm growth. Foray et al. (2007) argue that R&D expenditures are positively correlated with sales growth while Del Monte and Papagni (2003) show that R&D has a positive impact on firm growth but this is more pronounced in traditional industries than in the most 'high-tech' ones. Geroski and Toker (1996) find that innovations of the 209 large UK firms in their sample have a positive impact on annual turnover while Geroski and Machin (1992) identify that the firms that produced at least one 'major innovation' in their sample grew faster than firms that never did.

On the other hand, the literature (e.g. Heshmati and Lööf, 2006 Kirchoff et al., 2002 Oliveira and Fortunato, 2005 Bottazzi et al., 2001 Almus and Nerlinger, 1999) also fails to find a

strong link regarding the impact of innovation on firm growth. Whilst others, such as Brouwer et al. (1993) find that innovative activities only boost the growth, of firms with specific characteristics, such as above-average R&D spend. In addition there are studies show that innovative activities have a negative impact on firm growth, most commonly caused by the inability of the high cost of research to be recovered through increased sales or profits (Folkeringa et al., 2004 Coad and Rao 2006, 2007). Likewise Teece (1986) argues that there is no obvious reason why we should assume that innovations will translate into higher revenues or market shares for innovators unless they have access to "complementary" assets such as marketing, distribution and business networks.

Thus the innovation-firm growth literature is far from presenting a clear cut picture on whether and how firm growth is affected by innovations. The mixed results could suggest that innovation has no significant impact for firm growth, or maybe that innovations only affect the growth of a certain subset of firms with certain characteristics. If the latter case is true, one would fail to identify a clear significant relationship between firm growth and innovation unless different types of firms, innovations and industries are considered separately.

4.1.2 Innovative persistence

Industrial economists are faced with a related puzzle as one digs deeper into the time series properties of innovation and firm performance variables (such as profits, growth and productivity) as well as the relationship between these. While innovation and profits show some degree of persistence in their time series behaviour, firm growth lacks much persistence—sometimes seeming like a 'random walk'. How can one reconcile the dissimilar dynamics of innovation and firm growth variables if the underlying assumption of market selection is that innovative behaviour of firms should translate to performance? Should not the persistent innovators grow more persistently?

The innovation literature finds some degree of persistence in innovation and profits, and less so in growth rates. Persistence of innovation and profits refers to the degree to which innovating firms at any given time will continue to innovate and firms with above average profits will continue to make higher than average profits in the following periods. Innovative persistence and persistent profitability have important implications for firm growth as they can trigger dynamic increasing returns which result in lumpy growth (i.e. not in small, identical and incremental steps) and persistent correlated growth for the innovators and for firms with above average profits (Cefis, 2003; Malerba et al., 1997). Hence, if there is persistence in innovations and firm profits, one would expect these to show up as persistence in firm growth differentials. Yet, as discussed above, firm growth studies consistently report a lack of persistence in firm growth behaviour which is most puzzling for industrial economists.

There is general consensus that innovation persists over time at the firm level even though the persistence tends to weaken when one inspects innovation over longer periods of time (e.g. more than 5 years). Geroski et al. (1997) find that very few firms are persistent innovators. They show this finding is robust to how one measures innovation; either with patent data or the count of firms' major innovations. Cefis and Orsenigo (2001) and Cefis (2003) confirm the results of Geroski et al. (1997) that very few firms are truly persistent innovators. As these firms account for the majority of innovations in most sectors, they argue that in fact there is persistence in innovative activities. Non-innovators are also persistent: their probability of starting to innovate is very low if they have never innovated in the past. Peters' (2006) results show very high levels of persistence in innovation activities for both service and manufacturing firms and for both the innovating and non-innovating firms. Alfranca et al. (2002) also conclude that there is a significant degree of persistence in the innovation activities of food and beverage companies and that old innovators are the most likely candidates to introduce new innovations.

Persistence in innovative activities results from a range of factors. The first and most important one of these is the path dependent nature of organisational routines in which the firm specific innovative behaviour and capabilities are rooted (Nelson and Winter, 1982). The second reason for the persistence of innovations is that sunk costs associated with building an R&D facility encourages the firm to invest into R&D continuously (Sutton, 1991, 1999). This persistent R&D expenditure behaviour leads to persistent innovations. Thirdly, firms often undertake multiple R&D projects. Hence, even when a single project delivers results/innovations with irregular intervals, the sum of all R&D projects is likely to deliver outputs at a regular interval (i.e. yearly) leading to persistent innovations at the firm level. Fourthly, the positive feedback between innovation and profits leads to persistence in innovations. Firms that earn high profits due to their innovations can reinvest these earnings back into the innovative activities which will likely deliver new innovations (Cefis and Ciccarelli, 2005). Finally, firms that have invested in innovations in the past are more likely to innovate in the future as a result of the positive feedback effects resulting from absorptive capacity (Cohen and Levinthal, 1989,1990).

Innovative persistence needs to be understood in the context of industry evolution and the changing characteristics of the innovation regime. 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 tapers off, innovations become more cumulative and the innovators are mostly large firms (Abernathy and Utterback, 1978; Agarwal and Gort, 1996; Gort and Klepper, 1982; Klepper, 1996, 1997; Londregan, 1990; Malerba, 2007; Mazzucato, 1998, 2002). The earlier stages of the industry life cycle are characterised by less persistence in innovations while the level of persistence increases in the later stages of the industry evolution with the dominance of large firms. The innovative persistence literature documents that large firms tend to be more persistent in their innovative activities compared to small firms (Cefis, 2003; Cefis and Orsenigo, 2001; Rogers, 2004) with the exception of Japan where small firms are found to be more persistent innovators (Cefis and Orsenigo, 2001).

The firm profitability literature similarly suggests that there is a strong tendency for profits to persist, for example see Mueller's (1977) Jacobsen's (1988) Goddard et al. (1997) Cable and Jackson (2008). Unlike in the case of profits and innovations, with the exception of some studies (Abbring and Campbell, 2003, Chesher, 1979; Bottazzi et al., 2005; Contini and Revelli, 1989; Saito and Watanabe, 2006; Wagner, 1992) most of the firm growth literature finds almost no persistent structure in firm growth (Chan et al, 2003; Dunne and Hughes, 1994; Geroski, 1998; Hart and Oulton,1996 and 1997; Reichstein and Dahl, 2004; Singh and Whittington, 1975). Even in cases, where growth is found to be persistent, the level of persistence is much lower than what one would expect to conclude that success breeds success and failure breeds failure. It is thus very difficult to reconcile the evidence for dynamic increasing returns arising from the persistent behaviour in innovation and profit rates with the lack of this persistence in growth rates (and market shares)?

4.2 Financial markets and indicators: ratings of competitiveness

In this next section we continue our review by discussing a number of approaches that are applied within the FINNOV work programme to move research beyond the state of the art. This section will provide further background on the motivations for each approach and how they connect with the literature outlined within this review.

4.2.1 Extreme growth events and the presence of fat tails

To better understand the relationship between innovation and firm performance measures, one needs a good understanding of the time series behaviour of these variables, which often do not follow the assumption of a 'normally' distributed variable. One of the factors that may

lead to ‘fat tailed’ distributions is the persistency of innovation, both at the firm level but also at the level of the aggregate economy (e.g. as highlighted by Schumpeter in his notion of innovation coming in clusters and waves).The lack of persistence discussed in the section above is even more puzzling when one thinks of the robust evidence for fat tails in growth rate distributions. Firm growth rates do not follow a Gaussian distribution (as would be produced by a stochastic growth process) but display tent-like structures with significantly fatter (or heavier) tails compared to the Gaussian distribution (Axtell, 2001; Bottazzi and Secchi; 2005; Bottazzi et al., 2008; Coad and Rao, 2006; Dosi; 2005; Reichstein and Jensen, 2005). Fat tails imply that extreme growth events happen more frequently and the Pareto and Subbotin family distributions seem to fit the growth data much better than the Gaussian distribution. Evidence for fat tails is often interpreted as evidence for lumpy growth (instead of an iid. growth process) which results from economies of scale and scope, clustering of technological innovations and the increasing returns due to network externalities, knowledge accumulation, innovation activities and the self-reinforcing effects of the creation of managerial talents (Bottazzi and Secchi, 2005; p.19; Dosi, 2005).

While not testing the relationship between innovation and fat tails in different performance variables, the recent industry dynamics literature has in fact suspected that innovation might be a factor likely to cause persistent dynamics to emerge and thus drive the lumpy growth process. The disharmonious and lopsided nature of innovations that often come in waves would imply that the growth opportunities in a market are not identical, some being extremely large compared to the rest (Freeman, 1995; Schumpeter, 1934). The heterogeneous nature of growth opportunities results in some firms (e.g. successful and persistent innovators) experiencing extreme growth because the market opportunities they capture are extraordinarily large. Coad (2006) argues that the fat tails emerge due to indivisibility of the lumpy resources used for growth instead of the factors suggested by Bottazzi and Secchi (2005) that would lead to increasing dynamic returns and autocorrelated firm growth.

4.2.2 Financial and economic measures of firm default

Here we continue our discussion of the link between the industrial performance of firms, such as efficiency, profitability, investment and growth, with the financial dimension of firms' operations. Factors such as availability and cost of external financing, different reliance on debt vs. equity, differences in types of debt holders and maturity, and so on, obviously play a relevant role in the selection process, as they naturally interplay with investment decisions, thereby affecting the extent to which efficiency and profitability advantages can translate into growth. Such issues, going under the general heading of capital market imperfections, rely upon various theories on the existence of credit rationing or credit constraints to growth, whose common feature is to abandon the standard Modigliani-Miller result of independence of investment decisions of firms from debt structures and access to external financing. Drawing from the seminal contribution of Fazzari et al.(1988), an impressive amount of empirical work has tested the existence of non-neutralities in capital markets, almost invariably finding statistical significance for some measure of financial constraints (see reviews in Hubbard, 1998; Fagiolo and Luzzi, 2006; and Whited, 2006). A remarkable weakness of this strand of research resides in the pervasive reliance on cash flow as a proxy for financial imperfections, despite investment sensitivity to cash flow might arguably be considered as a void indicator for that kind of mechanisms (Kaplan and Zingales, 1997, 2001). Liquidity, at the end, is just a measure of the ability to generate ready to spend, and exclusively internal resources. There seems to be a need to include a wider range of financial indicators, as this would obviously help understanding whether different financial structures/characteristics ease or limit industrial outcomes. For instance, what is the relative role played by industrial and financial factors as determinants of firm default?

The analysis of firms' distress performed in the field of financial economics typically conceives default as primarily determined by unsound financial conditions, especially in the

short run before default occurs. According to a tradition of analysis followed since Beaver (1966)'s and Altman (1968)'s classical studies (for reviews see Altman and Saunders, 1998; and Crouhy et al., 2000), purely industrial factors tend to receive less attention and sometimes are left out of the picture. Of course, it is well understood that the probability to stay in the market as well as default risk is deeply intertwined with the ability to perform well along the economic dimensions of its operation, but the presumption is that the effect of variables like efficiency, profitability or growth records is more relevant several periods before default, and in any case perfectly embedded into shorter run financial indicators. However, at least as long as market frictions or other institutional factors are affecting the speed and extent to which industrial performances get reflected into the financial conditions of a firm, it is possible that looking exclusively at financial indicators cannot offer but a partial account of default dynamics. Starting from similar considerations Grunert et al.(2005) propose an ``augmented'' version of a standard financial model of default prediction which also includes two ``soft'' non-financial characteristics (managerial quality and market position) among the regressors.

Thus FINNOV posits that financial literature can benefit from the inclusion in the default analysis of a wider and more sensible subset of economic/industrial indicators. The aforementioned theories of firm-industry dynamics offer a solid guidance to our attempt, suggesting that size-growth dynamics, profitability and productivity represent the crucial dimensions of performance which one should include as possible determinants of default.

4.2.3 Measuring bubble dynamics

Profits and firm growth rates discussed above reflect the actual performance of firms in industrial markets. Market value and stock prices instead reflect expected profits and growth—as determined in financial markets. Studies that look into the impact of innovation on stock prices build on the efficient market hypothesis which assumes that the prices traded in the market reflect all known information and hence, the firms' innovative potential is captured by these prices.

Various studies that focus on the effect of innovation on the level of stock prices come principally from the applied industrial economics literature that models growth, innovation and stock prices over the industry life-cycle (Jovanovic and MacDonald 1994; Jovanovic and Greenwood 1999; Mazzucato and Semmler 1999) and the work on market values and patents (Pakes 1985; Griliches, Hall and Pakes 1991; Hall, et al., 2005). For example, Jovanovic and MacDonald (1994) make predictions concerning the evolution of the average industry stock price level around the "shakeout" period of the industry life-cycle. Focusing on the US tire industry, they build a model which assumes that an industry is born as a result of a basic invention and that the shakeout occurs as a result of one major refinement to that invention. They predict that just before the shakeout occurs, the average stock price will fall because the new innovation precipitates a fall in product price which is bad news for incumbents. Building on this work, Jovanovic and Greenwood (1999) also link stock prices to innovation by developing a model in which innovation causes new capital to destroy old capital (with a lag). Since it is primarily incumbents who are initially quoted on the stock market, innovations by new start-ups cause the stock market to decline immediately as rational investors with perfect foresight foresee the future damage to old capital (competence destroying innovations in the words of Tushman and Anderson 1986).

The studies discussed so far relate stock price dynamics to innovation mainly by linking changes in the stock price level to innovation, rather than linking changes in volatility of stock prices to innovation. As is well known, a proxy for risk in the Capital Asset Pricing Model is the standard deviation of returns. As innovation is one of the main sources of risk and uncertainty faced by firms, there are reasons to believe that the relationship between innovation and stock prices will be found especially in relation to the volatility not the level of

stock prices (or both due to the relationship between risk and return). And since innovation is not just risky but truly uncertain, in the Knightian sense, this is even truer. Yet very few studies provide insights into the relationship between innovation and volatility of stock prices.

One well known study that links stock price volatility to innovation is Shiller (2000), where it is shown that 'excess volatility', the degree to which stock prices are more volatile than the present value of discounted future dividends (i.e. the underlying fundamentals that they are supposed to be tracking according to the efficient market model), peaks precisely during the second and third industrial revolutions. He suggests that it is in uncertain situations such as those characterized by radical technological change, that current information about 'fundamentals' (i.e. current profits, dividends etc.) are less useful for making predictions about future market values.

Other studies suggest that there has been no trend increase of aggregate stock price volatility (Schwert 1989; 2002) except for during particular periods of 1970's and the 1990's. However, the increase did not persist following these periods. Firm specific volatility has, on the other hand, experienced a trend increase over the last 40 years (Campbell et al. 2001). Based on these insights, Mazzucato and Semmler (1999) and Mazzucato (2002; 2003) study the relationship between innovation and stock price volatility at the firm level over the industry life-cycle when the characteristics of innovation are changing (Gort and Klepper, 1982). The studies discussed above (find that both idiosyncratic risk and excess volatility were highest precisely during periods in which innovation was the most radical and market shares the most unstable

Another type of familiar bubble activity relates to the formation and dynamics of asset bubbles. Whilst much of the discussion to this point has focused on innovation, firm performance and the relationship to financial markets, we now explore the impact of financial market dynamics on consumers. Specifically, we are interested in reactions of agents to changes in asset markets; in this case the effect on household welfare, consumption, and income.

A real estate bubble is typically defined as a difference between actual housing prices and their estimated values. The estimates are calculated using a model with one or more fundamental determinants of the property prices. There are two widely used types of models. The first is a supply-demand model of the real estate market. The second is a present value model with rents representing future cash-flows. The relationship between property prices and fundamentals is stationary in both classes of models. In the supply-demand model, the demand shifters are for example income and interest rates. The supply shifters include depreciation and construction costs, among other variables. Examples of this type of a model can be seen in Gallin (2006) and Mikhed and Zemčík (2009a). Implications of the present value model for stationarity between asset prices and a stream of earnings are discussed in Campbell and Shiller (1987). Wang (2000) and Mikhed and Zemčík (2009b) apply this approach to the real estate markets.

Malpezzi (1999), Gallin (2006), and Mikhed and Zemčík (2009a,b) all employ panel data stationarity techniques to the US real estate market. These relatively new methods have a greater power to reject the null hypothesis of non-stationarity as compared to their univariate counterparts. A widely used panel data unit root test is introduced in Im, Pesaran, and Shin (2003). The test is based on the distribution of an arithmetic average of the t-statistics from the standard Dickey-Fuller unit root test. Pesaran (2007) proposes a variant of the test robust to cross-sectional dependence, which is likely to be present in the real estate data. Pesaran (2004) offers a test of this dependence. Mikhed and Zemčík (2009b) test for cointegration between real estate prices and rents by testing for stationarity of the price-to-rent ratio. They also employ recently developed panel data Granger causality tests from Hurlin (2004) and Hurlin and Venet (2004) to analyze mutual predictability of real estate

prices and rents, as implied by the present-value model. The panel data stationarity and Granger causality tests are applied to regional data for prices and rents in the Czech Republic, which serves as a blueprint.

Asset prices affect economic growth, mainly via their impact on household consumption. This holds true especially for real estate prices. Higher housing prices tend to make households feel wealthy and they consequently spend more. The wealth effect is enhanced if it is possible to borrow using property as collateral. Lower housing prices can have adverse effects and start a recession, as illustrated by the recent events in the United States. It is therefore important to reveal the exact nature of the link between asset prices and consumption. We do this both from the macroeconomic and microeconomic perspectives. First, using aggregate data, we derive the restrictions on the moments of a stochastic discount factor using Lucas (1978) consumption based inter-temporal capital asset pricing model. The Hansen and Jagannathan (1991) bounds are calculated using not only the stock market returns but also the returns on housing. The restrictions are used to find parameters of this model satisfying the volatility bounds. While the stochastic discount factor (the pricing kernel) does not have to be specified for the volatility bound to be computed, including real estate returns raises the issue of a proper treatment of housing. A house is not only an asset but it also affects the utility of a consumer by providing housing services. Therefore, rather than focusing on implications of the Hansen-Jagannathan bounds for a general pricing kernel, the discount factor is specified here using an asset pricing model with housing. Piazzesi, Schneider, and Tuzel (2007) supply a convenient framework for this type of analysis. The stochastic discount factor will be then modelled jointly with the property and stock (excess) returns. Since the pricing kernel is the inter-temporal marginal rate of substitution in this model, there is a direct correspondence between the kernel and consumption. We will first analyze the United States as a useful benchmark and then apply a similar approach to European countries.

Next, we focus on how changes in property prices affect consumption of individual households. Case, Quigley, and Shiller (2005) use panel data for OECD countries and for the US states to investigate whether the housing market wealth and financial wealth affect consumption. While the stock market wealth effect is weak, there is a strong relationship between housing wealth and consumption. The investigation is based on aggregate data for countries or states within a country. The first study to analyze the effect of changes in housing prices on consumption using household level data is Campbell and Cocco (2007). They use UK Family Expenditure Survey to construct a pseudo panel for regional cohorts from a time series of cross-sections. They control for national house prices and regional income and find a strong effect of regional house prices on consumption. However, the analysis is limited due to a measurement error in the pseudo-panel and due to the inability to precisely identify households for which the housing wealth effect is the largest.

A convenient framework to estimate the impact of real estate prices on the life-time utility (welfare) of households is given in Campbell and Cocco (2002). They use a life-cycle model with a finitely-lived household and risky labour income. The real estate prices matter in the model, since households can obtain a second one-period loan once they pay off a portion of their mortgage debt. A key element in the model is the process governing housing prices. In Campbell and Cocco (2002), the real log house price is a random walk with a drift. However, property prices tend to be positively autocorrelated (see Englund and Ioannides 1997) and possibly display heteroskedasticity observed in stock returns. To account for these stylized facts, the random walk process can be generalized to the two-state, two-mean, and two-variance Markov switching process used in Zemčík (2001) to model a consumption process.

4.2.4 Business history – a case study perspective

4.2.5 Developing macro-micro links – Agent based modelling

During the last fifteen years, the field of macroeconomics has experienced a rapid convergence towards a commonly accepted paradigm, baptized as new neoclassical synthesis (NNS) (Goodfriend and King, 1997), of which the most visible and fashionable outcome is the class of DSGE models. Remarkably, macroeconomics models published in top-ranking academic journals nowadays look almost similar to each other in structure, regardless of the research question they address or the emphasis they put on theoretical versus empirical analysis.

The main idea behind the NNS rests on the blending of key elements of neoclassical real business cycle theory with key elements of the new Keynesian tradition of the 1980s. A quick look at the contributions each one of them added to the synthesis should help us to put in perspective the pros and cons of the current state of macroeconomics. The research program launched at the end of the 1970s by adherents to the new Classical school and the real business cycle (RBC) approach was centred on a simple but far-reaching idea: in order to evaluate within a single and consistent framework, issues related to either short-run fluctuations and long-run growth, structural macroeconomic models should be firmly rooted on intertemporal general equilibrium (GE) foundations. In the words of Robert Lucas and Tom Sargent:

"*An economy following a multivariate stochastic process is now routinely described as being in equilibrium, by which is meant nothing more that at each point in time (a) markets clears and (b) agents act in their own self-interest. This development, which stemmed mainly from the work of Arrow [...] and Debreu [...], implies that simply to look at any economic time series and conclude that it is a disequilibrium phenomenon is a meaningless observation. [...] The key elements of these models are that agents are rational, reacting to policy changes in a way which is in their best interests privately, and that the impulses which trigger business fluctuations are mainly unanticipated shocks."* (Lucas and Sargent, 1978, p. 7)

A natural by-product of this approach is that microeconomic and macroeconomic analysis should no longer be seen to involve fundamentally different principles. Theoretical statements about household or firm behavior, as well as theoretical statements about the functioning of individual markets, can be immediately reconciled with a model of the aggregate economy:

"The most interesting recent developments in macroeconomic theory seem to me describable as the reincorporation of aggregative problems [...] within the general framework of 'microeconomic' theory. If these developments succeed, the term 'macroeconomic' will be simply disappear from use and the modifier 'micro' will become superfluous. We will simply speak, as did Smith, Marshall and Walras, of economic theory.9 (Lucas, 1987, pp. 107-8)"

According to this view, economic phenomena at a macroscopic level can be modelled - hence, explained - as a weighted sum of the equilibrium market outcomes of homogeneous individual decision makers[2], so that the per-capita dynamic behaviour of the aggregate is identical to that of a single microeconomic agent. The analytical cornerstone to reach this result consists in refurbishing the competitive GE model elaborated in the 1870s by Leon

[2] It seems worthwhile to notice that this procedure of microfoundation of macroeconomics is very different from the methodological counterpart used in physics. The latter starts from the micro- dynamics of the single particle, as expressed by the Liouville equation and, through the Master equation, ends up with macroscopic equations. In the aggregation process, the dynamics of the individual entities lose their degree of freedom and behaves coherently in the aggregate.

Walras, that is a configuration of prices and plans of action such that, at those prices, all agents can carry out their chosen plans and, consequently, all markets clear.

Real business cycle economists recurred, in particular, to the refinement proposed in the 1950s by Arrow and Debreu (1954), who showed that also individual intertemporal (on an infinite horizon) optimization yields a GE, as soon as the economy is equipped with perfect price foresights for each future state of nature and a complete set of Arrow-securities markets (Arrow, 1964), all open at time zero and closed simultaneously. Whenever these conditions hold true, the GE is an allocation that maximizes a properly defined social welfare function, or the equilibrium is Pareto-efficient (First Welfare Theorem).

At odds with RBC theorists, who insisted in ethereal parables built on models with perfectly competitive equilibria, the counterpart involved in the NNS i.e. new Keynesians (NEKs) - moved from facts, whose power is hard to ignore in the long-run. Among them, one is really remarkable. Shifts in aggregate demand, for example due to unexpected monetary policy, affect output substantially more than would be expected in an economy with perfectly flexible prices and wages.

The line of attack chosen by NEKs consisted in accepting the methodological glove thrown down by RBC theorists, showing that real and nominal rigidities – responsible in the end of the excess sensitivity of output to demand shocks can be derived from first principles on the one hand, and that a variety of types of adjustment frictions can be easily incorporated into dynamic GE models on the other one. A large literature has stressed that this re-interpretation of Keynes' ideas has almost nothing to do with what Keynes' himself thought about how a dynamic market economy really works. But this criticism has been largely considered by mainstream macroeconomists as a nuisance.

Summarizing, in its basic incarnation the NNS-DSGE model which is currently monopolizing macroeconomics is a dynamic (i.e., infinite horizon), rational-expectation GE model with two imperfections added: i) monopolistic competition in the goods market; and ii) a deterministic (à la Taylor) or stochastic (à la Calvo) time-dependent price-setting rule. While the mathematics required to solve the model may at times look difficult and intimidating, conceptually the model is disappointingly unrefined: starting from a discounted sum of infinite utilities and an intertemporal budget constraint, somewhere you will eventually find a marginal rate of substitution equating a relative price, and possibly an additional binding constraint that prevents the second-best from being achieved.

Nothing is said about true heterogeneity in preferences and beliefs; the behaviour of agents along disequilibrium paths; the net of non-market interactions linking agents; the insurgence of intratemporal and intertemporal coordination problems; in a nutshell, nothing is said about what really makes any macroeconomic system an object worth studying. In different contexts, Caballero (1992) and Gallegati (1993) show that RA models, by disregarding heterogeneity, non-convexities and direct interaction, abstract from stringent aggregation issues which inevitably lead the modeller to commit a fallacy of composition. It would be quite easy to provide back-of-the-envelope examples in which a RA does not represent at all the individuals populating the economy, so that the reduction of a group of heterogeneous agents to an RA, far from being an innocuous analytical convenience, is "[...] *both unjustified and leads to conclusions which are usually misleading and often wrong"* (Kirman, 1992).

Are there other ways to do realistic (i.e., with individual rules of conduct and interaction structures being consistent with empirical observations) and useful (in guiding policymakers and in helping us to forecast) macroeconomic analysis beyond that inspired by the NNS-DSGE approach? Here FINNOV argues for a positive answer. In particular, the solution we offer embrace the view that any economy –particularly, large economies composed of millions of individual entities may and should be described as a complex, adaptive, dynamic

system (Arthur et al., 1997). Complexity arises because of the dispersed and non-linear interactions of a large number of heterogeneous autonomous agents. While we can naturally observe and measure macro outcomes – for instance, quantity and price indexes, as well as their growth rates - aggregates could not be deduced directly from an examination of the behavior of a typical individual in isolation. Global properties emerge instead from the market and non-market interactions of people without them being part of their intentions, a notion which clearly resembles the time-honored invisible hand metaphor advanced by Adam Smith.

Agent-based computational (ABC) economics – that is the use of computer simulations to grow and study evolving artificial economies composed of many autonomous interacting agents - represents a promising tool for advancements along the research program sketched so far (Judd and Tesfatsion, 2006). The ABC approach allows us to build models with a large number of heterogeneous agents, where the resulting aggregate dynamics is not known a priori, and outcomes are not immediately deducible from individual behaviour. It is characterized by three main tenets: (i) there is a multitude of objects that interact with each other and with the environment; (ii) objects are autonomous (hence, they are called agents); no central or "top down" control over their behaviour is admitted; and (iii) the outcome of their interaction is computed numerically.

Our work arose from our conviction that the NNS-DSGE approach to the analysis of aggregate market outcomes is fundamentally flawed. The practice of overcoming the SMD result by recurring to a fictitious RA leads to insurmountable methodological problems and lies at the root of DSGE models' failure to satisfactorily explain real world features, like exchange rate and banking crises, bubbles and herding in financial markets, swings in the sentiment of consumers and entrepreneurs, asymmetries and persistence in aggregate variables, and so on. At odds with this view, our critique rests on the premise that any modern macroeconomy should be modelled instead as a complex system of heterogeneous interacting individuals, acting adaptively and autonomously according to simple and empirically validated rules of thumb.

The need to understand the implications of highly interconnected heterogeneous agents is highlighted by the recent events in the banking sector and the series of events marking the financial crisis. We allocate the final part of this state of the art review to consider the role of innovation in the financial services industry and consider how the evolution of innovation in this industry contributed to the credit crunch and financial crisis of recent years.

5 FINNOV research in the context of the 2008/09 international financial crisis

The recent financial crisis was caused by a 'credit crunch' in inter-bank lending that has been brought about because financial institutions were no longer ready to rely on traditional credit ratings. The increase in liquidity risk was caused by concerns that highly leveraged derivatives, such as credit default swaps and collateralized debt obligations, made the financial obligations of lending parties increasingly opaque. When banks are not sure of the stability of the institutions they are lending to and borrowing from, and are concerned about financial exposures as complex derivative positions are unwound, they lend less, thus producing the crisis.

This trajectory of cumulative patterns of financial innovation involves framing, standardising, analysing, securitising and re-engineering the risk of default, and has produced a huge increase in the use of technology (to measure and hedge exposures), the use of derivatives (that are now approximately 700 times the value of their underlying assets), and the use of leveraged business models based upon use of risk analysis technology (i.e. commercial banks using V-a-R). The current crisis reflects how a technological trajectory based on using financial engineering techniques to analyse and repackage credit risk has complicated the financial system and caused a substantial deviation between the models and the reality.

As a result, banks balance sheets are extremely difficult, if not impossible to value, which has shifted the focus of risk management from the risk of default, to liquidity risk and the problems financial institutions have in borrowing money in the short term inter-bank markets. As Nation States have bailed out the banking sector (again), this has now spread from banks to Nation States as investors worry about defaults and bond restructuring. New financial innovations, such as a credit default swap (CDS), allow these previously subjective and private concerns to be made public, which has the potential to create self fulfilling prophecies and crashes.

The financial crisis therefore relates directly to the main research agendas of FINNOV in financial innovation, the role of the financial system within the economy, and the social distribution of risks and rewards. As noted earlier, the relationships between social inequality and financial systems are complex but under-researched. They have been central to the current financial crisis – for example, an important proportion of the outstanding derivative contracts were derived from real assets in the subprime mortgage market. The value of these assets (and therefore derivatives) was supported by rising home prices that enabled subprime households to manage, and if necessary, restructure their mortgage payments. When US housing prices began to decline from September 2006, higher income volatility in the US compared to Europe increased the risks of default, this changed the value and volatility of the underlying assets and made the actual value of the complex financial derivatives they were based on much more opaque.

The roots of the financial crisis therefore go much deeper than changes in financial technology or banking regulation and reflect important shifts in the social distribution of risk within the US, and therefore global, economy. The social institutions that socialised risks in the post-war period have been gradually replaced by institutional structures that individualised risks (Hacker, 2006) and remove the slack in the system that provides a buffer against large scale losses. Institutional changes in the role of the *innovative enterprise* in the US economy and *an increase in income inequality* have removed institutional protection in a highly interdependent way that remains under-researched.

For example, the innovative enterprise – defined as a social process that generates higher quality, lower cost products, given prevailing factor prices – has been foundational for growth in per capita incomes. The development and utilization of productive resources that result in innovation entail a collective and cumulative process that employs large numbers of people over a sustained period of time. As a result, the innovative enterprise can provide stable, remunerative, and often creative employment to both its workforce and the network of firms and institutions to which it is connected. The widespread growth of the innovative enterprise in both the US and Europe in the 20th century was directly related to the rise of abundant "middle-class" employment and relatively more equal distributions of income. The result in the three decades after World War II was "sustainable prosperity" with stable and equitable economic growth.

Over the past three decades, US GDP per capita has grown at an average annual rate of almost 2 percent, but that growth has been neither stable nor equitable, as the distribution of income has polarized. This has been characterized in the United States by a decline in the stability of middle-class employment, measured by income volatility, since the early 1980s. The 1970s and 1980s saw widespread plant closings and a decline of well-paid, typically unionized, manufacturing jobs. This was partly a structural change in economy reflecting a long term shift towards service employment, but while this influenced the rate of change, the direction of change was influenced by government policy, politics and financial regulations. The American, Japanese and European economies all shifted toward services, but differed fundamentally in how those changes were undertaken. In the US, much more so than in Germany or Japan, profitable companies were restructured to maximize shareholder value by cutting well-paid "middle managers" who had traditionally finished their careers with their

current employers. Similarly, in the 2000s middle-class employment has been off-shored to developing nations such as India and China. Different institutional structures therefore influence whether organisational changes are innovative, in the sense of increasing resources, or simply re-allocate existing resources, which typically has involved concentrating them in particular social groups.

For example, high level corporate managers have seen very substantial increases in their incomes, particularly through the use of stock options. Corporate executives have benefited by repurchasing their own companies' stock to drive up earnings per share, which in turn typically result in higher stock prices. The combined repurchases of the S&P500 companies rose from $120 billion in 2003 to $597 billion in 2007. In 2007 repurchases alone represented 90 percent of the net income of these companies, while dividends were another 39 percent (Lazonick 2008). Similar changes have happened with Aggressive Tax Planning in which firms seek to push the boundaries of legal tax avoidance into the realm of tax evasion through complex and entirely unproductive financial structures (NESTA, 2006).

Lazonick (2010) analysis of different industries "strongly suggest that the explosions in executive pay (via stock options) are coming at the expense of innovation and the upgrading of employment opportunities in the US economy" (p.16). Lazonick (2010) demonstrates that leading US ICT companies, such as Microsoft, Cisco, IBM and Intel spend more on stock repurchases than investments in R&D to support future growth. In addition whilst investing profits into stock repurchases, these same companies were found to lobby for more public investment in the US high tech knowledge base. For example Intel lobbied for more public funding of research into nanotechnology. In other industries, for example Pharma, Lazonik (2010) finds a different scenario, whereby some of the largest pharmaceutical firms, such as Johnson and Johnson, Pfizer and Amgen justify their high prices for drugs in the US, with the need to recoup large R&D expenditures, whilst simultaneously reinvesting profits into stock repurchases to maintain share price. These examples demonstrate the trade off between financing higher executive pay via inflated share prices maintained through stock repurchases at the expense of investing in efforts to develop new innovation.

Changes in the relationships between firms and their employee, firms and their senior managers, and firms and the financial markets have a major influence on the supply of stable and remunerative 'middle-class' employment opportunities that provide good housing, health care, education, savings and pensions. The current financial crisis has been made worse by increases in economic insecurity: the large-scale subprime mortgage market emerged in the world's richest economy largely because many people did not have access to stable and remunerative middle-class jobs, and was particularly unstable in the US because when markets changed, subprime mortgage holders did not have sufficient protection to maintain their mortgage payments if they lost their jobs. The current crises therefore reflects systemic risks, that require effective institutional management (Moss, 2002)

Currently, the European economy, and its corporate governance and institutional networks are very different from the United States. However, how to maintain stable and equitable economic growth within a European setting is neither obvious nor inevitable. By investigating the current financial crisis within a novel Schumpeterian framework that pays explicit attention to wider concerns about sustainable, social inclusion and the role of innovative enterprises, we aim to inform a new and emerging agenda of academic research, public policy and corporate strategy related to finance and innovation in a world where the links between systemic liquidity and credit risks play important roles in both the financial sector, and in society more generally.

6 Conclusion

In conclusion this review of the literature scopes the foundation of the FINNOV research programme, focused around the key themes outlined in the introduction above. The FINNOV themes are concerned with financial institutions and modes of financing innovation; finance and the economics of risk and uncertainty; and the economics of innovation and inequality. The review signals that despite a significant trajectory of research in these thematic domains, there is a strong need for more research on the dynamics of innovation as well as a more nuanced understanding of the role and relationship of finance within the innovation process. Emerging from the financial crisis, formulating the appropriate policy for ensuring appropriate levels and types of finance are directed to innovation will be essential for continued economic development in Europe. To this end, this review specifically identifies a need for more research attention to be devoted to a study of the European 'case' compared to the general literature which predominantly explores activity in the US. Most importantly this review highlights the crucial contribution of evolutionary economics in understanding both the innovation process and the necessary financial conditions and environment for supporting innovation. It draws attention to the variety of new methodological approaches relevant to the study of innovation and financial dynamics. Critically, it also contributes to understanding the limitations of the innovation process towards achieving equitable forms of economic development which will be essential if the EC 2020 mission is able to achieve *smart growth* and *inclusive growth* together rather than in opposition.

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